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Blunted cardiac stress reactors exhibit relatively high levels of behavioural impulsivity

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HIGHLIGHTS

- Blunted cardiac stress responders exhibited greater motor impulsivity.
- Blunted cardiac stress responders exhibited lower inhibitory control.
- Greater impulsivity may be a link to maladaptive health and behavioural correlates.

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ABSTRACT

Blunted physiological reactions to acute psychological stress are associated with a range of adverse health and behavioural outcomes. This study examined whether extreme stress reactors differ in their behavioural impulsivity. Individuals showing blunted ($N = 23$) and exaggerated ($N = 23$) cardiovascular reactions to stress were selected by screening a healthy student population ($N = 276$). Behavioural impulsivity was measured via inhibitory control and motor impulsivity tasks. Blunted reactors exhibited greater impulsivity than exaggerated reactors on both stop-signal, $F(1,41) = 4.99$, $p = 0.03$, $\eta_p^2 = 0.108$, and circle drawing, $F(1,43) = 4.00$, $p = 0.05$, $\eta_p^2 = 0.085$, tasks. Individuals showing blunted cardiovascular stress reactions are characterized by greater impulsivity which may contribute to their increased susceptibility to outcomes such as obesity and addiction.

1. Introduction

Individuals differ markedly in their biological reactions to standard psychological stress exposures [10]. In addition to long-standing and comprehensive evidence to show that those who exhibit exaggerated cardiovascular reactions to acute psychological stress are at increased risk of developing various manifestations of cardiovascular disease [11], there is accumulating support to suggest that attenuated cardiovascular stress reactions are associated with a range of adverse health and behavioural outcomes [54]. These adverse outcomes include obesity [14,56,62] and substance abuse addictions, such as tobacco [26,32,34,59,61,64], alcohol [7,21,25,47,50,63] and/or other non-prescription drugs [47,50,67]. Attenuated biological reactions to stress also appear to be a feature of those who meet the criteria for exercise dependence [37], gambling addiction [51], and disordered eating [33,40].

A conceptual model has been proposed whereby modified frontolimbic function of the brain leads to reduced physiological stress reactivity, altered cognition, and unstable affect regulation which then leads to impulsive behaviours, with consequences for adverse health behaviours and addiction risk [46]. The association between impulsivity and cardiovascular stress reactivity in non-clinical populations is somewhat unclear. Two studies reported a negative association, higher impulsivity was related to lower cardiac reactivity [1,49]. Of these studies, one study used a self-reported impulsivity measure [1], while the other examined the relationship in young children and measured pre-ejection period (PEP), a less commonly reported cardiovascular index, as opposed to the more common measure of heart rate, making comparability difficult (HR; [49]). One study reported a positive association between cardiovascular reactivity and an aspect of impulsivity, temporal discounting [24]. Finally, no clear association was observed by others [48], however, selection of groups was made from extreme impulsivity questionnaire scores rather than cardiovascular reactivity. In one of the few studies to have included behavioural as well as self-report measures of impulsivity, pre-adolescent children high in impulsivity had diminished cardiac

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responses to a mental arithmetic task [6]. To our knowledge, no study in a young adult population has examined the relationship between cardiovascular stress reactivity and impulsivity using behavioural measures of impulsivity.

Given that impulsivity is associated with the unhealthy outcomes linked to attenuated biological stress reactivity, we re-examined its relationship with cardiovascular stress reactivity. However, instead of the predominantly used self-report measures, we administered two behavioural tests of impulsivity to our participants, selected as unambiguously exaggerated or blunted cardiac reactors following the stress testing of a substantial young adult sample. We considered that pre-selecting on the basis of stress reactivity and using behavioural measures would afford a more powerful test of the hypothesis that blunted stress reactors would be characterized by greater impulsivity. The examination of a young adult sample is particularly important given that impulsivity during this stage provides exaggerated risks to health development and may signify deficits in brain maturation [58].

2. Materials and methods

2.1. Participants

Two hundred and seventy six healthy University of Birmingham students (147 women) attended an initial laboratory stress-testing session during which cardiovascular stress reactivity was determined. Using cut-offs of the 15% highest and 15% lowest HR reactions, 23 exaggerated reactors and 23 blunted reactors were selected and returned to complete the impulsivity tasks. The mean (SD) age of the selected sample was 22.6 (8.09) years and their mean (SD) body mass index (BMI) was 22.9 (2.91) kg/m^2. The majority of the selected participants indicated they were “white” (89%). None of the participants had a history of cardiovascular disease, a current illness or infection, or were taking medication. All participants provided written informed consent, and the study was approved by the University of Birmingham ethics committee.

