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Predictors of anticipatory cortisol reactivity to subsequent stressors

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HIGHLIGHTS

- Examined anticipatory cortisol response after having reacted to a stressor once
- Male participants delivered speeches and performed math tasks in front of evaluators.
- Cortisol reactivity in Visit 1 predicted anticipatory cortisol reactivity in Visit 2.
- Self-perpetuating nature of the initial cortisol response may impact health.
- A dominant and confident interpersonal orientation counteracted this effect.

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ABSTRACT

Understanding the nature, predictors, and consequences of anticipatory biological stress responses are important in understanding long-term effects of repeated stressors. We examined anticipatory cortisol responses after an individual has actually experienced and reacted to a stressor once and is anticipating a second similar stressor. We hypothesized that how an individual reacts to the first stressor may predict that individual's anticipatory responses to further stressors. In Session 1, 77 male participants delivered speeches and performed arithmetic tasks in front of two evaluators. In Session 2 one week later, participants were told that they would do the same tasks again in front of evaluators. Stress cortisol reactivity in Session 1 (increase in cortisol from pre-stressor to post-stressor) predicted anticipatory cortisol reactivity in Session 2 (increase in cortisol from baseline to immediately pre-stressor). In addition, trait measures of low self-esteem and a "Submissive and Disconnected" interpersonal orientation predicted stronger anticipatory cortisol reactivity in Session 2. If the cortisol response to an initial stressor does in fact shape consequent anticipatory cortisol responses, this self-perpetuating nature of the initial cortisol response may contribute to negative long-term effects of repeated stressors on health. One factor that may be able to counteract this effect is a dominant and confident interpersonal orientation, which may lead to lower anticipatory cortisol reactions regardless of the response to the initial stressor.

1. Introduction

Most laboratory studies examining the human stress response have used a one-time stressor. This type of research has yielded important findings over the years. In real life, however, most people encounter the same type of stressor repeatedly. As Ottenweller [1] argued, a person's response to repeated stressors might be more important in terms of effects on long-term psychological and physical health (also see [2,3]). Research provided support for the differential effects of chronic versus acute stressors for both animals and humans [1,4,5]. The mechanism for the effects of chronic stressors may involve changes in cognitions and expectations (e.g., learned helplessness) and/or physiological changes (particularly in the regions of the brain involved in emotion processing) [4,6].

A person's stress response to repeated stressors may diminish over time (habituation). However, in some cases a person might show the opposite pattern—sensitization—and have increased stress responses to later stressors [2,3]. One important aspect of repeated stressors is anticipation. Humans have a well-developed capacity to anticipate future occurrences and to prepare for them psychologically, behaviorally, and physiologically based on prior experiences [7]. However, this capacity for anticipation may also have negative consequences if a person overestimates the probability of negative outcomes. One model of chronic stress focuses on the concept of allostatic load, which refers to cumulative wear and tear in physiological systems due to responding to recurring stressors [6]. Anticipatory processes may contribute to allostatic load: Chronic stressors may lead to chronic feelings of anxiety and an anticipation of negative outcomes (with associated changes in the

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nervous system, particularly the amygdala), contributing to increased allostatic load [8].

An increase in cortisol from pre-stressor to post-stressor (i.e., stress cortisol reactivity) is the prototypic endocrine response to stressors. Increase in cortisol when anticipating a stressor (anticipatory cortisol reactivity) may be conceptually and empirically different than stress cortisol reactivity [9,10], and may explain unique aspects of psychological well-being that stress cortisol reactivity does not (see [10] for a review). One way to examine anticipatory cortisol reactivity in the laboratory is to verbally describe to participants an upcoming stressor and then assess the increase in their cortisol levels as they anticipate the stressor [10]. However, it is possible that anticipatory cortisol responses are different after an individual has actually experienced the stressor once—and reacted to it behaviorally, psychologically, and physiologically (e.g., with a stress cortisol response)—and is anticipating a second similar stressor. In fact, how an individual reacts to a first stressor may shape that individual's anticipatory responses to further stressors that are similar.

In support of this notion, a recent study suggested that women who show a strong stress cortisol response to an initial laboratory stressor involving a threat to their social status show progressively larger anticipatory cortisol levels immediately before future similar stressors (progressive anticipatory sensitization) [9]. In that study, anticipatory cortisol levels were assessed only *once at each session*, immediately before the stressor. Thus, that study did not examine the *increase* in cortisol when anticipating further stressors. That study also did not include men and did not examine traits that may predict anticipatory cortisol levels. Finally, Turan et al. [9] found that meditation practice can reduce the association between the stress cortisol response to an initial stressor involving a threat to the ego and anticipatory sensitization to future stressors, and proposed that one mechanism for the moderating effect of meditation may be through its effects on reducing the importance of the ego. Thus, effects on one's perceived social status in the dominance hierarchy (and associated feelings of self-worth) may constitute an important factor shaping anticipatory cortisol responses in a situation involving negative social evaluation.

