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Are neuroticism and extraversion related to morning cortisol release in healthy older people?

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ABSTRACT

The cortisol awakening response (CAR) is a discrete component of the hypothalamic-pituitary-adrenal axis (HPA-axis) function that has been widely related to both health and some personality traits. There is evidence that neuroticism and extraversion affect health and well-being and play a damaging or protective role, respectively. In this study, we aimed to explore the relationship between these personality dimensions and morning cortisol concentrations in people aged 55 or older. To do so, morning saliva samples were collected on two consecutive weekdays from a total of 160 older men and women. Neuroticism and extraversion were assessed using the Eysenck Personality Questionnaire-Revised, short form (EPQ-RS). Our results showed that neuroticism was negatively related to overall morning cortisol concentrations (AUC_G) (i.e., area under the curve with respect to the ground in cortisol levels), but not to the CAR. When we explored sex as a moderator, neuroticism was related to a CAR of increased magnitude in women, although this relationship was not significant in men. No significant relationships were found between extraversion and CAR or AUC_G, regardless of sex. In conclusion, neuroticism – but not extraversion – was related to HPA-axis function in older adults, highlighting its potential relevance in health alterations associated with HPA-axis functioning.

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1. Introduction

There is a physiological response to waking characterized by an increase in cortisol concentrations, peaking between 30 and 45 min post-awakening (Stalder et al., 2016; Fries et al., 2009). This response is considered to be an indicator of cortisol rhythm regulation, as a part of normal healthy human circadian physiology. The sharp increase in cortisol after awakening has been defined as the dynamic of a post-awakening increase in cortisol levels (the cortisol awakening response, hereinafter CAR), usually measured through the area under the curve with respect to the increase (AUC_I) or through the difference in cortisol concentrations between the moment of awakening and 30–45 min later. Additionally, the overall morning cortisol production combines information about the cortisol levels just after awakening and the CAR, which can be assessed through the area under the curve with respect to the ground (hereinafter, AUC_G) (see Pruessner et al., 2003).

Some brain structures, such as the hippocampus, amygdala and prefrontal cortex, contribute to the regulation of the HPA-axis activity due to the high levels of expression of Glucocorticoid receptors there (Fries et al., 2009; Herman et al., 2005; Patel et al., 2000). Interestingly, neuroticism and extraversion have been considered important moderators of the age-related loss of volume and structural connectivity in the prefrontal cortex in older people, with higher neuroticism and lower extraversion being related to a greater age-related decline (Jackson et al., 2011).

For instance, higher neuroticism has been related to disorders and diseases associated with HPA-axis dysregulation, such as mild cognitive impairment (Kuzma et al., 2011), depressive and anxiety disorders (Ormel et al., 2013), Alzheimer's disease (Dar-Nimrod et al., 2012), chronic pain (Ramirez-Maestre and Esteve, 2013), and diabetes and metabolic syndrome (Mommersteeg and Pouwer, 2012). Given the importance of personality traits for health and their relationship with HPA-axis functioning (Lahey, 2009), several studies have investigated the role of neuroticism and extraversion in CAR and AUC_G, showing mixed results. Hauner et al. (2008) reported a reduced AUC_G in adolescents with high neuroticism and introversion compared to those with low neuroticism and introversion. Hill et al. (2013) reported that higher extraversion predicted heightened AUC_G in people from 18 to 78 years old, whereas van Santen et al. (2011) found that a reduced CAR was associated with higher extraversion. However, no significant relationships were found between neuroticism and the CAR in the Hill et al. (2013) and van Santen et al. (2011) studies. By contrast, Portella et al. (2005) reported heightened CAR and AUC_G in people from 21 to 57 years old with high neuroticism compared to those with low neuroticism. These results agree with Mangold et al. (2012), who observed that people with low neuroticism and acculturation showed increased CAR compared to other groups (high neuroticism and acculturation, high neuroticism and low acculturation, low

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neuroticism and high acculturation) in adults from 18 to 38 years old. Finally, other studies reported no relationships between neuroticism or extraversion and CAR or AUC_G (e.g., Chan et al., 2007; Munafo et al., 2006; Laceulle et al., 2015). Methodological issues may have contributed to these discrepancies in the results. None of the aforementioned studies used electronic devices to control for adherence in the cortisol measurements (Kudielka et al., 2003). Nor did they consider the variation in cortisol profiles (increase or decrease in cortisol levels immediately after awakening) (Almela et al., 2012; Thorn et al., 2006) or measure the CAR and AUC_G for at least two days, as recommended (Stalder et al., 2016). Thus, the lack of control over adherence to the protocol could result in a non-reliable CAR measurement, affecting the results (Stalder et al., 2016; Clow et al., 2010a, 2010b; Kudielka et al., 2003). Recently, no significant relationships between neuroticism and AUC_G and CAR were found in healthy young people when an electronic device was used to control saliva sampling times (Garcia-Banda et al., 2014). Another aspect to be considered is that these studies investigated the relationship between personality and CAR in adolescents, young people and/or samples with a broad age range (i.e., including young adults and older people). Important changes have been reported in both neuroticism and extraversion (Eysenck, 1988) and CAR in older ages (see Fries et al., 2009; Clow et al., 2010a, 2010b); thus, age differences might affect the relationship between neuroticism, extraversion and CAR. However, no previous studies have analyzed this relationship specifically in older people.

