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State, not trait, neuroendocrine function predicts costly reactive aggression in men after social exclusion and inclusion

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ABSTRACT

Social exclusion increases aggressive behaviour, and the possible neuroendocrine underpinnings of the effect are largely unknown. Here, we examined the extent to which testosterone and cortisol responses to social exclusion would predict subsequent reactive aggression. Men were randomly assigned to a social exclusion (SE) or inclusion (SI) condition of 'Cyberball', a computer ball-toss game. Aggression was then measured using the Point Subtraction Aggression Paradigm (PSAP). Saliva was collected at three points for the measurement of testosterone and cortisol. Regression analyses indicated that testosterone concentrations 10-min into the PSAP (controlling for pre- and post-Cyberball testosterone) were positively correlated with aggressive behaviour, irrespective of SI/SE. Post hoc analyses for the conditions separately, however, suggested the relationship was stronger for SI men ($R^2_{change} = 13.3\%$, $F_{1,\ 29} = 5.28$, $p = 0.03$) than for SE men ($R^2_{change} = 1.8\%$, $F_{1,\ 26} = 0.49$, $p = 0.49$). Aggressive behaviour was also positively correlated with cortisol concentrations 10-min into the PSAP (controlling for pre- and post-Cyberball cortisol) irrespective of SE/SI. When both hormones were included in the regression model, the interaction of baseline 'Cortisol' × 'Testosterone' × 'Experimental Group' approached significance ($R^2_{change} = 5.4\%$, $F_{1,\ 55} = 3.53$, $p = 0.07$), but no significant effects were observed in either group alone. The findings add to evidence that individual differences in state neuroendocrine function map onto variability in human social behaviour.

1. Introduction

Psychologists from a broad array of theoretical perspectives concur on the importance of social relationships for humans, with affiliation considered a basic human drive (Baumeister and Leary, 1995; Blackhart et al., 2009). There is much evidence that the quality of a person's social bonds impacts physical and mental health (Aldabe et al., 2010; Wilkinson and Marmot, 2003). Although there are evolutionary benefits to social inclusion, social exclusion has been cast as an adaptive behaviour as well, whereby others who are costly to one's inclusive fitness are avoided (Leary et al., 2006). Social exclusion also can be viewed as an act of aggression using the standard definition of aggressive behaviour, which is behaviour intended to harm or injure another, and with the type of harm or injury physical, psychological, social, or financial (Baron and Richardson, 1994; Leary et al., 2006). Social exclusion is thus a form of relational aggression through the harm it does to social relationships (Murray-Close et al., 2010).

Exclusion induces a hostile mindset (DeWall et al., 2009; Romero-Canyas et al., 2010; Twenge et al., 2001), which may underlie the many reports of increased aggressive behaviour in the excluded from studies using both non-experimental (e.g., Downey et al., 2000; Murray-Close et al., 2010; Pellegrini et al., 2007) and experimental approaches (Wesselmann et al., 2010) (reviewed in Leary et al., 2006). Aggression after social exclusion in laboratory studies usually fits the definition of reactive aggression rather than proactive aggression (Ayduk et al., 2008; Buckley et al., 2004; DeWall and Bushman, 2009; Kirkpatrick et al., 2002; Twenge et al., 2001; Warburton et al., 2006; Wesselmann et al., 2010). Reactive aggression is typically a defensive, retaliatory response to perceived or actual provocation that is characterized by anger and high physiological arousal, whereas proactive aggression does not involve provocation, is aimed at gaining resources (e.g., money, territory, social status, and mating opportunities), and does not typically involve physiological arousal (Crick and Dodge, 1996; Dodge and Coie, 1987). In the laboratory studies of aggression after exclu-

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sion, the aggressive behaviour was not costly to the individual; the greatest cost to the individual in the experimental setting was the loss of social status from the exclusion itself, with aggressive behaviour occurring when there was little opportunity to regain status by other means. For example, in many of the studies, the excluded aggressor acted under conditions of anonymity without any likelihood of meeting the target. When there is the possibility of influencing the rejector(s), however, the excluded individual instead may act ingratiatingly despite a hostile mindset (reviewed in Maner et al., 2007; Romero-Canyas et al., 2010), and there is some evidence of increased affiliative or prosocial behaviour in the excluded individual towards others than the rejector(s) (Gross, 2009; Maner et al., 2010). Thus, situational factors appear to moderate the behaviour of the excluded, with aggressive behaviour after exclusion more likely to occur under conditions of anonymity and when there is no expectation of interaction with the rejector.

That aggressive behaviour after exclusion has been found towards others and in the absence of the instigator of the threat to status suggests that aggression may be a behaviour pattern that occurs in response to a variety of threat contexts depending on the extent to which automatic, emotional processing is activated rather than, or relative to, deliberative processing (Anderson and Bushman, 2002; Berkowitz, 2008; Richetin and Richardson, 2008; Todorov and Bargh, 2002). Recent evidence suggests impulse control and cost-benefit analysis operate in parallel as determinants of aggressive behaviour (e.g., Archer et al., 2010; Archer and Southhall, 2009). Thus, social exclusion may diminish impulse control (Twenge and Baumeister, 2005), but also may require low cost conditions for aggressive behaviour to be expressed.

