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Response Inhibition in the Parametric Go/No-Go Task in Psychopathic Offenders

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Abstract

Previous research on response inhibition in psychopaths has failed to find consistent evidence for aberrant inhibitory ability, despite strong expectations to the contrary. However, previous examinations have utilised inhibition paradigms that suffer from critical shortcomings, such as a lack of ecological validity and overly simplistic response criteria. To assess inhibition under conditions close to the demands of everyday settings, the current study employs a parametric Go/No-go task in male offenders (n = 77). Additionally, rather than treating psychopathy as a categorical descriptor, a dimensional approach is taken to assess the relationship between individual psychopathic traits and response inhibition performance. Results indicate significant relationships between response inhibition and individual facets of psychopathy as measured by the Psychopathy Checklist: Screening Version. A positive relationship was found between inhibitory ability and interpersonal aspects of psychopathy, reflecting an enhancement of inhibitory functioning for those scoring high on this facet. In addition, a negative association was found between psychopathic lifestyle characteristics and response inhibition. Whereas the negative association mirrors the conceptualisation of the lifestyle facet, the positive association between interpersonal psychopathic aspects and response inhibition might reflect a propensity for adaptive behaviour that enables psychopaths to adequately manipulate their victims and mask their true nature.

Keywords: Psychopathy, PGNG, PCL

1. Introduction

Psychopathy is a disorder often diagnosed in forensic settings by means of the Psychopathy Checklist-Revised (PCL-R; Hare, 1991, 2003). The factor structure of the PCL-R as well as its' screening version, the Psychopathy Checklist: Screening Version (PCL:SV; Hart et al., 1995), consists of four facets, measuring the interpersonal (tendency to display superficial, grandiose and deceitful behaviours), affective (lack of remorse and empathy, and individuals not accepting responsibility for their own actions), impulsive lifestyle (impulsivity, irresponsibility and a lack of goals) and antisocial behavioural characteristics (poor behavioural controls, as well as adolescent and adult antisociality) of psychopaths (Cooke et al., 1999; Hill et al., 2004; Vitacco et al., 2005). Given the incorporation of impulsive behaviours into the definition of psychopathy, explicitly in the lifestyle facet, one might expect psychopaths to express enhanced levels of impulsivity when measured under experimental conditions, but the evidence for elevated impulsivity levels in this context is currently inconclusive (Kiehl et al., 2000; Verona et al., 2012; But see: LaPierre et al., 1995; Varlamov et al., 2011).

Impulsivity is a multi-facetted construct. A recent meta-analysis by Sharma and colleagues (Sharma et al., 2013) revealed low inter-correlations between aspects of impulsivity assessed via self-report (e.g. extraversion/positive emotionality, neuroticism/negative emotionality, disinhibition), and those assessed using behavioural approaches (e.g. inattention, inhibition, impulsive decision-making). However, importantly, inhibitory functioning was identified as a key factor in both self-report and behavioural impulsivity measures. Further highlighting the multi-facetted nature of impulsivity, previous research has highlighted the difference between motor impulsivity, the inability to inhibit automatic responding, and cognitive impulsivity, the absence of planning (e.g. Brunner and Hen, 1997; Bechara et al., 2000). This distinction is important given that previous research

into psychopathy has revealed a consistent pattern of results when assessing cognitive impulsivity (Blanchard et al., 1977; Widom and Newman, 1985; Newman et al., 1992; Bechara et al., 2000), but evidence for enhanced motor impulsiveness in psychopathy is weaker (Kiehl et al., 2000; Verona et al., 2012; but see: LaPierre et al., 1995; Varlamov et al., 2011). One manner in which cognitive impulsivity has been assessed is through the application of the delay of gratification task (Bechara et al., 2000). Previous research using the delay of gratification task in psychopathic offenders revealed a general unwillingness in white psychopaths to choose a delayed large reward over a smaller immediate reward (Blanchard et al., 1977). However, whether or not psychopathic participants express a deficit in cognitive impulsivity, as indexed by the delay of gratification paradigm, has been shown to be dependent on additional personality traits. Newman et al., (1992) revealed superior performance, indicated by a higher willingness to delay gratification, in psychopathic inmates expressing low levels of trait anxiety. Similarly, successful psychopaths (being characterised by reduced amount of convictions) were found to show intact delay of gratification behaviour (Widom and Newman, 1985), indicating that specific personality traits affect the expression of enhanced or reduced levels of impulsivity in psychopathic participants.

Motor impulsivity, in contrast, is commonly assessed by the Go/No-go task, but research into the relationship between inhibitory ability and psychopathic traits has uncovered little evidence of behavioural inhibitory deficits in psychopathic prison populations using this approach (Kiehl et al., 2000; Verona et al., 2012; But see: LaPierre et al., 1995; Varlamov et al., 2011). The standard Go/No-go task requires participants to indicate, via keypress, when a predefined, commonly appearing target is presented (the ‘Go’ response), building a prepotent response to the stimulus. On the minority of trials, this prepotent response has to be withheld in response to a second target (the ‘No-go’ response). While this paradigm has been used successfully to inform the structure of the inhibition

system (Criaud and Boulinguez, 2013; Steele et al., 2013), the task design has been criticised because of its simplicity, as several authors have reported behavioural ceiling effects on No-go trials (e.g. commission error rates of between 0.18 and 17.70 %; Fallgatter and Strik, 1999; Heinzel et al., 2013; Mulligan et al., 2014), in addition to its lack of ecological validity (Langenecker et al., 2007; Votruba and Langenecker, 2013). The lack of context in determining the No-go target, i.e. a fixed No-go target, is at odds with the functioning of the inhibitory system in natural settings and could account for unexpectedly high performance on the standard task and has led researchers to question whether this task is an adequate measure of response inhibition ability (Mulligan et al., 2014).

