Personality and Individual Differences 55 (2013) 600–605

Contents lists available at SciVerse ScienceDirect

Personality and Individual Differences

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

The cortisol awakening response and the big five personality dimensions

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ARTICLE INFO

Article history:
Received 3 November 2012
Received in revised form 30 April 2013
Accepted 3 May 2013
Available online 12 June 2013

Keywords:
Cortisol awakening response
Personality
Big five
Gender
HPA axis

ABSTRACT

The present study investigated the association between the big five personality dimensions and the cortisol awakening response (CAR), a physiological parameter reflective of HPA axis activity. One hundred and seven participants completed the big five inventory (BFI; John, Donahue, & Kentle, 1991) and collected salivary cortisol samples at 0, 30, and 60 min after awakening on a weekday morning. The cortisol awakening response under the curve (CARauc) and the cortisol awakening response with respect to increase (CARi) were used as outcome variables in the statistical analyses. Hierarchical linear regression analyses were conducted using the data of 92 participants. Gender and age were included as covariates in block one of the regressions, followed by the personality dimensions in block two. Extraversion emerged as a significant predictor of CARauc. No other personality dimensions were significantly predictive of CARauc or CARi. Interestingly, gender emerged as the strongest predictor in the CARauc, with females exhibiting greater cortisol release across the awakening period than males. Our results suggest that extraversion and gender may be particularly important variables to consider in the regulation of the HPA axis.

1. Introduction

Cortisol is widely regarded as an accurate measure of hypothalamic–pituitary–adrenal (HPA) axis activity. It is released in response to an acute stressor (Kirschbaum & Hellhammer, 1994), but it also follows a diurnal pattern with production sharply increasing 20–45 min after awakening and then decreasing throughout the day (Clow, Thorn, Evans, & Hucklebridge, 2004; Pruessner et al., 1997). This distinct rise in cortisol during the awakening period is referred to as the cortisol awakening response (CAR).

While measurements of cortisol responses to specific stressors in the laboratory provide information on HPA reactivity, the CAR provides insight into the general functioning of the hypothalamic–pituitary–adrenal (HPA) axis (Clow et al., 2004). Therefore, the CAR is an important physiological parameter to consider in relation to long-term stress, health conditions, and psychological traits (Chida & Steptoe, 2009; Fries, Dettenborn, & Kirschbaum, 2009; Kudielka & Kirschbaum, 2003; Wüst, Wolf, et al., 2000). Individual differences in the CAR have been reported across a variety of studies (e.g., Almeida, Piazza, & Stawski, 2009; Pruessner, Hellhammer, & Kirschbaum, 1999; Schulz, Kirschbaum, Pruessner, & Hellhammer, 1998), thus highlighting the need to study psychosocial and environmental influences possibly linked to systematic variations in cortisol release across the awakening period.

In terms of studying the individual differences in the CAR, the big five personality theory provides an appropriate theoretical framework; the big five theory has been widely studied in relation to health and well-being (e.g., Friedman, Kern, & Reynolds, 2010; Jerram & Coleman, 1999), and there is also some evidence for a biological basis for the five factor model (DeYoung et al., 2010). Notably, neuroticism has been associated with both negative mental and physical health outcomes (see Lahey, 2009). Conscientiousness, on the other hand, has been linked to positive health behaviors, overall well-being, and longevity (Hill, Turiano, Hurd, Mroczek, & Roberts, 2011). Especially considering the role HPA axis regulation may play in the maintenance of health and well-being (e.g., Pruessner et al., 2010), further understanding physiological correlates of the big five personality dimensions remains an important research endeavor.

An elevated CAR has been positively associated with neuroticism (Portella et al., 2005), and related traits, including negative affectivity (Polk, Cohen, Doyle, Skoner, & Kirschbaum, 2005) and hopelessness reactivity (van Santen et al., 2011). However, there have been some mixed findings in this area of research; Walker, O'Connor, Schaefer, Talbot, and Hendrickx (2011) reported a negative association between the CAR and trait anxiety, and Thorn, Hucklebridge, Evans, and Clow (2009) reported that seasonality, a trait-like variable representing the propensity to exhibit mood changes across the seasons, was negatively correlated with the CAR.

There has been some research on the relationship between the CAR and extraversion. Recently, van Santen et al. (2011) reported a trend association ($p = .10$) between extraversion and flatter CAR levels. In contrast to this finding, Hauner et al. (2008) previously reported an association between introversion (i.e., low extraversion),

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0191-8869/$ - see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.paid.2013.05.010

as measured by the Eysenck Personality Inventory, and low CAR levels among both male and female adolescents. Previous research has also suggested no association between morning salivary cortisol and extraversion (Munafò et al., 2006). Overall, research suggests that there is little consensus regarding the direction of association between the CAR and extraversion.

The literature on personality traits and the CAR, albeit limited, provides conflicting evidence for the association between personality factors and HPA functioning. Aside from the trend association between extraversion and lower CAR levels, van Santen et al. (2011) did not find any other associations between the remaining big five factors and the CAR. It is possible that demographic factors, including age and gender, also contribute to the observed individual differences in the CAR. Females have exhibited greater CAR than males (Almeida et al., 2009; Kunz-Ebrecht, Kirschbaum, Marmot, & Steptoe, 2004; Wright & Steptoe, 2005), and there has been some evidence to suggest that the magnitude of the CAR may increase with age (Almeida et al., 2009; Kudielka & Kirschbaum, 2003). For that reason, these demographic variables were also included as covariates in the models of the present study.

