Salivary cortisol patterns in psychopathic and non-psychopathic offenders

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ABSTRACT

Previous research has described diverse biological correlates of the psychopathic personality. Efforts to understand the underpinnings of low fear responses in psychopathic individuals have drawn attention to the possible role of abnormalities in hypothalamic-pituitary-adrenal (HPA) axis function, but studies to date have been largely limited to youth or to adult community samples. The current study therefore examined morning basal cortisol levels and responses to a psychosocial stress task in a forensic clinical sample of psychopathic offenders ($n = 14$), non-psychopathic offenders ($n = 22$), and non-offender controls ($n = 14$). Morning cortisol levels were similar in all three groups. Throughout the stress task, psychopathic offenders showed significantly lower cortisol than controls; non-psychopathic offenders showed a similar but non-significant trend towards lower cortisol. The three groups did not differ, however, in cortisol response slopes. Implications of these findings are discussed in the framework of current theories about biological mechanisms underlying psychopathic personality.

1. Introduction

Psychopathic personality is a clinical construct, traditionally defined as a combination of interpersonal, behavioral, and affective characteristics associated with a socially deviant lifestyle [1]. A body of research has reported diverse biological correlates of this severe personality disorder (for a review, see [2,3]; more recently [4]). There is, for example, considerable evidence for neurocognitive and affective-emotional processing deficits in individuals with psychopathic personality, with concurrent neurobiological abnormalities (e.g., [5]). Psychopathic samples show structural and functional abnormalities in the orbitofrontal-ventromedial prefrontal cortex and the cingulate cortex: brain regions involved in decision-making and behavioral control; these abnormalities may underlie features like impulsivity and sensation seeking [6,7]. Disturbed functioning of the hippocampus and amygdala may interfere with learning and emotional processing, especially fear, possibly accounting for shallow affect and a lack of empathy in psychopathic individuals [6–8]. Irregularities in functioning of the hypothalamic-pituitary-adrenal (HPA) axis have also been linked to features of psychopathy [9,10]. It has long been postulated that low cortisol might contribute to the diminished fear observed in psychopathic personality [11,12]. An earlier study reported an inverse correlation between serum cortisol levels and affective-interpersonal psychopathic traits (PCL-R factor 1) in adolescent male offenders with a history of violent acts [13]. Another study found lower mean cortisol levels in psychopathic offenders compared to non-psychopathic offenders and controls [9]. In juvenile offenders, Feilhauer et al. [14] found evidence that low basal cortisol levels might reflect a general deficit in behavioral regulation. These findings indicate that psychopathy has a strong biological basis.

The above studies focused on diurnal cortisol levels as an indicator of HPA axis abnormalities. Cortisol reactivity to stress, however, may be particularly relevant in light of hypothesized low fear [11], indifference to punishment [15], and lack of conscience development [16] in psychopaths. In non-psychopathic healthy students, lower cortisol response to a stressful task was related to maladaptive perfectionism [17]. In lines with these results, studies have shown that chronic stress leads to blunted cortisol stress responses as a self-protective mechanism of the overactivation of the HPA-Axis that results in a hypoactive HPA-axis [18]. A meta-analysis focusing on gender differences showed that males had higher cortisol reactivity than females [19]. In a recent meta-analysis using the virtual Trier Task as a stressor reported again that males showed higher cortisol reactivity than females and participants below 25 years old had higher cortisol reactivity than older...
participants [20]. Early studies in arrested men awaiting trial [21] and maximum security patients awaiting a stressful test battery [22], investigating urinary catecholamine responses to anticipated stressors noted associations between psychopathic traits and blunted reactivity. Although psychopathic characteristics have been linked to blunted cortisol reactivity to induced stress in non-clinical youth samples (e.g., [23]), little research appears to have focused on this association in prison or clinical populations. One exception is a study of 49 incarcerated antisocial 18-year-olds who underwent the Trier Social Stress Task (TSST); results showed that psychopathic traits (PCL-R factor 1, in particular the affective facet) were weakly related to a steeper decline in pre-stress to post-stress cortisol, but only among participants who showed no stress-related cortisol increase (“nonresponders”) and after controlling for length of current imprisonment [24]. The few previous studies of cortisol reactivity in adults with psychopathic traits have been conducted in community samples (e.g., [9]). To date, no study has investigated cortisol secretion in response to stress in a clinical forensic sample of adults with psychopathic personality.