With respect to the fixed stimulus-response nature in the classic Go/No-go task, recent evidence suggests that assessing response inhibition in isolation, as is the case in the standard Go/No-go task, is not necessarily appropriate given the interplay between inhibitory ability and related executive functions, such as information updating and mental set-shifting (Miyake et al., 2000). According to the Unity Diversity Model of Miyake and colleagues (2000), the executive functions of inhibition, set-shifting and information updating are highly related and as such, drawing resources from one reduces the processing capacity of the others. This interaction with additional executive functioning processes is not captured by the standard Go/No-go task, and led to the development of the parametric Go/No-go task (PGNG; Langenecker et al., 2007). The PGNG is a response inhibition task designed to overcome the problems of ceiling effects and context-independency of the standard Go/No-go task by increasing difficulty: increasing the number of potential targets and flexibly determining the current target using an alternation rule (the definition of the current trial as No-go or Go trial depends on the previous target trial). Applying these design manipulations leads to an increased cognitive load on the underlying central resource and an incorporation of the two related executive functions, set-shifting and continuous information update

(Langenecker et al., 2007; Plewnia et al., 2013). The addition of these design features has led to the PGNG capturing response inhibition deficits in, for example, bipolar disorder, where impulsivity is by definition part of the disorder (American Psychiatric Association, 2013), although response inhibition deficits had been unseen when utilising the standard Go/No-go task in bipolar patients (e.g. Elliott et al., 2004; Altshuler et al., 2005; Langenecker et al., 2010; Ryan et al., 2012).

Research on the parametric Go/No-go task has yet to be applied to a forensic population, but research in a subclinical undergraduate sample hints to the utility of this task in capturing specific abnormalities in psychopathy (Weidacker et al., 2017). In the subclinical sample, participants exhibiting high traits of Blame Externalization, as measured by the Psychopathic Personality Inventory-Revised (PPI-R; Lilienfeld and Widows, 2005), expressed prominent deficits in inhibitory ability when measured with the PGNG (Weidacker et al., 2017). However, research into the relationship between the PPI-R and the PCL has revealed only modest concurrent validity for the total scores of these assessment instruments, and no relationship between the PCL and the Blame Externalization subscale of the PPI-R (Poythress et al., 1998; Benning et al., 2005; Malterer et al., 2010; Miller and Lynam, 2012), and as such it is unclear whether the reported inhibitory deficit in subclinical manifestations of this disorder generalises to a forensic sample. While the full PGNG with its three stage parametric design has not yet been applied to forensic psychopaths, Krakowski et al. (2015) utilised a version of the Go/No-go task bearing strong similarities to the lower difficulty level of the PGNG, consisting of an alternation rule to define response inhibition in response to two target stimuli, and reported decreased accuracy on response inhibition trials in psychopathic offenders compared to controls (Krakowski et al., 2015). However, Krakowski and colleagues (2015) utilised a between-groups design which relied on the total psychopathy scores and as such was not designed to investigate the influence of the facets of the PCL:SV

on inhibitory ability. Furthermore, psychopathy is commonly seen as a dimensional construct instead of being categorical in nature (Walters et al., 2007). Relying solely on the total score can for example lead to masking effects when only some aspects of psychopathy are be related to the postulated deficit. Indeed, it is possible for one aspect of psychopathy to relate positively to the deficit while another may be negatively related (Snowden and Gray, 2011; for a discussion see Hicks and Patrick, 2006). For example, given the observed real-world behaviour of psychopathic offenders, the lifestyle aspects of psychopathy might relate to deficient response inhibition (Hare, 2003; Sharma et al., 2013). In contrast, the interpersonal aspects, might be expected to relate to more adaptive behaviours, given that previous research found them to be related to better verbal intelligence and better decision making (Ishikawa et al., 2001; Vitacco et al., 2005). In order for an individual to be successful in manipulating others and gaining gratification in the long-term, immediate impulses have to be restrained, and, as such, improved response inhibition might be related to the interpersonal aspects of psychopathy. Hence, there is considerable value in determining the individual contributions of the four facets to inhibitory deficits, which are indistinguishable when summated to form the total psychopathy score.

In light of the previous research in subclinical and forensic samples (Krakowski et al., 2015; Weidacker et al., 2017) utilising complex forms of the Go/No-go task, the current study applies the PGNG to a criminal sample assessed with the four facet model, captured by the PCL:SV. Based on the diagnostic criteria included in the PCL, the lifestyle aspects of psychopathy are expected to relate to deficient response inhibition in terms of increased errors on No-go trials. In line with previous research relating the interpersonal facet of the PCL to more adaptive characteristics, adequate response inhibition, such as improved accuracy to No-go trials, is expected for participants scoring highly on these characteristics.