2.2. Cardiovascular reactivity screening procedure

Individuals were required to refrain from eating for 1 h, drinking caffeine or smoking for 2 h, and from physical exercise and drinking alcohol for 12 h, prior to laboratory stress testing. Systolic (SBP) and diastolic (DBP) blood pressure and HR were measured at minutes 2, 4, 6 and 8 during a 10-minute baseline and paced auditory serial addition stress test (PASAT) using a semi-automatic arm sphygmomanometer (Omron, IL). A single measure was also taken during a 10 minute adaptation period for familiarity, although this measure was disregarded. The PASAT [35] reliably perturbs cardiovascular activity [31,57] and has good test–retest reliability [70]. Participants were presented with a series of single digits and were required to add the present number to the previously presented number, and report their answer aloud. To increase potential stress, participants were filmed, received brief bursts of loud aversive noise, and were placed on a leader board: the protocol has been described in detail elsewhere [37]. Immediately following the PASAT, participants rated their perceived level of task engagement and stressfulness using a 7-point Likert-type scale ranging from 0, not at all to 6, extremely.

Participants' cardiovascular reactivity was calculated as the mean PASAT level minus mean baseline level. Individuals scoring within the top and bottom 15% of HR reactions were invited back to complete the behavioural tasks. HR reactivity, rather than SBP or DBP, was the chosen selection criteria as blunted HR reactivity is more consistently associated with adverse health and behavioural outcomes [8,33,55], and the deactivation in anterior cingulate cortex is related to HR reactivity [19,20,31], as well as being implicated in impulsivity [27].

2.3. Impulsivity tasks

The stop-signal task (Inquisit by Millisecond, Seattle) measures the inhibitory control aspect of impulsivity and has been detailed elsewhere [43]. Participants were required to respond as fast and accurately as possible to a left or right arrow in the centre of the computer screen: the *go task*. On 25% of the go task trials, an auditory beep (stop signal) is presented and participants are required to inhibit their response to the go task on that trial; the *stop task*. Consequently, failing to inhibit when presented with a stop signal indicates poor impulse control and greater impulsivity [43]. Following a tracking procedure [43], the delay between the stop signal and the go signal (*stop-signal delay*), originally set to 250 ms, is adjusted to ensure the participant inhibits their response approximately 50% of the time. Therefore, the main outcome in the present study is the mean stop signal reaction time (SSRT); longer times indicate greater impulsivity and less inhibitory control. The current study consisted of 32 practice trials, then three experimental blocks of 64 trials which were used for data analysis. The stop-signal task has a respectable pedigree as a measure of impulse control [41,43,68].

The circle drawing task [4] is a measure of motor impulsivity. Participants were asked to trace the outline of a large printed circle (50.80 cm ø), using their index finger from a starting point at the top of the circle. In condition 1 (neutral), participants traced around the circle. In condition 2 (inhibition), they were instructed to trace the circle as slowly as possible without stopping. Circle Time Difference was then calculated by subtracting the inhibition condition time from the neutral condition time; smaller time differences indicate greater impulsivity [3].

2.4. Behavioural task laboratory procedure

The behavioural tasks were undertaken in a laboratory specifically designed to minimize external or environmental distractions likely to affect performance. Task order was counterbalanced and the study employed a double-blind testing procedure, such that neither participant nor experimenter was made aware of the stress reactivity status of the participant.

2.5. Data analysis

Group differences in participant characteristics, stress task performance and engagement, and cardiovascular baseline and reactivity variables were tested using univariate ANOVA for continuous variables, and chi-square for categorical variables. Repeated measures ANOVAs were used to confirm that the stress task perturbed cardiovascular activity. Univariate ANOVAs were used to compare reactivity group differences in impulsivity, with partial η^2 reported as effect size. Three participants for the stop-signal task and one participant for the circle drawing task were not included in the analysis due to technical failures.

3. Results

3.1. Socio-demographics and cardiovascular stress reactivity

The summary socio-demographic and anthropometric data, PASAT ratings, and cardiovascular baseline and stress reactivity measures are presented in Table 1. There were no significant group differences in sex, age, PASAT total score or self-reported stress task impact (all p's > 0.05).

From the overall screening procedure of 276 participants, the respective ranges for HR ($M = 17.08$, $SD = 11.56$), SBP ($M = 18.25$, $SD = 8.59$), and DBP ($M = 12.16$, $SD = 5.84$) reactivity were as follows: −7.75 to 75.00 bpm; −2.25 to 46.50 mm Hg; −1.25 to 28.50 mm Hg. Repeated measures ANOVA indicated that the stress task significantly perturbed HR, $F(1,275) = 602.35$, $p < 0.001$, $\eta^2_p = 0.678$, SBP, $F(1,275) = 1245.47$, $p < 0.001$, $\eta^2_p = 0.819$, and DBP, $F(1,275) = 1197.78$, $p < 0.001$, $\eta^2_p = 0.813$.