The current study was therefore designed to investigate cortisol secretion in response to experimental psychosocial stress in groups of offenders with and without psychopathic personality, compared to healthy, non-psychopathic, non-offender controls. We hypothesized that offenders with psychopathic personality would show a blunted cortisol response to a stress-inducing speech task, whereas non-psychopathic offenders and healthy controls would show the expected cortisol increase. Given the lower baseline cortisol levels observed in a previous study of imprisoned psychopathic offenders [25], the present study also examined morning cortisol levels. We expected to find lower morning cortisol levels in offenders with high psychopathic traits than in either non-psychopathic offenders or healthy non-offender controls.

2. Methods

2.1. Participants

All participants were Dutch citizens and native speakers; the majority (80.4%) were white. Criminal offenders (n = 36) at the Forensic Psychiatric Center de Rooyse Wissel (FPCdRW) in Venray, the Netherlands, received an information letter, asking them to participate in the current study on a completely voluntary basis. Offenders were divided according to their scores on the PCL-R; PCL-R score of 15.57 (SD 5.48); for the 13 psychopathic offenders (PCL-R = 14) offenders. PCL-R data were missing for two offenders (one in each subgroup), resulting in a total score between 0 and 40. We used the second (revised) edition of the instrument [29]. A cut-off score of 26 [30] was used to define two subgroups: non-psychopathic offenders (PCL-R score < 26) and psychopathic offenders (PCL-R score ≥ 26). PCL-R scores were missing for two offenders (one in each subgroup), resulting in 35 available total scores. The PCL-R has high internal reliability (Cronbach’s α = .80 [31]). Factor analytic studies have also indicated good validity of the instrument (e.g., [29]).

2.2. Assessment of psychopathic personality

The Psychopathic Checklist-Revised (PCL-R [27]), a semi-structured interview, is the common metric for assessment of psychopathy, in research as well as in clinical practice [28]. The PCL-R is a 20-item interview and a review of the subject’s file records and history. In order to get a total PCL-R score these interview and file record data need to be integrated. Items are scored 0 does not apply, 1 somewhat applies, and 2 fully applies, resulting in a total score between 0 and 40. We used the second (revised) edition of the instrument [29]. A cut-off score of 26 [30] was used to define two subgroups: non-psychopathic offenders (PCL-R score < 26) and psychopathic offenders (PCL-R score ≥ 26).

Due to logistical constraints, obtaining an estimate of stress-free, basal cortisol levels in all participants was possible only during the morning. Because cortisol levels can show large fluctuations at this time of day, three saliva samples were collected at 20 min intervals, at 8:00, 8:20, and 8:40h to yield a more reliable estimate of basal levels (Cronbach’s α = .75 for the log-transformed values). In the offender group, these samples were taken under supervision in the clinic at least one hour after awakening and brought to the university the same day. On the day of testing, control participants collected the morning samples at home, indicating on a form the exact times of sample collection, and brought the samples to the university in the afternoon.

Participating offenders were always instructed to avoid caffeine and alcohol the night before. After the saliva sample (T1) was taken to assess pre-task cortisol levels. Participants were then asked to perform a 5 min speech on a topic of their choice and
were left alone in the room for 10 min to prepare it. The test supervisor and a psychologist then entered the room to judge the participant’s speech. At the end of the speech, the two panel members left the room, ostensibly to discuss their evaluations. Five minutes later they returned and gave positive feedback to all participants. After this the second saliva sample was taken (T2, 25 min after receiving instructions). A final sample (T3) was taken ten minutes after T2. At the end of the session, all participants were fully debriefed about the experimental procedure and the goals of the study.

2.5. Cortisol assay

Samples were stored at-40 °C until transported to the laboratory of Dr. J. Sulon (Department of Reproductive Physiology, University of Liège), where an in-house radioimmunoassay was performed in duplicate on 50 µl of saliva, with salivary free cortisol in competition with an HPLC preparation of cortisol-3CMO coupled with 2-125Iodohistamine as tracer for specific antibodies raised against cortisol-3CMO-BSA. The lower detection limit of the assay was 0.2 nmol/L. Intra- and inter-assay coefficients of variation were both < 10%.