The present study included two visits (sessions). In Session 1, male participants underwent a Trier Social Stress Test (TSST) [11], which involved delivering speeches and performing arithmetic tasks in front of two evaluators. Changes in testosterone and cortisol levels in Session 1 have been reported in an earlier article [12]. Another main goal of the study was to examine increase in cortisol when anticipating a second similar stressor (after participants underwent the stressor once in Session 1). For this purpose, participants came for a second visit (Session 2) one week later and were told that they would do a second TSST. However, after providing a saliva sample at baseline, being told that they would do another TSST (with detailed descriptions of the speech and arithmetic tasks of the TSST and of the evaluators and the camera), and providing another saliva sample 25 min later, participants were told that they would actually not do the second TSST. Data on Session 2 were not reported in the earlier article, since the focus of that article was changes in testosterone and cortisol in Session 1. In contrast, the present article focuses on anticipatory cortisol reactivity in Session 2 as the outcome, and we use personality measures and cortisol reactivity in Session 1 as predictors.

Our goal was to examine and compare levels of anticipatory cortisol responses in Session 1 (after being told about the upcoming TSST but not having actually experienced it yet) and in Session 2 (after actually having gone through a TSST session a week earlier), and more importantly, to examine associations between stress cortisol reactivity in Session 1 and anticipatory cortisol reactivity in Session 2. In addition, we examined the degree to which relevant psychological states and traits (dominance, self-esteem, fear of negative evaluation, and depressive tendencies) could predict the anticipatory cortisol reactivity in Session 2. These predictors were selected on the basis of interpersonal theory and previous findings that one's standing in the social hierarchy—and psychological consequences of this standing—can affect cortisol levels in situations involving negative evaluation by others (which would have implications for one's social standing [9,10,13]). Individuals low on perceived dominance feel that they are not able to influence and control other people, and individuals low in self-esteem have a low sense of self-worth or personal value. A situation with social-evaluative threat may lead to particularly strong anticipatory stress responses for these individuals who have doubts about their value or their standing with respect to others [13]. The same argument may be advanced for individuals who have strong fears of being evaluated negatively: Sensitivity to evaluation may enhance the impact of perceived threats to one's value. Finally, depression is associated with negative self-views [14] and thus may be associated with stronger anticipatory stress responses.

For comparison purposes, we conducted parallel analyses examining stress testosterone reactivity and anticipatory testosterone reactivity. Testosterone can be considered to be another "social" hormone [15]. There is evidence that testosterone also increases in social-evaluative situations [12], in anticipation of certain stressors and challenges [16,17], and that the change in testosterone is associated with changes in cortisol levels in both between and within person analyses [18,19].

To summarize, the aims of the study were:

1. To examine and compare levels of anticipatory cortisol responses in Session 1 (after being told about the upcoming TSST but not having actually experienced it yet) and in Session 2 (after actually having gone through a TSST session a week earlier).
2. To test the hypothesis that stress cortisol reactivity in Session 1 can predict anticipatory cortisol reactivity in Session 2.
3. To examine the associations that anticipatory cortisol reactivity in Session 2 shows with relevant personality measures and clinical conditions (trait dominance, interpersonal disconnectedness, self-esteem, depression, and fear of negative evaluation).
4. To examine similar research questions for testosterone.

Our overall aim was to contribute to knowledge of the nature and predictors of anticipatory cortisol reactivity and associated processes, which might help us have a better understanding of the effects of chronic stressors on physical and emotional health [8,20].

2. Methods

2.1. Participants

A total of 85 male undergraduate students participated in the larger study on hormone reactivity to social stressors [12]. Only male participants were included to have a relatively large sample size with a single sex (the study by Turan et al. [9] on anticipatory cortisol reactivity included only women). Eight participants either could not be scheduled for a second visit or did not show up for their second visit. Therefore, current analyses on anticipatory hormone reactivity included 77 participants who participated in both Session 1 and Session 2 (46 white, 31 black; $M = 21.12$ years, $SD = 4.10$). Exclusion criteria were: diagnosis of an endocrine disease, using corticosteroid-based medications or recreational drugs, habitual smoking, getting treatment for depression or anxiety, or having an active cancer. Participants who had general anesthesia in the past four weeks, or had a fracture in the past eight weeks were rescheduled for a later time. Participants with the following conditions were rescheduled for when they were at least two weeks symptom free: being sick, having gum disease, or having an inflammation in the mouth.

2.2. Procedures

The study was undertaken with the understanding and written consent of each participant, with the approval of the Institutional Review Board at the University of Alabama at Birmingham, and in compliance with national legislation and the Code of Ethical Principles for Medical