2. Method

2.1 Participants

Seventy-seven non-dyslexic male prisoners with normal or corrected-to-normal vision have been assessed (age *M* = 41.18, *SD* = 13.33, ranging from 21 to 78 years). Two additional participants did not complete behavioural testing and their data is not incorporated in the analyses. The experiment was approved by the Ethics Committee of Swansea University, Cardiff University and the National Offender Management Systems and all participants provided written informed consent before taking part in the experiment. Participants (90.91 % White British/English) were recruited from the category C prison, Channings Wood in South England, a medium security institution. The prisoners from Channings Wood were assessed on further psychopathy and impulsivity related variables as part of a large scale project, additional outcomes of this project are reported elsewhere. Offenders within the resettlement and drug therapeutic units as well as offenders at increased risk of self-harm were not approached for the current study due to them being potentially different in behaviour and therapeutic experiences to the main prison population.

Full scale intelligence (FSIQ) was measured via the two subtest version of the Wechsler Abbreviated Scale of Intelligence (WASI; Wechsler, 1999), estimating full scale intelligence based on the Matrix Reasoning and Vocabulary subtests. In the current sample, FSIQ could not be obtained from three participants due to them being transferred to other prisons during the study time-period. FSIQ in the remaining participants ranged from 63 to 133 (*M* = 99.58, *SD* = 15.97).

The duration of imprisonment ranged between 1 and 444 months (M = 62.63, SD = 82.69). Participants age of first conviction ranged between 11 and 65 years (M = 23.55, SD = 11.88). In terms of number of previous convictions, the current sample expressed a range of 0 to 51 (M = 8.99, SD = 11.33), which related to 0 to 126 previous offenses (M = 20.80, SD = 28.65). The index crimes committed were composed of 11.7 % theft/burglary, 2.6 %

robbery, 13 % drug offenses, 11.7 % assault, 3.9 % murder, 51.9 % sexual offenses, 2.6 % driving-related offenses, 1.9 % fraud, and 1.9 % miscellaneous minor charges (e.g. mischief). These index crimes related to 50.6 % violent and 49.4 % non-violent offenses. Information regarding education level was present for 61 of the 77 participants. Duration of education ranged from 6 to 17 years (M = 10.21, SD = 3.46) in these participants the maximum educational qualification achieved was: 4.9 % primary school, 27.9 % General Certificate of Secondary Education, 13.1 % A levels, 1.6 % National Vocational Qualification (NVQ) Level 1, 32.8 % NVQ Level 2, 1.6 % NVQ Level 3, 1.6 % Higher National Certificate, 4.9 % Bachelor degree, and 11.5 % had a postgraduate diploma.

2.2 Task Design

The stimuli were the 12 letters of the alphabet between O and Z, with X, Y and Z as target letters and the remaining 9 letters serving as distractors. Stimuli were shown in capitals in white font on a black background. The experiment was programmed using Matlab R2010b (Mathworks Inc., Massachusetts, USA) and the Psychtoolbox package (Brainard, 1997; Kleiner et al., 2007). All stimuli were presented centrally on an 18” Monitor, running at a resolution of 1280 * 1024; keyboard responses were obtained from a standard USB keyboard.

The parametric Go/No-go Task was adapted from that reported in Langenecker et al. (2007) containing three stages of varying cognitive demands. Within the presented stream of letter, participants were required to monitoring for target stimuli which were defined depending on PGNG stage. Each letter was presented for 500 ms, interleaved by a jittered inter-stimulus interval (ranging from 900 ms to 1100 ms in steps of 50 ms) during which a fixation cross was displayed in the centre of the screen. In the first stage of the PGNG, a prepotent response was acquired by requiring participants to press a button with their dominant index finger as soon as they detected any of the target letters X, Y or Z and to ignore all other letters. The second phase of the PGNG introduced an inhibitory component

(measured by the percentage correctly inhibited trials; PCIT) by asking the participants to only respond to the target letters if the previous target letter was not identical (i.e. respond to X following Y, but not X following X), ignoring any of the non-target letters that were presented in between. Here, only the target letters X and Y were presented, in addition to the non-target letters. The third PGNG stage measured response inhibition under higher task demands by using the same non-alternation rule as in stage two, but here all three target letters were presented.

The first stage consisted of 150 trials of which 40% required a Go response, in the second and third stage 180 trials were presented each, of which 40% were Go trials and 10% were No-go trials. Total task duration was 13 minutes; Stage 1 was completed within 3.8 minutes and the stages 2 and 3 within 4.5 minutes each. Between stages participants had time to read the instructions for the next PGNG stage. Additionally, the experimenter verified that task instructions were understood by use of paper and pencil explanations of exemplar trial sequences.

At each level, the presentation of the letter stimuli was pseudo-randomized, with the restriction that one to four lure letters were presented in between target letters. Additionally, all target letters were presented equally often per level, and on Go and No-go trials.

Participants were screened for aberrant responses and all participants performed within three standard deviations from the mean PCIT. Votruba and Langenecker (2013) defined two types of outlying performance, skipping and fading. Skipping performance relates to omitting Go responses in favour of increased No-go accuracy and being characterised by excessively poor Go accuracy and near perfect No-go accuracy in one of the higher difficulty levels (2 or 3). Fading performance is present in participants, who express a substantial decline at performance across time, being identified via increased response time

variability in level 3 but not level 2 of the PGNG. None of these types of aberrant performance patterns were present in the current dataset.