Based on previous research and theory on personality and CAR, we hypothesized that neuroticism would be positively predictive of CAR and that extraversion would be negatively predictive of CAR. Neuroticism, a trait that encompasses an individual's propensity to experience negative emotions (Larsen & Buss, 2005), should, theoretically, be linked to an elevated CAR, a physiological marker that seems to be influenced by negative emotional traits and states (Polk et al., 2005; Portella et al., 2005). Extraversion, on the other hand, is a trait characterized by a high arousal threshold and a need for environmental stimulation (Larsen & Buss, 2005). Therefore, we hypothesized a negative association between extraversion and CAR, in that higher extraversion scores would be associated with a lowered CAR.

2. Method

2.1. Participants

One hundred and seven participants were recruited for the study through local newspaper advertisements and posters at academic institutions and community centers in Auckland, New Zealand. Participants were excluded if they smoked or took hormone-based or steroid medication. Petrol and supermarket gift vouchers (valued at $20) were provided to participants for taking part in the study.

2.2. Measures

2.2.1. Big five inventory

The big five inventory (BFI) is a 44-item scale used to measure each of the big five personality dimensions using short phrases (John, Donahue, & Kentle, 1991). For each item, participants respond on a 5-point Likert scale ranging from (1) "disagree strongly" to (5) "agree strongly". Each of the personality dimension subscales had adequate internal consistency in the present study: neuroticism (Cronbach's $\alpha = .843$), extraversion (Cronbach's $\alpha = .848$), agreeableness (Cronbach's $\alpha = .766$), conscientiousness (Cronbach's $\alpha = .788$), and openness (Cronbach's $\alpha = .664$). Evidence of test–retest reliability and validity has been previously reported on the scale (Pervin & John, 2001).

2.2.2. Demographics

Basic demographic data were also collected. Participants were asked to indicate their age, gender, ethnicity, and highest level of education completed.

2.3. Procedure

Participants collected cortisol samples during a weekday morning (Monday–Friday). They were provided with a total of three salivettes (Sarstedt AG & Co., Germany), which are small plastic test tubes that include a cotton swab. Detailed written instructions regarding the appropriate salivary cortisol collection (i.e., chew on the cotton swab until fully saturated and then place in the test tube) were provided to the participants. Participants were instructed to not eat, drink or brush their teeth until sampling had been completed, but otherwise, they were to go about their morning tasks as normal (as per recommended protocol for assessing CAR, see Wüst, Wolf, et al., 2000). We instructed participants to collect samples upon awakening, and 30 and 60 min following awakening.

In order to guard against protocol non-adherence, which is a potential issue with the collection of bodily fluids in a domestic setting (Thorn, Hucklebridge, Evans, & Clow, 2006), the following strategies were employed: (1) participants were given flexibility in the collection of the saliva sample (i.e., a regular work day during the week was the only criteria; the date was not predetermined by the research team), and (2) participants were to record the date and time of awakening on their survey and salivettes. This acted to prompt the participant to collect samples at the appropriate time, and it also allowed for the research team to check for non-adherence to protocol (i.e., to ensure participants collected samples 30 min apart). Samples were kept frozen until analysis at LabPlus, Auckland City Hospital. Participants completed the questionnaires on the same day they collected their saliva samples. The study was approved by the authors' institutional ethics committee.

2.4. Analyses

2.4.1. Cortisol analysis

In order to determine cortisol concentration (nmol/l), salivary cortisol assays were performed commercially at LabPlus, Auckland City Hospital. Using the cortisol values (at awakening, at 30 and 60 min after awakening), the following CAR summary values were calculated: the CAR area under the curve with respect to the ground (CARauc; the total volume of cortisol released over the wakening period), the area under the curve with respect to increase (CARi; Pruessner, Kirschbaum, Meinlschmid, & Hellhammer, 2003). Both CAR values are presented in Fig. 1.

The CARauc reflects the overall secretion of cortisol from awakening to 60 min after awakening, and is calculated by the formula: $(((0\ \text{min cortisol} + 30\ \text{min cortisol}) \times .5)/2) + (((30\ \text{min cortisol} + 60\ \text{min cortisol})/2) \times .5)$. The CARi reflects the area under the curve with in reference to the increase in cortisol following awakening, calculated using the formula: CARauc – 0 min cortisol (for details regarding the calculations, see Pruessner, Kirschbaum, et al., 2003). Due to non-adherence to protocol and issues with cortisol analysis, the data for 15 participants were not included in the calculation of CAR values. Eight participants did not adhere properly to the cortisol sampling protocol. These cases were removed from the cortisol data, leaving 92 participants for the statistical analyses.

2.4.2. Statistical analysis

Hierarchical linear regressions were conducted to determine the influence of the big five personality dimensions on the CAR. CARauc and CARi were used as outcome variables in the regression analyses. Age and gender were entered into the models as covariates (block one). The big five personality dimensions were entered in block two. This hierarchical approach was employed to assess