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The cortisol awakening response: Associations with trait anxiety and stress reactivity

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ABSTRACT

This study investigated the extent to which trait anxiety and state anxiety in response to stress are associated with the cortisol awakening response (CAR).

Fifty-one healthy participants were recruited. State anxiety measures were taken in anticipation of and during a laboratory stressor. Salivary cortisol levels were measured immediately upon awakening (at 0, 15, 30, and 45 min) on two consecutive mornings. Cortisol awakening response was assessed by the area under the curve with respect to zero (AUC_G).

The magnitude of the CAR was found to be negatively associated with both trait anxiety and anticipatory anxiety. Moreover, regression analysis showed that the effects of trait anxiety on the AUC_G were mediated by anticipatory anxiety.

These results suggest that the CAR is influenced by trait anxiety. Moreover, the effect of trait anxiety on the CAR seems to operate by impacting on psychological stress reactivity (i.e., anticipatory anxiety).

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1. Introduction

Over the last 15 years the cortisol awakening response (CAR) has received a large amount of attention (O'Connor et al., 2009a). It is defined as the cortisol secretory response during the first 45–60 min immediately after awakening and recent research has indicated that the magnitude of the CAR is influenced by individual differences in personality. Previous research on the relationship between the CAR and personality has often focused on neuroticism related traits due to links with future health risk. Although subjective measures of health consistently suggest that neuroticism is associated with a range of self reported complaints and somatic symptoms (e.g., Taylor et al., 2008), the relationship between neuroticism and objective indices is inconsistent (Friedman & Booth-Kewley, 1987). These inconsistencies are evident within the CAR literature with findings indicating either that the CAR is blunted (e.g., Therrien et al., 2008), enhanced (e.g., Portella, Harmer, Flint, Cowen, & Goodwin, 2005), or even no different (e.g., van Santen et al., 2011) in individuals high in neuroticism (or other related trait factors) as compared to suitable comparison groups. To help elucidate these findings, it may be useful to explore potential mediating pathways. Research has postulated that neuroticism can influence health by increasing reactivity towards stress (e.g., Bolger & Zuckerman, 1995) and that reactivity measures taken in anticipation of and during a stressor are able to differentiate those high and low in neuroticism related traits (e.g., Bolger & Zuckerman, 1995; Infrasca, 1997). As changes in cortisol have been found to occur in response to stress (see McEwen, 2007), it is possible that measures of psychological reactivity to stress may help explain the association between neuroticism and the CAR. For example, those high in neuroticism have previously been shown to exhibit a heightened psychological response to stress (Bolger & Zuckerman, 1995), which may have a knock on effect on hypothalamic pituitary adrenal (HPA) axis mediated stress responses. However, to the best of our knowledge, irrespective of the nature of the relationship, no studies have explored whether psychological stress reactivity is one of the mechanisms through which neuroticism related traits may influence the CAR. Moreover, it is important to note that neuroticism, as conceptualised within the five factor model of personality, is a broad construct which has been found to elicit mixed physiological results in terms of stress research (as discussed above). Therefore, in the current study the effects of trait anxiety were examined as this variable has been shown to be a more homogenous neuroticism-related dimension (see Luteijn & Bouman, 1988).

When examining the impact of stressful encounters on the CAR, there has been large variability in the types of stressors explored, ranging from measures of day-to-day stressors/hassles (e.g., Adam,

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Hawkley, Kudielka, & Cacioppo, 2006), to psychological responses to laboratory-based stressors (e.g., Fabian et al., 2009). In the present study it was thought important to explore the impact of psychological responses to a laboratory-based stressful event on the CAR in order to standardise the stressful encounter that participants were exposed to. Therefore, here we explored the associations between psychological responses to negative images using stimuli from the International Affective Picture System (Lang, Bradley, & Cuthbert, 1999) and the CAR. In particular, two components of the psychological response to stress were measured (anticipatory anxiety: anxiety in anticipation of the stressor; task anxiety: anxiety during the stressor) as these components have previously been found to be significantly associated with cortisol responses to an acute stressor (e.g., Elzinga, Schmahl, Vermetten, van Dyck, & Bremner, 2003). Exploring the relationship between state anxiety and the CAR was used to provide an index of how someone's general reaction to everyday stress may impact on cortisol output.

A number of methodological and measurement issues may have accounted for the inconsistencies outlined in the previous personality, stress and CAR research findings. First, participant non-adherence to the sampling protocol is known to be a serious problem in CAR research and the importance of the timing of the samples has been found to be vital (O'Connor et al., 2009a; Thorn, Hucklebridge, Evans, & Clow, 2006). Second, it is essential to control for potential confounding variables. The effects of individual differences such as age, gender, awakening time, depression symptomatology and body mass index (BMI) on the CAR are inconsistent (for reviews see Almeida, Piazza, & Stawski, 2009; Fries, Dettenborn, & Kirschbaum, 2009). Moreover the directionality of any observed relationship is difficult to determine due to these mixed results. Nevertheless, the potential explanatory effect of such factors is thought important to consider in any CAR analysis. Therefore, in the current study, we removed participants suspected of non-adherence to the sampling protocol and examined the effects of age, gender, awakening time, BMI and depression symptomatology in all analyses.