2.3 Psychopathy Assessment

Individual psychopathy levels were assessed using the PCL:SV (Hart et al., 1995). The PCL:SV contains 12 items relating to specific aspects of the psychopathy personality, which are assessed on a three point Likert scale (0 = clearly absent, 1 = possibly present, 2 = clearly present). The items of the PCL:SV can be factorized into four facets: Interpersonal (Items: Glibness/superficial charm, grandiose sense of self-worth, deceitful), affective (Items: Lack of remorse or guilt, callous/lack of empathy, not accepting responsibility for own actions), behavioural lifestyle (Items: Lack of realistic long-term goals, impulsivity, irresponsibility) and antisocial behaviour (Items: Poor behavioural control, adolescent antisociality, adult antisociality) according to Vitacco et al. (2005). The PCL:SV was rated, based on file review and collateral information from wing officers and treatment programme staff, by trained graduate or doctoral level raters whose individual reliabilities had been checked via the Darkstone programme of PCL-R training (intra-class correlation coefficient for the two raters total PCL-R was 0.88, $F(5, 5) = 47.40$, $p < 0.001$). The PCL:SV total scores in the current sample ranged from 2 to 22 ($M = 11.01$, $SD = 4.89$), the full range of scores, 0 to 6, was present for each individual PCL:SV facet: Interpersonal ($M = 1.81$, $SD = 1.66$), affective ($M = 2.86$, $SD = 1.64$), lifestyle ($M = 2.88$, $SD = 1.94$), and antisocial behaviour ($M = 3.44$, $SD = 1.82$). Internal consistency (Cronbach's alpha) in the current sample equalled 0.80 for the total score and ranged from 0.67 to 0.84 for the facet scores and is in the acceptable to good range.

2.4 Statistical Procedure

The dependent variables of the PGNG are response time and accuracy (percent target correct, 'PCTT') on Go trials assessed independently at each of the three parametric levels.

Additionally, the percentage correctly inhibited trials (PCIT) is measured at level 2 and 3 of the PGNG, where the presence of a No-go trial is defined by the alternation rule. Normality was assessed via visual inspection of histograms, which revealed a deviation from the normal distribution for PCTT only.

In an attempt to replicate previous findings on the influence of PGNG difficulty level, such as prolonged response times and a reduction in accuracy rates as cognitive load increases, two repeated-measures analyses of variances (ANOVA) were run using SPSS IBM version 22 on the dependent variables (response time and PCIT) with PGNG level as the within-subjects factor. For PCTT, the non-parametric alternative to a repeated measures ANOVA, the Friedman's test, was carried out. For the repeated measures ANOVAs, Greenhouse-Geisser corrected statistics are reported where violations of sphericity were found, and post-hoc paired *t*-tests of all frequentist analyses were corrected for multiple comparisons using Bonferroni correction.

In addition to the standard frequentist approach to data analysis, we conducted Bayesian analyses using the program JASP (Love et al., 2015) to support the conclusions drawn from the current data. In the Bayesian alternative to the repeated measures ANOVA, an assessment is made of the strength of support that the data provide for a hypothesis. Importantly, this approach is also capable of providing support for the absence of an effect. The resulting statistic, the Bayes factor (BF), indicates the strength of evidence in favour of the model, e.g. the effect that PGNG difficulty level affects the dependent variable. The strength of evidence is measured as a ratio (e.g. 4 to 1) in favour of the hypothesis over the null. A Bayes factor greater than three is interpreted as suitable criterion for evidence in support of a hypothesis (Wetzels and Wagenmakers, 2012). Applying Bayesian statistics requires the determination of a prior distribution relating to the magnitude of the effect, normally based on previous research. Since this is the first application of the PGNG to a

prison sample, conservative default values (Cauchy distribution) were used as priors to the analyses, as advocated by (Rouder et al., 2012).

To assess whether WASI FSIQ, age, duration of imprisonment , number of previous offenses, or years of education could potentially confound results, and therefore have to be included into the repeated measures analyses as covariates, bivariate Pearson Correlation Coefficients were carried out, the result of this analysis is shown in Table 1. None of the variables significantly correlated with PCIT and they were therefore not included as covariates in the main analyses.

Second, to assess the effect of psychopathy levels on response inhibition in the PGNG, four separate repeated measures ANOVAs were conducted on PCIT, with each containing one of the four PCL:SV facets as covariate to assess their influence on PCIT. Significant effects were then reanalysed using Bayesian linear regression on the appropriate variable (mean PCIT across levels for a main effect of the covariate and the difference between level 2 and level 3 for an interaction between PCL:SV facet scores and difficulty level). In addition to the effect sizes per analyses, 95 % confidence intervals (CIs) were computed using SPSS IBM version 22 for the parametric analyses and bootstrapping (N = 10000) as implemented in MATLAB version R2010b for nonparametric analyses.

3. Results

3.1 PGNG load dependent results

A summary of the effect of difficulty level on response time, Go accuracy and No-go accuracy rates is shown in Figure 1. The repeated measures ANOVA of response time for Go trials as the dependent variable indicated the expected main effect of difficulty level ($F(1.83,139.2) = 45.15$, $p < 0.0001$, $\eta^2_p = 0.37$, CI = 0.25 to 0.47), with response at level 3 being greater compared to both level 1 ($t(76) = 9.52$, $p < 0.0001$, $d = 1.53$, CI = 1.13 to 1.93) and level 2 ($t(76) = 7.10$, $p < 0.0001$, $d = 1.14$, CI = 0.78 to 1.51) as well as a significant

increase in response times from level 1 to level 2 ($t(76) = 2.80$, $p < 0.05$, $d = 0.45$, CI = 0.13 to 0.77). The Bayesian repeated measures ANOVA indicated that the model including the effect of difficulty level was strongly preferred over the null model (BF= $1.26*10^{13}$) and post-hoc Bayesian paired t-tests indicated that all levels differed from each other as indicated by the frequentist analysis (BF level 1 vs level 2: 4.67, BF level 1 vs level 3: $5.12*10^{11}$, BF level 2 vs level 3: $1.78*10^{7}$).

