Biological Psychology 83 (2010) 108–115

Contents lists available at ScienceDirect

Biological Psychology

journal homepage: www.elsevier.com/locate/biopsycho

Trait and state positive affect and cardiovascular recovery from experimental academic stress

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ARTICLE INFO

Article history:
Received 18 October 2009
Accepted 19 November 2009
Available online 26 November 2009

Keywords:
Stress
Recovery
Heart rate variability
Positive affect
Negative affect

ABSTRACT

As compared to negative affect, only a small number of studies have examined influences of positive affect on cardiovascular stress responses, of which only a few were concerned with cardiovascular recovery. In this study, heart rate, low- and high-frequency heart rate variability, blood pressure, and levels of subjectively experienced stress were obtained in 65 students before, during and after exposure to academic stress in an ecologically valid setting. Higher trait positive affect was associated with more complete cardiovascular and subjective post-stress recovery. This effect was independent of negative affect and of affective state during anticipation of the stressor. In contrast, a more positive affective state during anticipation of the challenge was related to poor post-stress recovery. The findings suggest that a temporally stable positive affect disposition may be related to adaptive responses, whereas positive emotional states in the context of stressful events can also contribute to prolonged post-stress recovery.

The vast majority of research on the role of emotional factors in physiological responses to acute stress has focused on negative affect. Overall, research suggested that negative affect such as anxiety, neuroticism, or depression was associated with decreased cardiovascular reactivity and poor recovery to baseline following stressor completion (Chida and Hamer, 2008; Pieper and Brosschot, 2005). However, some studies demonstrated opposite or no effects (e.g., Hughes and Stoney, 2000; Knepp and Friedman, 2008). To date, only a comparatively small number of studies have explicitly examined influences of positive affect on cardiovascular stress responses, of which only a few were concerned with cardiovascular recovery (see, e.g., recent review by Chida and Hamer, 2008).

Psychophysiological recovery is defined as the rate and/or degree to which a response approaches prestress levels following a stressful experience (Haynes et al., 1991). It is part of the normal physiological response to acute stress which is constituted by turning on an adaptive response and shutting it off after stressor termination (McEwen, 1998). Efficient emotional and cardiovascular recovery from stressful events may be an indicator of the capacity for successful adaptation. In several theoretical concepts, adaptive responses have been characterized as a distinct initial reaction but more efficient recovery from the normal stress response; for instance: autonomic flexibility (Friedman and Thayer, 1998), physiological flexibility (Hoehn-Saric and McLeod, 2000), physiological toughness (Dienstbier, 1989), allostatic regulation (McEwen, 1998), or resilience (Lazarus, 1993; Tugade et al., 2004). Inflexible (i.e., prolonged, but also initially weak) responses are thought to hinder proper adaptation to changing environmental demands.

Inefficient recovery may eventually result in unfavorable physical sequelae. Although responses to acute stress in the laboratory are not of clinical importance in themselves, they may index the way that individuals respond to ordinary psychological demands in daily life, and accumulation of maladaptive responses may eventually have pathophysiological significance (Chida and Hamer, 2008). This relationship was shown in prospective studies; delayed heart rate recovery, for instance, was associated with higher carotid atherosclerosis two years later (Heponiemi et al., 2007). It was also suggested that the efficiency of cardiovascular recovery may be more relevant to the development of cardiovascular disease than the magnitude of stress responses, i.e., cardiovascular reactivity (e.g., Pieper and Brosschot, 2005). Nevertheless, compared to studies on individual differences in cardiovascular reactivity to a stressor, only a small proportion of research has explicitly addressed the issue of recovery (Chida and Hamer, 2008; Linden et al., 1997; Pieper and Brosschot, 2005).

It has been suggested that positive affect may protect against slow or prolonged recovery from stress (Ong et al., 2006; Tugade and Fredrickson, 2004), and that cardiovascular responses to

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doi:10.1016/j.biopsycho.2009.11.008

positively valenced stimuli may be of shorter duration than those to negative stimuli (Brosschot and Thayer, 2003). However, too little research has been done so far to draw strong conclusions (Chida and Hamer, 2008). One additional issue is that it has not yet been carefully distinguished in the literature on positive affect between effects of emotional traits (i.e., stable dispositions to experience particular moods) and transitory states brought on by specific situations. But the physiological concomitants of positive affect seem to depend strongly on whether it is of a trait or state nature. Induced high-activated positive affect such as joy or exhilaration produces increases in markers of physiological arousal, which are very similar to those of state negative affect. In contrast, trait positive affect has been shown to be associated with low baseline levels of physiological arousal and health outcomes that are opposite to those of trait negative affect (Pressman and Cohen, 2005). Trait positive affect may influence recovery from acute stress, because it is associated with greater flexibility in thinking and problem solving (Ashby et al., 1999; Dreisbach and Goschke, 2004) and adaptive coping strategies such as positive reappraisal or problem-focused coping (Folkman and Moskowitz, 2000; Tugade et al., 2004). State positive affect may make individuals less prone to rumination, which may prolong cardiovascular activation (Brosschot and Thayer, 2003), or may "undo" the effects of negative emotions (Fredrickson et al., 2000). Studies on negative affect (anger, rumination) suggested that both affective traits and states can play a role for cardiovascular recovery (Key et al., 2008; Lai and Linden, 1992; Vella and Friedman, 2009).