Salivettes from one non-psychopathic offender did not contain sufficient saliva for assay. Cortisol data were thus available for 14 healthy controls, 22 non-psychopathic offenders, and 14 psychopathic offenders.

2.6. Statistical analysis

Cortisol values were first log-transformed to normalize their distributions. Group differences in morning cortisol levels were investigated with analysis of variance with repeated measures, controlling for age. To assess associations between psychopathy and cortisol during the stress task, we performed multilevel regression analysis [34], using Stata v.13 procedure MIXED (Stata Corporation, College Station, Texas). Because cortisol measures taken at three time points were nested within participants, two-level models allowed us to estimate and compare overall cortisol levels and response slopes more accurately, also controlling for differences in time of day at T1 and for age. Fixed effects are expressed as unstandardized β coefficients; β divided by the standard error (SE) is approximately Z-distributed. Statistical tests were two-tailed, with α = .05.

3. Results

3.1. Morning cortisol levels

Mean (SD) cortisol levels at 8:00h, 8:20h, and 8:40h were 8.31 (4.08) nmol/L, 7.67 (4.56) nmol/L, and 6.93 (3.65) nmol/L, respectively. Analysis of variance with repeated measures controlling for age revealed a non-significant decrease in cortisol over the three time points, F(2,92) = 1.69, p = .19, with no significant main effect of group, F(2,46) = .45; p = .64. Furthermore, the group by time interaction was non-significant, F(4,92) = 1.26; p = .30, indicating no difference among the three groups in cortisol slope over this 40-min interval.

3.2. Cortisol levels and reactivity during the stress task

Multilevel regression results are summarized in Table 1. Overall, the three-way comparison of effects of the dummy variable group indicated that psychopathic offenders had significantly lower cortisol levels throughout the stress task than healthy controls; among non-psychopathic offenders, there was a similar but non-significant trend toward lower cortisol levels, relative to controls. Psychopathic offenders showing significant lower cortisol levels throughout the task suggests lower cortisol patterns in this subsample of offenders. The stress induction procedure successfully activated the HPA axis, with an estimated 48% increase in cortisol during the 35 min interval from pre-stress (T1) to post-stress (T3) measures, over all participants and controlling for time of day. Results did not, however, support the hypothesis of blunted stress reactivity in the psychopathic offender group. As shown in Table 1, healthy controls showed a significant increase in cortisol following stressor onset (time effect). Although the negative betas for group by time interaction effects suggest diminished reactivity in both offender groups, the estimated cortisol response slopes for these groups were not significantly different from those of healthy controls.

4. Discussion

The present study investigated cortisol levels and stress reactivity in male criminal offenders from a forensic clinic and healthy, non-offender controls from the general community. Based on theory as well as previous research findings, we had hypothesized that psychopathic offenders would show deviant patterns of salivary cortisol secretion. Results partially confirmed this, in that the psychopathic offenders showed overall lower cortisol levels than controls throughout the stress task. We did not, however, observe significant differences among psychopathic offender, non-psychopathic offender, and healthy control groups in morning cortisol levels, and the hypothesized blunting of the cortisol response from pre- to post-stress in psychopathic offenders was not statistically significant.

There are two plausible interpretations of our main finding of lower cortisol throughout the experimental stressor in the psychopathic offender group. As one possibility, offenders with higher psychopathic traits may have lower basal cortisol levels, even under stress-free conditions [9]. However, although we had no measures of basal cortisol later in the day, the fact that the three groups showed no significant difference in cortisol levels in the morning of the test day suggests that...
physiology was not associated with overall lower diurnal cortisol levels. Alternatively, lower cortisol in the psychopathic group throughout the stress task may be interpreted as an indication of blunted stress reactivity, even in the absence of significant group differences in the estimated cortisol response slopes over the three pre- to post-stress time points. If the T1 “baseline” measure was elevated due to anticipatory anxiety, as is often the case [32], and to a greater extent in the control group than in the psychopathic group, the net effect might well be relatively blunted cortisol in the psychopathic offender group throughout the task. If we consider the pre-task cortisol measure as part of the total stress response, cortisol levels over the three time points are analogous to the area-under-the-curve with respect to ground (AUCg) measure of the cortisol stress response as formulated by Pruessner et al. [35]. To distinguish between these alternative explanations, we would need a more complete cortisol day profile, including a sample at the same time of day as stressor onset, on a stress-free control day.