In summary, this study had two main aims: (1) to clarify the direction of the relationship between trait anxiety and the CAR, and (2) to explore whether the impact of trait anxiety is mediated through psychological stress reactivity (i.e., changes in state anxiety in anticipation and during a stressor).

2. Materials and methods

2.1. Design and participants

Fifty-one healthy students and staff from a large university in England were recruited to take part in a study looking at the effects of emotional regulation on health. Participants were excluded if they suffered from any hormonal disorder, regularly used recreational drugs, were taking steroid-based or neurological/psychotropic medication, scored above 15 on the Beck Depression Inventory as this is the threshold for possible depression in community samples (BDI: Beck & Steer, 1987; Beck, Ward, Mendelson, Mock, & Erbaugh, 1961), or had been to see a psychologist/psychiatrist in the past 6 months. Forty participants (14 males and 26 females) were included in the final sample (see cortisol analysis section later) with a mean age of 24.4 years (7.06 SD) and BMI of 22.63 (3.32 SD). The sample size was informed by previous research investigating the relationship between personality and the CAR (Portella et al., 2005) and by a power calculation using G*Power 3 (Faul, Erdfelder, Lang, & Buchner, 2007). Effect size was set at $d = .77$, alpha at .05, power at .80. This recommended a total sample size of approximately 30 participants. Fifty-one were tested to allow for outliers, drop outs and suspected non-adherence. Participants were reimbursed £20 for their time and inconvenience. A correlational design was utilised to analyse the association between trait anxiety and state anxiety in anticipation and during an acute laboratory stressor (day 1) and the CAR on two consecutive days (day 2 and day 3).

2.2. Procedures and measures

All research was approved by the University Departmental Ethics Committee. Upon arrival on day 1 participants were asked to rest for 15 min before the stressor task commenced. To examine stress reactivity, the 6-item short form of the State-Trait Anxiety Inventory (STAI: Marteau & Bekker, 1992) was used. Participants were asked to rate how they feel right now (e.g., I feel calm) on a 4-point Likert scale ranging from 1 (not at all) to 4 (very much), with higher scores indicating higher levels of state anxiety. The STAI short form is a commonly used measure to assess state anxiety with research indicating that the reliability and validity of the scale is acceptable (Marteau & Bekker, 1992). This scale was administered immediately after the 15 min rest ("anticipatory anxiety 1") and again approximately 20 min later during the stressor task set up ("anticipatory anxiety 2"), and 20 min into the stressor during a resting break which lasted approximately 1 min ("task anxiety"). In the present study, the scale for anticipatory anxiety 1, anticipatory anxiety 2 and task anxiety yielded good internal consistency with alphas of .72, .72 and .81, respectively. To examine the influence of trait anxiety and depression symptomatology, the trait version of the STAI (Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983) and the BDI (Beck et al., 1961) were also administered. The trait scale of the STAI is a 20-item measure used to assess trait levels of anxiety. Participants have to rate how they generally feel (e.g., I feel pleasant) on a 4-point Likert scale ranging from 1 (almost never) to 4 (almost always). The BDI is a 21-item scale used to analyse how one has been feeling in the past week. Each statement has at least four possible answer choices, which range in intensity. For both scales, higher scores indicate higher levels of trait anxiety or depression. Research indicates that the reliability and validity of the STAI-trait and BDI is acceptable (Beck & Steer, 1987; Rule & Traver, 1983). In the present study, the STAI and BDI yielded good internal consistency with alphas of .95 and .79, respectively. In order to assess the CAR, saliva samples were collected on two mornings (day 2 and day 3) following the laboratory stress task. The researcher guided participants in their selection of two suitable week days for the collection of the saliva samples. This was to prevent sampling on a weekend, as weekday versus weekend differences have been found to impact on the CAR (Clow, Thorn, Evans, & Hucklebridge, 2004).

2.2.1. Laboratory stress task

The stressor task involved subjects being exposed to 120 negative images from the International Affective Picture System (IAPS: Lang et al., 1999) for 1 h. In terms of the negative images, only those which have previously been found to elicit high levels of negative affect and arousal were used (Lang et al., 1999). The negative pictures included images of dead and mutilated bodies, war scenes, and pictures of medical conditions. Participants were warned during the stressor task set up about the nature of these picture contents. Exposure to IAPS negative images is known to elicit anxiety (Dichter, Tomarken, & Baucom, 2002; Simmons, Matthews, Stein, & Paulus, 2004) which we confirmed in a pilot study where anxiety levels increased significantly after exposure to unpleasant IAPS images compared to before, $t(25) = -.3.20$, $p < .01$. Therefore, two measures of each participant's stress reactivity were computed and utilised in the current study: anticipatory anxiety (anticipatory anxiety 1 + 2) and task anxiety.

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