Analysing the effect of difficulty level on Go accuracy rates with the nonparametric Friedman's test revealed a significant main effect of level ($\chi 2(2, N = 77) = 18.49$, $p < 0.001$, Kendall's $W = 0.12$, CI = 0.05 to 0.23). Post-hoc Wilcoxon Signed Rank Tests indicated that this effect was driven by significantly decreased Go accuracy rates in both level 2 ($Z = -2.84$, $p < 0.05$, $r = -0.23$, CI = -0.36 to -0.08) and level 3 ($Z = -4.01$, $p < 0.001$, $r = -0.32$, CI = -0.36 to -0.08) when compared to level 1, whereas accuracy rates of level 2 and 3 were not significantly different from each other ($Z = 0.71$, *ns*). Repeating this analysis using the Bayesian repeated measures ANOVA indicated that the model including the repeated measures factor difficulty stage was preferred over the null model (BF: 8.32 to 1). Post-hoc Bayesian paired *t*-tests supported the outcome of the frequentist analysis, by indicating the evidence favours the hypothesis that level 2 leads to a reduction in performance compared to level 1 (BF = 3.52), and that performance at level 3 is poorer than at level 1 (BF = 39.69). Contrary to this there was evidence in favour for the null hypothesis for their being no different in performance between level 2 and level 3 (BF (null) = 6.06).

Analysing the effect of difficulty level on response inhibition, as measured by PCIT, using a repeated measures ANOVA indicated a significant main effect of level ($F(1,76) = 37.38$, $p < 0.0001$, $\eta^2_p = 0.33$, CI = 0.16 to 0.47) in the direction of a decrease in accuracy on No-go trials from level 2 ($M = 76.33$, $SD = 19.57$) to level 3 ($M = 65.01$, $SD = 18.99$). Mirroring this effect, the Bayesian repeated measures ANOVA on PCIT, indicated that the

model including the repeated-measures factor difficulty level was very strongly preferred over the null model (2.53×10^5).

3.2 No-go Accuracy and Psychopathy

To investigate the effect of the interpersonal PCL:SV facet (Facet 1) on PCIT, a repeated measures ANCOVA was conducted on PCIT entering Facet 1 as covariate. The analyses yielded a significant main effect of the interpersonal facet ($F(1,75) = 6.38$, $p < 0.05$, $\eta^2_p = 0.08$, CI = 0 to 0.21), while no significant interaction was found between the interpersonal facet and difficulty level ($F(1,75) = 0.003$, *ns*). The Bayesian linear regression similarly examined the relationship of mean PCIT and the interpersonal facet and there was predictive evidence for this facet on PCIT (BF = 3.51). Visual inspection of the resulting scatterplot (Figure 2) revealed a positive relationship between Facet 1 and response inhibition as measured by PCIT across difficulty levels.

Following the same approach as above, the affective facet (Facet 2) did not show a relationship with response inhibition ($F(1,75) = 1.38$, *ns*) nor was there a significant interaction between the affective facet and difficulty level ($F(1,75) = 0.06$, *ns*).

Relating the lifestyle facet (Facet 3) of the PCL:SV to response inhibition showed no main effect of Facet 3 ($F(1,75) = 0.62$, *ns*), but a significant interaction between Facet 3 and task difficulty ($F(1,75) = 5.15$, $p < 0.05$, $\eta^2_p = .06$, CI = 0 to 0.19). Since the Analyses of Covariance relate to differences between the two levels of the within-subject factor difficulty level, this effect indicates that scores on Facet 3 are relating to the change in performance between level 2 and level 3. As shown in Figure 3, Facet 3 significantly relates to an increased reduction in inhibitory performance (calculated via subtracting level 3 from level 2 PCIT) when changing from medium to high difficulty. Bayesian linear regression on this difference score between PCIT level 2 and level 3 similarly expressed some evidence for

Facet 3 predicting the change in inhibitory performance across difficulty levels (BF = 2.11), with high scores on the lifestyle facet being associated to worse response inhibition.

The antisocial behaviour facet (Facet 4), did not relate to response inhibition accuracy ($F(1,75) = 0.22$, *ns*) nor was there an interaction with difficulty level ($F(1,75) = 3.59$, *ns*).[1,2,3]

4. Discussion

In the current forensic sample, previous research on the basic PGNG variables has been replicated (e.g. Langenecker et al., 2005; Langenecker et al., 2007), such as an increased slowing of response times and a reduction in Go as well as No-go accuracy rates when cognitive load increased. Additionally, specific associations between the psychopathy facets as measured with the PCL:SV and response inhibition accuracy were found. In line with previous research relating the interpersonal aspects of psychopathy to more adaptive behaviours, such as enhanced decision-making and better verbal intelligence (Ishikawa et al., 2001; Vitacco et al., 2005), the current research revealed improved response inhibition for participants scoring high on the interpersonal aspects of psychopathy. Furthermore, psychopathic characteristics relating to impulsive lifestyle were associated with response inhibition deficits, mirroring the facets diagnostic criterion of impulsivity in behaviour (Hare, 2003). Furthermore, results were stable after correcting for age, intelligence levels, years of education as well as duration of imprisonment.