In our investigations of reactive aggression using modified versions of the Point Subtraction Aggression Paradigm (PSAP, originally designed by Cherek, 1981), reactive aggressive responses are made at a cost to earning financial reward (Carré and McCormick, 2008; Carré et al., 2009). Nevertheless, the extent of aggressive behaviour changes with cost of the behaviour, with more aggressive responses evident when there is less financial cost (Carré et al., 2010), suggesting an influence of cost-benefit analysis. We thus hypothesized that social exclusion would increase aggressive behaviour in the PSAP, in keeping with the evidence that social exclusion diminishes impulse control and impairs decision-making (Rilling et al., 2008; Twenge and Baumeister, 2005). Furthermore, there is evidence that social exclusion increased the desire for money and the distress over its loss in participants (Zhou et al., 2009), and thus excluded individuals may be more prone to retaliate to an opponent's stealing of their points. We have argued that there is greater intrinsic reward of the aggressive behaviour under conditions in which it is most costly, which is supported by higher ratings of enjoyment of the PSAP in conditions of high cost of aggression and a positive correlation between aggressive responses and enjoyment of the PSAP only in conditions of high cost of aggression (Carré et al., 2010). Thus, we also tested whether social exclusion would strengthen these relationships.

The investigation of social exclusion and costly aggressive behaviour also provided us with the opportunity to investigate individual differences and the context-specificity of the relationships between endocrine function and aggression. There is substantial evidence for a rise in testosterone in men in specific contexts, most notably competitive situations and sexual encounters (see reviews by Archer, 2006; Booth et al., 2006; van Anders and Watson, 2006). The Biosocial Model of Status posits that testosterone promotes dominance behaviour aimed at preserving status, and thus testosterone concentrations in men are highly sensitive to changes in status (Mazur and Booth, 1998). Based on the latter, one would predict that social exclusion, because of loss of status, decreases testosterone concentrations in men. Many studies, however, have failed to find winner/loser differences in testosterone responses (Carré et al., 2009; Mehta and Josephs, 2006; Schultheiss et al., 2005; van der Meij et al., 2010), and the one study of testosterone concentrations after social exclusion found a decrease in testosterone after inclusion and no change after exclusion (DeSoto et al., 2009). Nevertheless, individual differences in testosterone responses predicted subsequent competitive behaviour more so for losers than for winners (Carré et al., 2009; Mehta and Josephs, 2006). Thus, individual differences in testosterone responses may contribute to the expression of aggressive behaviour to a greater extent after social exclusion than after inclusion.

Behaviour after social exclusion may involve neuroendocrine factors other than testosterone. One study reported a drop in progesterone (a hormone considered relevant for affiliative behaviour) after social exclusion among participants high in social anxiety (Maner et al., 2010). There also is some evidence for a rise in cortisol concentrations after social exclusion, but when found, the effect is small and limited to subgroups of participants (reviewed in Zoller et al., 2010). There has been one investigation of endocrine function after social exclusion with respect to subsequent aggressive behaviour: Ford and colleagues found that those individuals who increased cortisol concentrations after exclusion were more derogatory towards a partner (Ford and Collins, 2010). This result fits the relationship that has been reported between cortisol and aggressive behaviour, with aggressive behaviour associated with low baseline cortisol (reviewed in Poustka et al., 2010; van Goozen et al., 2007) and high cortisol reactivity (e.g., Gerra et al., 2001; Lopez-Duran et al., 2009).

Cortisol also has been reported to moderate the relationship between testosterone and aggression, whereby a relationship between the testosterone and aggressive behaviour is found only among those with low cortisol concentrations (Dabbs et al., 1991; Popma et al., 2007). Cortisol also was found to moderate the change in testosterone in men after winning or losing a competition (Mehta et al., 2008), and the interaction of cortisol and testosterone predicted dominance (Mehta and Josephs, 2010). Van Honk and colleagues have proposed that a combination of low cortisol and high testosterone concentrations are hallmarks of a predisposition to aggression (Terburg et al., 2009; van Honk et al., 2010). Nevertheless, the extent to which baseline concentrations of either testosterone or cortisol or their reactivity or their interaction best predict aggressive behaviour is still unknown. Thus, the present experiment investigated the extent to which baseline and changes in testosterone and cortisol could explain individual differences in costly aggressive behaviour after social exclusion compared to after social inclusion.

2. Methods

2.1. Participants

Undergraduate men were recruited from Brock University ($n = 78$, all self-identified as Caucasian). Four participants taking prescription medications (e.g., SSRIs, glucocorticoids, Ritalin) were removed from the analyses, resulting in a sample of 74 men (mean age = 19.96, S.D. = 2.43).

2.2. Procedure

Arrival. (See Fig. 1 for a timeline of the experimental procedures.) Participants were tested individually within the hours of 12:00 and 18:00 h to minimize diurnal variation in hormone concentrations. On arrival, each participant completed consent forms, a demographic questionnaire, and posed for a photograph (headshot while posed in a neutral facial expression). Next (about 15 min after arrival), the participant provided a 1–2 mL saliva sample (baseline sample) while the experimenter loaded the photograph into the computer program. Participants were told that they would first play an online ball toss game (Cyberball) that would allow them to interact with three other participants before the main experimental task.

Cyberball. Participants were assigned randomly to the social inclusion or social exclusion condition of Cyberball, a widely used, reliable experimental procedure for simulating the experience of social exclusion (Williams, 2007; Williams et al., 2000; Williams and Jarvis, 2006). To increase the believability of the task, the participant's