



## Neuroticism and cortisol: The importance of checking for sex differences



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### ABSTRACT

Existent research documents an unclear and contradictory pattern between cortisol and personality variables, especially neuroticism. Specifically, no effect, positive correlations and negative correlations have all been reported to exist between cortisol and neuroticism. The current study tested whether males and females have a fundamentally different relationship between HPA activation and neuroticism and if this might partially account for some of the discrepancy in findings. Saliva samples ( $n = 183$ ) for cortisol were collected three times across a 90 min period. Neuroticism was measured via the NEO-FFI. For men, neuroticism was positively correlated with cortisol level ( $r = .29$ ). For women it was negatively correlated. The negative correlation between neuroticism and cortisol level remained when oral contraceptive use was statistically controlled, and the statistical significance actually increased (partial  $r = -.20$ ). This suggests a slight suppressor effect, explainable by prior research on correlates of oral contraceptive use. Overall, these findings may offer some explanation for the discrepant results that have been reported in the existing literature regarding neuroticism and cortisol measures.

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Broadly, the term neuroticism refers to individual differences in the negativity of emotional reactions to social stressors. The trait is usually measured via self-report to questions regarding irritability, tendency to worry or become angry, feelings of vulnerability, and response to stress or problems (Costa and McCrae, 1992). Neuroticism may be formally defined as a tendency towards more negative emotional reaction when faced with stressors like threats, criticism, frustration or loss of resources (Ormel et al., 2013). Because cortisol is the hormone that is most closely associated with a biological reaction to a stressor, it has sometimes been hypothesized that some relationship ought to exist between cortisol and the trait neuroticism (Garcia-Banda et al., 2014; Ormel et al., 2013; Mason, 1968). This study tests the hypothesis that males and females exhibit different relationships between cortisol and psychological variables, particularly the trait neuroticism.

## 1. Introduction

### 1.1. Neuroticism, cortisol and gender specific effects

Prior research on hypothalamic-pituitary-adrenal (HPA) activation and trait or state characteristics has been specifically noted to be unclear and contradictory as a whole (van Santen et al., 2011; Hill et al., 2013; Ormel et al., 2013; Chida and Steptoe, 2009). There is not a consistently found correlation between personality and cortisol, and more specifically neuroticism and cortisol have been found to be positively related, negatively related, and not related. This is in some contrast to theoretical understandings of personality, mood and HPA activity (Garcia-Banda et al., 2014). Early investigations failed to find the hypothesized effect. Schommer et al. (1999) measured personality traits including neuroticism and found no relationships to cortisol levels whether measured as a baseline or as change after a stressful event. The sample of healthy male and female adults were grouped together for hypothesis testing. Subsequent research has often resulted in a similar lack of relationship regardless of how cortisol is measured. For example, Chan et al. (2007) investigated the connections between neuroticism, depression and cortisol. They found that the cortisol awakening response (CAR) did not relate to neuroticism. Men and women were not tested separately, they were tested as a single group. Ferguson (2008) also found no relation between neuroticism and cortisol.

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Ferguson used the degree of cortisol change in a sample of healthy adults with samples taken at noon and later in the afternoon. Again, men and women were tested as a single, combined group. Recently, Hill et al. (2013) and van Santen et al. (2011) also reported no correlation between neuroticism and cortisol. Both studies combined men and women and statistically removed the effects of gender before testing whether neuroticism related to cortisol.

On the other hand, Zobel et al. (2004) investigated neuroticism and its association with cortisol in a sample of 121 adults. Using the NEO-FFI, they found that neuroticism was correlated to both maximum cortisol levels as well as cortisol area under the curve (which captures total release across a given time period). Zobel and colleagues found significant gender effects: neuroticism and cortisol levels were noted to be more closely related among males. They speculated that a gender specific interaction might exist.

Two years after Zobel and colleagues work, Oswald et al. (2006) used a sample of 86 healthy adults, and tested males and females separately. Oswald exposed all participants to a stressful experience and measured plasma-based cortisol before and after. Among females (but not males) neuroticism was associated with cortisol response to the stressor such that high neuroticism was associated with lesser cortisol response.

Two years after the Oswald et al. findings were published, a larger sample (170 females and 60 males) again measured personality traits with a focus on neuroticism. In this case, cortisol was measured across the day on consecutive days, allowing HPA activity to be measured as baseline, as an average, or as diurnal variation. Trait neuroticism was not associated with any measure of cortisol as a main effect. However, the pattern of main effects prompted further testing. An unpredicted sex by neuroticism interaction emerged, such that males (only) who were more neurotic had a flatter slope in diurnal cortisol fluctuation. The difference for males and females was found for measures taken at morning, mid-day and evening, suggesting it is a real effect, even though not a priori hypothesized (Hauner et al., 2008).