Whereas the majority of previous research using the standard Go/No-go task has not found reduced response inhibition functioning related to psychopathy in forensic or community samples (Kiehl et al., 2000; Verona et al., 2012; Kim and Jung, 2014), response inhibition deficits in the PGNG were related to increased scores on the Blame Externalization subscale of the PPI-R in a student sample (Weidacker et al., 2017) and to the lifestyle facet of the PCL:SV in the current forensic sample. Given that the PCL:SV lifestyle facet is determined by PCL:SV items relating to impulsivity in behaviour, a lack of long-term goals

as well as irresponsible behaviour (Hart et al., 1995), the here found positive relationship to response inhibition deficits is not surprising.

In contrast to previous results in subclinical psychopath groups (Weidacker et al., 2017), criminals scoring highly on the interpersonal characteristics of psychopathy expressed better response inhibition. The interpersonal aspects of psychopathy, consisting of grandiose sense of self-worth, superficial charm as well as deceitful behaviours, were previously found to be related to improved decision-making and higher verbal intelligence (Ishikawa et al., 2001; Vitacco et al., 2005). In line with research on successful psychopaths showing less risky decision making and better executive functions (Ishikawa et al., 2001; Zimak et al., 2014), it can be speculated that improved response inhibition enables psychopathic personalities to obtain short-term goals related to deceitful behaviour, a characteristic which seems to be more pronounced in forensic than subclinical samples since the previous investigation of the PGNG in students did not reveal improvements in response inhibition to be related to psychopathic traits (Weidacker et al., 2017). Whether this dissimilarity to previous research in subclinical samples relates to differences in the construct of psychopathy employed, PPI-R versus PCL:SV, is beyond the scope of this study and should be specifically tested in future studies by using the self-report versions of the PCL-R, such as the Self-report Psychopathy scale, which resembles the factor structure of the PCL-R more closely than the PPI-R (Williams et al., 2007; Malterer et al., 2010).

Interestingly, neither psychopathic traits measured by the affective facet nor those included in the antisocial behaviour facet of the PCL:SV had an effect on response inhibition performance. The affective PCL:SV facet relates to characteristics such as lack of remorse or guilt, callous/lack of empathy, and not accepting responsibility for own actions (Vitacco et al., 2005). Previous research on subclinical levels of psychopathic traits revealed PPI-R Blame Externalization to be related to reduced inhibitory performance in the PGNG

(Weidacker et al., 2017). In the PCL:SV, Blame Externalization is not measured as a separate factor, but instead forms part of the PCL:SV item measuring the failure to accept responsibility, which is a part of the PCL:SV affective facet (Vitacco et al., 2005). The outcomes of the current investigation indicate that despite its link to Blame Externalization, the affective facet does not relate to response inhibition deficits in a forensic sample. This may be because Blame Externalization is assessed as a separate subscale in the PPI-R allowing its negative affect on PGNG response inhibition to be more clearly observed. In the PCL:SV, its influence may be obscured by its inclusion into a subscale with two further psychopathic characteristics (items: lack of remorse or guilt, callous/lack of empathy, not accepting responsibility for own actions) in the affective facet of the PCL:SV.

The antisocial behaviour facet of the PCL:SV on the other hand relates to aspects that are theoretically in line with enhanced motor impulsivity, such as poor behavioural control, adolescent antisociality, and adult antisociality (Hart et al., 1995). However, individual levels of antisocial behaviour characteristics did not influence response inhibition in the PGNG. Previous research has linked the antisocial behaviour facet to more criminal versatility/activities (Williams et al., 2007) as well as to increased risk taking as measured by the Iowa Gambling Task (Mahmut et al., 2008). Increased disadvantageous risk taking in the Iowa Gambling Task has been regularly associated to enhanced impulsivity, especially in terms of UPPS-P Lack of Premeditation (Zermatten et al., 2005; Franken et al., 2008) and the BIS-11 Nonplanning and Motor Impulsiveness scales (Snowden and Gray, 2011). However, according to Sharma et al., (2013) the inter-correlations between behaviourally assessed motor impulsivity and self-reported impulsivity levels are relatively low. Further, research into Antisocial Personality Disorder (ASPD; American Psychiatric Association, 2013) revealed a response inhibition deficit in the standard Go/No-go task at only the trend level when comparing their behaviour to healthy controls (Dolan and Park, 2002). Importantly,

Dinn and Harris (2000) utilized a Go/no-go task identical to that of LaPierre et al. (1995), placing a high demand on the cognitive control processes, in ASPD participants scoring highly on the PCL:SV. Their results did not indicate a response inhibition deficit in participants expressing elevated levels of psychopathy and antisocial personality traits (Dinn and Harris, 2000). Based on previous findings of elevated impulsivity levels in participants scoring high on antisocial personality traits, it can be assumed that participants scoring highly on antisocial traits do express enhanced levels of impulsivity when measured via self-report. However, this increased impulsivity does not transfer to response inhibition as measured behaviourally, possibly due to self-reported impulsivity inventories tapping into different aspects of the multi-facetted construct of impulsivity than experimental response inhibition assessments do (Sharma et al., 2013).