As for positive affect, Fredrickson et al. (2000) showed that cardiovascular recovery was faster when positive mood was induced by viewing a film after a stressful situation than when negative mood was induced. However, since the film was presented after the stress condition, it seems likely that the positive film simply lifted the mood of the participants. That is, the induced positive affect might have indirectly influenced recovery from the stressful situation by replacing the negative affective state after the stressful situation by a more positive one, essentially distracting the participants more from their negative experience. In another study, Tugade and Fredrickson (2004) found that positive mood at the beginning of the experiment correlated with speed of recovery after a speech preparation task. The study design, however, did not allow to differentiate whether the effect may be attributable to trait or state variance of positive affect.

Tugade and Fredrickson (2004) assumed that certain individuals ("resilient" individuals) may have a greater tendency to draw on positive emotions in times of stress, which then may speed recovery. Therefore, in addition to trait positive affect, we investigated naturally occurring (i.e., not induced) state positive affect during the anticipation of academic challenge. This was done to examine whether it may provide advantages to approach a challenge with positive affect. By including both trait and state measures, we were able to examine unique contributions of state and trait positive affect to cardiovascular recovery.

Most of the above-cited studies did not allow to distinguish whether effects are genuinely attributable to positive affect or are merely due to low levels of negative affect. If genuine effects of positive affect exist, positive affect should be related to cardiovascular recovery independently of negative affect levels (Pressman and Cohen, 2005). Therefore, we obtained measures of both positive and negative affect and tested the unique effects. Importantly, it has been shown that positive emotions can co-occur with negative affect, even in the midst of personally significant stress (Folkman, 1997; Moskowitz et al., 1996; Ong et al., 2004). Several studies showed effects of positive affect on physiological responsivity or health that were independent of negative affect levels (Chida and Steptoe, 2008; Pressman and Cohen, 2005; Steptoe et al., 2007).

By controlling negative affect in regression analyses, we also eliminated possible effects of overall emotional arousal, the remaining variance reflecting predominantly positive emotional valence (and vice versa). In this context, a finding of Brosschot and Thayer (2003) seems important. This study showed that negative emotional valence, but not emotional arousal, was related to poor recovery after emotional episodes, whereas only arousal, but not valence, was related to initial reactivity. Hence, giving valence priority over arousal, effects on recovery rather than reactivity could be expected in the present study.

Experimental stress studies typically employ artificial stimuli that rarely occur in the real world. In the present study we used a real-world stressor with high ecological validity for the studied population. First-year psychology students were exposed to an examination situation in which they had to answer a difficult statistics question. Performance in this task had much more significance for the participants than classical laboratory tasks such as mental arithmetic tasks. This feature is important, because with more naturalistic stress conditions, the recovery period is of longer duration and of greater relevance to possible implications (Linden et al., 1997). We obtained measures of cardiovascular recovery several minutes after termination of the stress situation, because individual differences in recovery at more extended periods are probably more relevant to possible health related effects than those shortly after the stressor. Considerable individual differences in cardiovascular recovery can be well expected until ten minutes after termination of the stress situation, if the task is personally relevant (e.g., anger provocation or emotion recall tasks; Key et al., 2008; Linden et al., 1997).

Heart rate, heart rate variability (HRV), and blood pressure were obtained in the present study, which are the most commonly used variables in the literature on the impact of personality characteristics and mood states on cardiovascular reactivity and recovery. The different frequency components of HRV are used to evaluate autonomic input into cardiac rhythm. The high-frequency (HF) component is generally thought to be mainly of parasympathetic origin, whereas the low-frequency (LF) component is considered by most researchers as a product of both sympathetic and parasympathetic influences on the heart (Berntson et al., 1997; Task Force, 1996). Due to the likely contamination of LF by parasympathetic influence, in many studies the LF/HF ratio has been reported, too, which has also been shown to be a more consistent characteristic of individuals than LF and HF power (Sloan et al., 1995). Higher LF/HF ratios indicate increases in sympathetic activity and imply reductions in parasympathetic control of heart rate. Changes in heart rate are influenced by both sympathetic and parasympathetic activity. During baseline conditions and moderate stress, vagal control prevails, whereas influence of the sympathetic nervous system increases at higher levels of stress (Obrist, 1981). Differential effects in connection with psychological factors in performance situations have also been shown for diastolic blood pressure, which varies primarily as a function of peripheral vascular resistance, and systolic blood pressure, which is more strongly related to cardiac activity (see, e.g., Gramer and Saria, 2007).

In summary, our main hypothesis was that individuals high in trait positive affect would show more complete cardiovascular recovery after a realistic academic stress situation, and that this effect could be demonstrated independently of trait negative affect and of affective state during anticipation of the stressor. We expected an additional beneficial effect of state positive affect during anticipation of the examination situation, which would also be independent of negative affect.