Nonetheless, the possibility of sex differences in the relationship between neuroticism and cortisol appears largely overlooked; findings of gender and personality interactions remain isolated. It is interesting to note that three separate labs have found gender specific effects for cortisol and neuroticism, but the findings have not been synthesized. First, Oswald et al. did not include Zobel's findings in their lit review, even though they found similar gender specific effects for neuroticism and cortisol just two years prior. Second, publishing research four years after Zobel, and two years after Oswald et al. Hauner again found evidence that men and women might differ in how neuroticism is related cortisol. Yet, even though Zobel was cited – there was no mention of the male specific effect that Zobel and colleagues found. Furthermore, although Hauner et al. essentially replicated the gender by neuroticism interaction that has been published two years prior by Oswald, Oswald was not reviewed. No research specifically designed to formally test whether males and females differ in HPA activation and neuroticism exists to the knowledge of the current authors and the possibility seems often discounted. The norm is for gender effects to be statistically controlled rather than investigated on their own merit.

To further make this point, a consideration of van Santen et al.'s findings (2011) reviewed above is illustrative. They reported no relationship between cortisol awakening response (CAR) and multiple personality traits, including neuroticism. Even though sex differences were stated to exist in cortisol reactivity, these differences – rather than being investigated as a potential variable of interest – were removed by treating gender as a standard covariate to be controlled and then men and women were grouped together. In their discussion of the lack of the expected neuroticism – cortisol relationship, three studies are noted. One of which is Hauner

et al. (2008). It is speculated that the lack of effect might be due to failure to consider psychopathology of participants. Of interest to the current report, the possibility that sex of the participant might moderate the relationship was not considered, even though one of three prior works cited specifically stated their results suggested this possibility. The possibility of sex differences, on the whole, seems largely overlooked in the literature.

In contrast to the current hypothesis that sex differences need to be considered to uncover neuroticism – cortisol relationships, Lauceulle et al. (2014) reported HPA activation and personality traits among adolescents were related. Using a large sample ( $n=334$ ), baseline cortisol as well as the increase in cortisol associated with morning awakening were reported to be correlated to neuroticism, extraversion and conscientiousness. The results, as reported by the authors, suggest that cortisol was related to personality. On the other hand, a careful read may note multiple correlations were tested without any correction reported (e.g., in terms of the single measure cortisol variables and personality traits, there are 42 correlation coefficients reported, and only six are significant at the  $p < .05$  level with no Bonferroni or other correction reported and presumably not done) making the results potentially equivocal. These researchers overall employed excellent methodology, and it seems possible that if – instead of controlling for gender- they had treated sex differences in cortisol reactivity as a variable of interest the results would have potentially been stronger (strong enough to have survived a Bonferroni correction).

Finally, there have been studies which specifically select a sample of persons with very high versus very low levels of neuroticism and then checked for group differences in cortisol levels or HPA activity (Portella et al., 2005; Garcia-Banda et al., 2014). Garcia-Banda and colleagues found neuroticism predicted more cortisol—but only in some measures (across a 12 h period, but not in early morning). Portella et al. (2005) found that neuroticism predicted higher morning cortisol responses. Although this effect was found in a sample that had equal numbers of men and women, it may be of interest that hormonal effects were partly controlled by excluding women who were in the pre-menstrual time of the cycle. Subsequent research has shown that women's CAR is different near ovulation (Wolfram et al., 2011), suggesting this may have been a key methodological distinction. Table 1 provides a summary of some of the recent investigations of neuroticism–cortisol associations here reviewed.

The pattern may suggest that for men more neuroticism is associated with greater HPA activity (Zobel et al., 2014), and that controlling for estrogen changes in women participants may uncover a similar relationship in a combined sample (Portella et al., 2005). Several studies suggest that when men and women are combined and/or effects of gender are statistically removed, no clear relationship emerges, and, moreover, that the possibility that sex of the participant may moderate the relationship is often not tested (Chan et al., 2007; Ferguson, 2008; Garcia-Banda et al., 2014; Hill et al., 2013; van Santen et al., 2011). At least one study suggests that for women, the relationship between cortisol and HPA activity may be negative or blunted (Oswald et al., 2006). The possibility that sex or gender differences could exist and explain some of the discrepancy is bolstered by considering research on sex differences in HPA activity.

## 1.2. Sex differences in HPA

Medical history illustrates pitfalls of assuming that men and women respond the same way physiologically: while most medical research historically had been performed using only males, it is now acknowledged this was problematic and led to medical recommendations that were fundamentally better suited to men than to women (Schiebinger, 2003). There are immutable physiological as

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