Regarding possible limitations of the current study, sample size is an issue and could have influenced the results of the frequentist analyses. However, we additionally used Bayesian statistics, an analysis that is informative and valid even with small sample sizes (Andraszewicz et al., 2014) to increase confidence in the reported results. Another limitation is the distribution of the full scale intelligence scores, which is representative for UK prison populations (Copestake et al., 2013), but might not necessarily hold for Northern American prison populations, which have been found to be comparably lower (Cooke et al., 2001). Finally, the psychopathy scores were calculated based on file review, without an accompanying interview. When employing the PSL:SV this is a valuable strategy for research purposes (Hart et al., 1995), but might have influenced the resultant psychopathy scores. Future studies will seek to address these issues to confirm the findings of the current report.

The strength of the present task design is that in the PGNG, response inhibition is measured in conjunction of other major executive functions such as set-shifting and

continuous information update. Previous research factorising executive functions revealed that these executive functions, continuous information updating, set-shifting and response inhibition, operate in conjunction to optimise cognitive control, (Miyake et al., 2000; Friedman et al., 2008; Miyake and Friedman, 2012). By incorporating into the inhibition task the requirement to set-shift and update WM information, the capacity to trade-off one type of functioning against another related cognitive control function is reduced. This dependency of response inhibition on set-shifting and continuous information update as revealed by Miyake et al. (2000) is incorporated in the design of the PGNG, where an alternation rule is employed. The apparent discrepancy between previous null effects when investigating the effect of psychopathy on response inhibition in the standard Go/No-go task (Kiehl et al., 2000; Verona et al., 2012) and the uncovered relationships when utilising the PGNG (Weidacker et al., 2017) supports the view that this task is more likely to capture aberrant response inhibition. There is evidence that it is the dynamic parametric approach of the PGNG and associated increased difficulty, which reveals response inhibition deficits previously unseen when using the standard Go/No-go task (Langenecker et al., 2010; Ryan et al., 2012). In terms of psychopathy for example, LaPierre et al. (1995) reported a deficit in response inhibition performance in psychopathic offenders when utilizing a Go/No-go design, which incorporated a high demand on spatial attention by including a measure of uncertainty in the location of targets which appeared at pseudorandom locations. Similarly, Krakowski and colleagues (2015) found response inhibition deficits in psychopathic offenders when applying the second stage of the PGNG (Krakowski et al., 2015). Krakowski and colleagues (2015) reported deficient response inhibition in offenders scoring high on the PCL:SV, but the here reported increase in response inhibition was absent or potentially masked when relying on the total psychopathy score-which shows the importance of a multi-

dimensional approach, being capable of taking the factor structure of the PCL:SV and related measures into account.

In sum, research into the link between response inhibition and psychopathy regularly found no relationship when inhibitory ability was assessed in a simple context (Kiehl et al., 2000; Verona et al., 2012), but recent research suggests apparent deficits when testing response inhibition capabilities under increased cognitive load (LaPierre et al., 1995; Krakowski et al., 2015; Weidacker et al., 2017). The current investigation reveals that this deficit in response inhibition is solely linked to the lifestyle characteristics expressed by forensic psychopathic personalities and additionally uncovers improved response inhibition being related to interpersonal aspects of psychopathy. Taken together, psychopathic participants are having adequate response inhibition ability in the standard Go/No-go tasks, but express a deficit in response inhibition when the inter-related cognitive functions, such as set-shifting and continuous information update are taxed as well. As such, psychopathic participants scoring high on the lifestyle aspects of the PCL-SV seem to experience a specific response inhibition deficit when executive functioning load is high, which is unrelated to intelligence but tightly related to the lifestyle aspects of psychopathy. On the other hand, psychopaths being characterised by increased interpersonal characteristics generally express increased inhibitory ability under medium as well as high cognitive load, and therefore experience an advantage in terms of hiding their impulses. This might mean that they could be more efficient in misleading their victims. Whether or not this is, for example, the case in successful psychopaths should be addressed by future research.

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Footnotes

[1]The repeated measure ANOVAs regarding the influence of psychopathic traits as measured by the four facet on PGNG PCIT was repeated using age, WASI FSIQ, and education level as covariates. The inclusion of these covariates did not significantly affect the outcomes of analyses. The interpersonal facet still expressed a significant main effect on PCIT ($F(1,55) = 5.29$, $p < 0.05$), while not interacting with difficulty level ($F(1,55) = 0.39$, *ns*); The affective facet still did not express a significant main effect ($F(1,55) = 3.55$, *ns*) or interaction with difficulty level ($F(1,55) = 0.82$, *ns*); The lifestyle facet still interacted with difficulty stage ($F(1,55) = 5.42$, $p < 0.05$), while not expressing a significant main effect ($F(1,55) = 1.39$, *ns*); The antisocial facet, however, expressed a significant interaction with difficulty level ($F(1,55) = 4.13$, $p < 0.05$) after correcting for age, WASI FSIQ, and education level. The main effect was still not significant ($F(1,55) = 1.82$, *ns*). The interaction between the antisocial facet and difficulty level was due to lower PCIT scores when changing from level 2 to level 3 in the PGNG at high scores on the antisocial PCL:SV facet.

[2]An additional repeated measures ANCOVA was carried out to assess whether time spent in prison affects PCIT ($F(1,75) = 0.59$, *ns*). No significant main effect of PCIT was found for duration of imprisonment nor an interaction of duration of imprisonment with PGNG difficulty level ($F(1,75) = 0.01$, *ns*).