Therefore, the present study aimed to investigate how neuroticism and extraversion traits are related to CAR and AUC_G in people aged 55–78 years old. To do so, 160 older participants collected three saliva samples during the first 45 min after awakening on two consecutive weekdays, and they completed the Eysenck Personality Questionnaire-Revised, short form (EPQ-RS). Based on previous literature, we expected to find positive relationships between AUC_G, CAR and extraversion (Hill et al., 2013; Hauner et al., 2008). Regarding neuroticism, we did not have any specific directional hypotheses, due to the contradictory results found by previous studies (Garcia-Banda et al., 2014; Hill et al., 2013; Hauner et al., 2008; Chan et al., 2007; Portella et al., 2005). Additionally, we aimed to explore the importance of sex in the relationship between neuroticism, extraversion and HPA-axis function (CAR and AUC_G), in order to add evidence to the reported data on sex differences (DeSoto and Salinas, 2015; Fries et al., 2009; Lynn and Martin, 1997).

2. Material and methods

2.1. Participants

People aged 55–78 years old were recruited through informative advertisements. The exclusion criteria were: smoking >10 cigarettes a day, consuming drugs of abuse, having surgery under general anesthesia during the past year, the presence of neurological or psychiatric disorders, the use of drugs that affect cognitive or emotional functions, or that influence HPA function (e.g. glucocorticoids, benzodiazepines). All the female participants were postmenopausal and not receiving hormonal replacement therapy.

The final sample was composed of 160 native Spanish speakers (81 men) from 55 to 78 years old (Total sample: M = 64, SD = 4.464; Men: M = 64; SD = 4.975; Women: M = 64; SD = 3.899) with a medium subjective socioeconomic status (measured using the MacArthur Scale of Subjective Social Status; Adler et al., 2000; from 1: lowest, to 10: highest; Total sample: M = 5.99, SD = 1.197; Men: M = 6.11, SD = 1.331; Women: M = 5.87, SD = 1.036). Most of them had an educational level beyond high school (84.4%) and were retired (88.8%). Regarding marital status, 66% were married, 10.1% single, 11.3% divorced and 12.6% widowed.

2.2. Procedure

The study was performed according to the Declaration of Helsinki, and the Ethics Committee of the University approved the protocol. All the participants received verbal and written information about the study and signed an informed consent.

Participants completed the Spanish version of the Eysenck Personality Questionnaire short form (EPQ-RS; Eysenck and Eysenck, 1997) to obtain scores on neuroticism and extraversion. Moreover, they provided 3 saliva samples on two consecutive weekdays. The samples were taken immediately after awakening (0) and 30 min (+30) and 45 min (+45) post-awakening. Additionally, they recorded in a log their awakening time and the time of each saliva collection. The participants were thoroughly instructed about how to provide the saliva samples, and they were also given detailed written instructions (for more details, see Almela et al., 2012).

2.3. Measures

2.3.1 Eysenck Personality Questionnaire-Revised (Eysenck and Eysenck, 1975)

We used the Spanish version of the Eysenck Personality Questionnaire-Revised, short form (EPQ-RS; Eysenck and Eysenck, 1997). The EPQ-RS comprises a total of 48 items to which participants are asked to respond "yes" or "no". It makes it possible to obtain scores for the three personality dimensions: neuroticism, extraversion and psychoticism. The scales range from 0 to 12, with higher scores indicating more neuroticism, extraversion or psychoticism. The alpha values range from 0.65 to 0.82 for men, and from 0.67 to 0.82 for women.

2.3.2 Cortisol analysis

Saliva was centrifuged at 3000 rpm for 5 min, resulting in a clear supernatant of low viscosity. After that, the saliva was stored at −80 °C until the assay was performed in duplicate by competitive solid phase radioimmunoassay (tube coated) with the commercial kit Spectria Cortisol RIA from Orion Diagnostica (Espoo, Finland). All the samples from each subject were analyzed in the same assay and in duplicate, with within- and inter-assay variation coefficients below 8%.

2.4. Data management and statistical analyses

Cortisol data were log transformed because they did not show normal distribution. The areas under the curve with respect to the ground (AUC_G): $(((S2_{+30} + S1) \times time_{S2-S1}) / 2) + (((S3_{+45} + S2_{+30}) \times time_{S3-S2}) / 2))$; and with respect to the increase (AUC_I): $AUC_G - (S1 \times \Sigma time))$; were calculated as measures of the AUC_G and CAR, respectively (see Pruessner et al., 2003).

Previous studies have reported the importance of ensuring the accuracy of CAR sampling, with it being crucial to take the first saliva sample right after awakening (Stalder et al., 2016; Clow et al., 2010a). Additionally, it has been indicated that self-reported sampling accuracy cannot be relied upon (Almela et al., 2012; Broderick et al., 2004; Kudielka et al., 2003), and that a lack of increase in cortisol levels after awakening might be due to a delay in the first saliva sample (Thorn et al., 2006), although undiagnosed pathologies unknown to the participant might also contribute to CAR disruptions (for more details see Stalder et al., 2016; Clow et al., 2010a). As the exclusion of participants with suspected inaccurate saliva sampling could result in a selection bias that would reduce the generalization of the results (Stalder et al., 2016), we considered the possibility of confirming the results for the complete sample in a subsample of participants who showed a positive CAR (>0) on both days, following the method described in Almela et al. (2012) and Thorn et al. (2006). A total of 98 participants (45 men) showed a positive CAR ($AUC_I > 0$) on two days (the 2-Day CAR group), 49 participants (26 men) showed a positive CAR on only one day, and 13 participants (10 men) did not show a positive CAR on any day (the

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