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Behavioral and self-reported sensitivity to reward are linked to stress-related differences in positive affect

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ABSTRACT

Despite the high prevalence of stress exposure healthy adaptation or resilience is a common response. Theoretical work and recent empirical evidence suggest that a robust reward system, in part, supports healthy adaptation by preserving positive emotions even under exceptionally stressful circumstances. We tested this prediction by examining empirical relations among behavioral and self-reported measures of sensitivity to reward, trait resilience, and measures of affect in the context of experimentally induced stress. Using a quasi-experimental design we obtained measures of sensitivity to reward (self-report and behavioral), as well as affective and physiological responses to experimental psychosocial stress in a sample of 140 healthy college-age participants. We used regression-based moderation and mediational models to assess associations among sensitivity to reward, affect in the context of stress, and trait resilience and found that an interaction between exposure to experimental stress and self-reported sensitivity to reward predicted positive affect following experimental procedure. Participants with high sensitivity to reward reported higher positive affect following stress. Moreover, positive affect during or after stress mediated the relation between sensitivity to reward and trait resilience. Consistent with the prediction that a robust reward system serves as a protective factor against stress-related negative outcomes, our results found predictive associations among sensitivity to reward, positive affect, and resilience.

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1. Introduction

The role of stress in the etiology of mood and anxiety disorders is well documented (Hammen, 2005; Pizzagalli et al., 2007; van Praag, 2004). Although individual responses to a stressor (traumatic or otherwise) vary, with many individuals reacting positively, relatively little is known of the factors contributing to this positive adaptation (Bonanno, 2004). Extensive cross-species research documents the role of reward and reward-related neural circuitry in the development of psychiatric disorders (Bogdan et al., 2013; Bogdan and Pizzagalli, 2006; Corral-Frías et al., 2015, 2013; Epstein et al., 2006; Franklin et al., 2012; Keedwell et al., 2005; Krishnan et al., 2007; Pizzagalli et al., 2009, 2007; Steele et al., 2007). Reduced ability to experience reward or pleasure (i.e. anhedonia) is a central feature of many stress-related disorders (Elman et al., 2009; Knutson et al., 2008; Pizzagalli et al., 2007) and evidence suggests that stress-induced dysregulation of the reward system increases vulnerability to some of these disorders (e.g., depression, posttraumatic stress disorder, substance use) (Bogdan et al., 2013; Corral-Frías et al., 2015; Elman et al., 2009; Knutson et al., 2008). Recent studies reveal marked reductions in reward approach behavior and reduced reward-related neural reactivity in the context of early-life or acute experimental stress (Bogdan and Pizzagalli, 2006; Dillon et al., 2009; Lighthall et al., 2012; Mehta et al., 2010; Treadway et al., 2013), suggesting a prominent role of stress in the appearance of anhedonic symptoms and related psychiatric disorders (Corral-Frías et al., 2015; Nikolova et al., 2012). However, cross-species evidence has demonstrated that stress may lead to an increase in reward salience (Chaijale et al., 2015), burst firing of rodent ventral tegmental area (VTA) dopamine neurons (Anstrom and Woodward, 2005), and increased dopamine release, reward-related behaviors and neural activation in humans (Mather and Lighthall, 2012; Scott et al., 2006), altogether highlighting the

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importance of understanding the complex relationships between the reward system, stress and related psychopathology.

A robust reward system appears to protect against the deleterious effects of stress and the presence of positive trait-like emotions decreases the risk of psychopathology following stress (Charney, 2004; Southwick et al., 2005). Optimism, humor, and an ability to experience reward or pleasure predict responses to stress (Bonanno, 2004; Charney, 2004; Folkman and Moskowitz, 2000; Fredrickson, 2001; Haglund et al., 2007; Southwick et al., 2005; Tugade and Fredrickson, 2004). Congruently, increased reward-related neural activity (e.g., ventral striatal reactivity in response to reward) appears to protect against the damaging effects of recent-life (Nikolova et al., 2012) and early-life (Corral-Frías et al., 2015) stress. However, these studies have explored the moderating role of reward processing on the relationship between stress and positive affect using retrospective measures of stress. Laboratory studies would be the most informative way to analyze the interactions between reward- and stress-related behaviors, but to date, no studies have examined the relationships between sensitivity to reward and the responses to an experimentally induced laboratory-based stressor.

Given this previous evidence (Corral-Frías et al., 2015; Nikolova et al., 2012), the present study used a quasi-experimental design to test the hypothesis that sensitivity to reward moderates the relationship between stress exposure and positive affect after stress. Moreover, based on previous literature suggesting positive affect is used to cope with stressful life experiences and thus mediate the relationship between stress and resilience (Gloria et al., 2013; Tugade and Fredrickson, 2004) we examined the prediction that positive affect following and during exposure to stress mediates relations between sensitivity to reward and self-reported trait resilience. We hypothesized, in congruence with existent literature, higher reward sensitivity will be associated with higher positive affect in the context of stress and in turn with greater reports of trait resilience.