The observed lower cortisol levels in psychopathic offenders during the stress induction procedure sheds light on previous findings of impaired acquisition of conditioned fear responses in this group, possibly related to their insensitivity to punishment and correctional sanctions [15]. Lower activation of the HPA axis under stress-inducing conditions is consistent with previously reported underarousal of the autonomic nervous system in psychopathic individuals [16,36–38]. This relates to the findings reported in aggressive children [39], adolescents with conduct disorder [40], young adult male violent offenders [13], and psychopathic offenders [9] showing lower HPA activity. In line with the fearlessness theory of psychopathy [11] and prior evidence on decreased HPA activity to fear response and insensitivity to punishment [8,41], the current results provide added support to the notion of a hypoactive stress-response system in psychopathy.

Results should be viewed in light of some limitations. First, morning cortisol levels were determined without controlling for the time of awakening. This means that morning levels could potentially have been influenced by the cortisol awakening response (CAR), the well-described sharp increase in cortisol secretion immediately after morning awakening. The CAR peaks within approximately 30–45 min; levels then decrease, so that the CAR is no longer reliably detectable 60 min after awakening [42]. Because wake-up times in the clinic were always before 7:00 h, and the majority of control participants also reported awakening before that time, we regard contamination of the morning cortisol measurements (starting at 8:00 h) by the CAR as unlikely, and yet this can’t be completely ruled out. In the event that wake-up times were actually earlier in the offenders than in the control group, one would expect a greater influence of the CAR in the controls, as evidenced in higher morning cortisol or a different time course. The absence of a significant group effect or group by time interaction in cortisol measured 3 times over an interval of 40 min supports the conclusion that psychopathy and/or incarceration were unrelated to morning cortisol levels. Nevertheless, care should be taken in the design of future studies to isolate the CAR from measures taken later in the morning. Second, for practical reasons the stress task was performed at different times of day, often in the morning. In general, cortisol levels are more stable in the afternoon, and stress tasks performed in the afternoon are more likely to induce a cortisol response [35]. As expected based on its normal circadian rhythm, cortisol was indeed lower at the onset of stress tasks conducted later in the day (see Notes, Table 1). However, the timing of the stress task is unlikely to have biased our results: not only were there no significant differences in time of day or in the time of task onset, but the actual time of task onset did not impact the estimated change in cortisol from T1 to T3 (β = 0.083, p = .117). Third, it would have been informative to have included measures of DHEA [43], salivary alpha-amylase [24] or testosterone [8]; these hormones—either alone or in relation to cortisol levels—have been linked to psychopathic traits and may help explain the biological mechanisms underlying deviant responses to stress and punishment [8,25]. The ratio between testosterone and cortisol, for example, may predispose to more severe forms of aggression [8,44]. Fourth, no information on early life stress or trauma was obtained, although such experiences can have longlasting effects on cortisol levels and stress reactivity [e.g., 9,18, 45,46]. Finally, we were unable to include female offenders in the current study; gender differences remain an important topic for future research, as there are large gender differences in hormonal patterns in relation to social behavior [19, 47,48]. Despite these limitations, the current findings extend previous research by relating two important aspects of HPA activity (diurnal cortisol levels and stress reactivity) to psychopathic traits in adult offenders. Particularly, we observed an overall lower pattern of cortisol secretion in offenders with psychopathic traits that did not show the typical cortisol increase after stress induction compared to controls. This adds to a growing body of work suggesting that low responsiveness to stress, might be a neurobiological marker underlying the fearlessness of psychopathy which relates in turn to insensitivity to the negative consequences of their antisocial behavior [37,49,50]. Future research would benefit from longitudinal studies examining cortisol patterns across the life span not only to unravel causal relations but also to establish whether low cortisol reactivity is indeed a neurobiomarker of psychopathy. Since psychopathy might thus relate to an insensitivity of the negative consequences of their antisocial behavior, treatment programs need to focus more on the positive outcomes of positive behavior rather than pointing out the negative effects of antisocial behavior. Furthermore, the acknowledgment of a biological predisposition, like for instance a consistent distinct cortisol output in psychopathy versus non-psychopathy, may become a useful tool in the application of tailored biopsychological interventions.

“All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.”

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