2. Materials and methods

2.1. Participants

One hundred fifteen undergraduate and twenty five graduated students participated. Undergraduate students were recruited through an online University of Arizona subject pool sign-up system, available only to undergraduate students enrolled in INDV101 courses. Graduate students were recruited through a graduate student list serve and completed the study as volunteers. Graduate students were evenly distributed in both groups. Nine (14.1%) and 16 (23.9%) of the participants in the Control group and Experimental group respectively were graduate students. A Pearson's chi square test showed that graduate students were not unevenly represented in one group or the other ($\chi^2(1) = 2.043$; $p = .15$). Participants were at least 18 years of age (mean = 21.35 ± 4.32, ranging from 18 to 32). Both male ($N = 59$) and female ($N = 81$) participants were recruited; 64.4% of whom self-identified as White, 18.4% as Hispanic, 8.1% as Asian, 3.7% as Black, 2.2% as Hawaiian or Pacific Islander, and 0.7% as Native American (two did not provide this information).

Participants were pseudo-randomly assigned to a Control or Experimental group before arriving in the laboratory. Demographic characteristics did not differ significantly between the Control and Experimental groups (Table 1), nor did initial anxiety indices (Beck et al., 1988), defense style (Muris and Merckelbach, 1996), or self-report sensitivity to reward (Carver and White, 1994). Study exclusion criteria included: (1) not completing the majority of the study (2) self-reported psychiatric diagnosis, and (3) medical diagnosis of neurological, metabolic, or hormonal disorders.

Table 1
Demographic characteristics of the sample.

	Control	Experimental	*t*	*P*
Age	20.93 ± 4.21	21.68 ± 4.44	.986	.362
Sex	F: 36 M: 24	F: 37 M: 30	−.768	.444
BAI	13.31 ± 12.01	12.77 ± 12.23	−.253	.801
BIS	19.33 ± 2.39	19.67 ± 2.35	−.788	.433
BAS (Drive)	11.05 ± 2.48	11.61 ± 2.80	−1.17	.243
BAS (Fun Seeking)	12.03 ± 2.27	12.39 ± 2.23	−.899	.371
BAS (RR)	17.30 ± 2.19	17.50 ± 2.28	−.750	.455
DSQ (Mature)	5.64 ± 0.95	5.76 ± 0.96	.685	.495
DSQ (Immature)	3.87 ± 0.88	3.93 ± 1.04	.248	.379
DSQ (Neurotic)	4.69 ± 1.02	4.87 ± 1.05	.883	.680

Means ± standard deviations; BAI, Beck Anxiety Inventory; BIS, Behavioral Inhibition Scale; BAS, Behavioral Activation Scale; RR, Reward Responsiveness; DSQ, Defense Style Questionnaire.

Thus data from four participants who did not complete the study were excluded from the analysis, three participants in the Control and three in the Experimental group were additionally excluded due to self-reported psychiatric diagnosis. No participant reported neurological, metabolic, or hormonal disorders. Additionally, 42 participants (27 Control and 15 Experimental) were excluded in cortisol and 12 participants from heart rate statistical analysis (3 Control and 9 Experimental) due to a malfunction of the freezer where samples were stored and malfunction for heart rate collection device respectively.

2.2. Consenting and online procedures

Participants completed an online consent form before completing a set of online questionnaires, which included a general demographics questionnaire, the Beck Anxiety (Beck et al., 1988), a resilience questionnaire (Wagnild and Young, 1993), the Behavioral Inhibition Scale/Behavioral Activation Scale (BIS/BAS;(Carver and White, 1994)), and the Defense Style Questionnaire (Muris and Merckelbach, 1996). Participants additionally were asked to report any history of neuroendocrine, neurological or psychiatric disorder as well as current or past use of medications.

2.3. Experimental procedures

Participants were asked to come to the laboratory at least five hours after waking to reduce time-related circadian changes in levels of free salivary cortisol (peak levels occur shortly after awakening (Hansen et al., 2008)). Upon arrival, participants read and signed a written informed consent form and then completed a monetarily rewarded task (Monetary Incentive Delay; MID) (Knutson et al., 2000). Those in the Experimental group experienced the Trier Social Stress Test (TSST) (Kirschbaum et al., 1993); those in the Control group experienced a placebo version of the TSST (Het et al., 2009). Finally, participants in both groups completed the MID a second time.

Physiological response (heart rate and salivary cortisol) and self-reported affective state were measured before, during and after the stress/control manipulation (see Fig. 1A for a timeline). The entire experimental protocol lasted about 90 min. Upon completion of the study, all participants were debriefed, and dismissed. Undergraduate students were granted research credits for their participation.

2.3.1. Resilience measure

A 25-item 7-point Likert-style self-report questionnaire assessed trait resilience (Wagnild and Young, 1993). This scale includes two subscales: *personal competence* (17 items), which reflects determination and resourcefulness, and *acceptance of self and life* (8 items), which reflects acceptance of life and sense of peace in the face of adversity.