[3] A between-subjects repeated measures ANOVA using response inhibition in level 2 and 3 as within-subjects factor and violent vs. non-violent index crimes as a grouping variable revealed no main effect of violence of index crimes ($F(1,75) = 0.01$, *ns*) nor an interaction with PGNG difficulty level ($F(1,75) = 0.12$, *ns*). Similarly, investigating the effect of having a sexual offence as index crime in a between-group repeated measures ANOVA, did not reveal a main effect of the grouping variable ($F(1,75) = 0.67$, *ns*) nor an interaction with PGNG difficulty level ($F(1,75) = 2.12$, *ns*).

Table 1. *Pearson correlation coefficients and associated p-values for the relationships between PCIT per level and sample characteristics.*

	PCIT level 2	PCIT level 3	WASI FSIQ	Age	Months in Prison	Years of Education	E level 1	E level 2	E level 3	Number of previous offenses
PCIT level 3	**0.65 (< 0.001)**	-								
WASI FSIQ	0.10 (0.40)	0.18 (0.13)	-							
Age	-0.04 (0.72)	0.05 (0.68)	**0.35 (0.002)**	-						
Months in Prison	0.08 (0.47)	0.08 (0.51)	-0.10 (0.40)	**0.23 (0.04)**	-					
Years of Education	-0.05 (0.69)	0.04 (0.79)	**0.35 (0.006)**	**0.35 (0.006)**	0.05 (0.73)	-				
E level 1	**0.24 (0.03)**	0.20 (0.09)	0.01 (0.93)	**-.47 (< 0.001)**	**-0.27 (0.05)**	-0.08 (0.53)	-			

E level 2	**0.47**	0.20	-0.03	**-.46**	-0.07	-0.02	**0.64**	-		
	(< .001)	(0.08)	(0.83)	**(< 0.001)**	(0.52)	(0.91)	**(< 0.001)**			
E level 3	0.15	0.06	-0.05	**-.47**	-0.18	0.02	**0.78**	**0.75**	-	
	(0.18)	(0.59)	(0.68)	**(< 0.001)**	(0.11)	(0.85)	**(< 0.001)**	**(< 0.001)**		
Number of previous offenses	-0.03	-0.19	-0.32	-0.01	0.26	0.02	-0.10	0.05	-0.05	-
	(0.83)	(0.11)	**(.01)**	(0.91)	**(0.03)**	(0.91)	(0.41)	(0.64)	(0.65)	

Note. Significant correlation coefficients are shown in bold. The associated *p*-values are shown within brackets. PCIT = Percentage Correctly Inhibited Trials in the PGNG per difficulty level, WASI FSIQ = Wechsler Abbreviated Scale of Intelligence - Full Scale Intelligence Quotient, E= Efficiency ratio per PGNG level. The efficiency ratio of the PGNG is a measure that describes the balance between reaction time on Go trials and accuracy ((PCTT/RT)* 100).

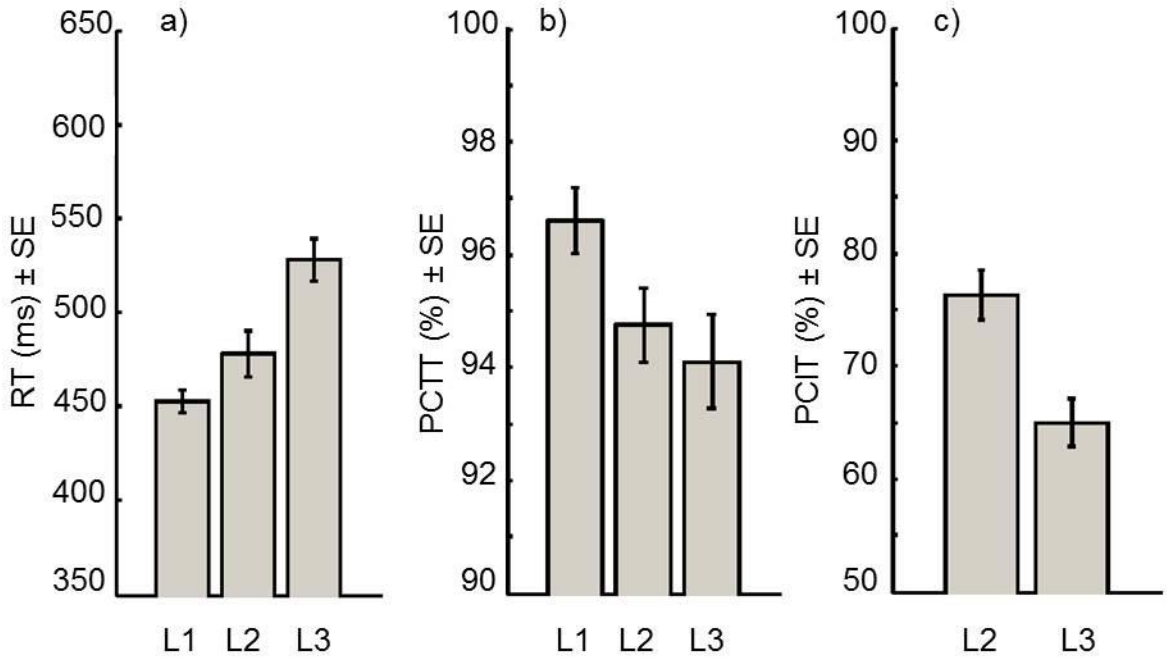

Figure 1. a): Bar graph of the means and standard errors of response times (RT) per difficulty level of the PGNG (L1 = level 1, L2 = level 2, L3 = level 3). b) Bar graph of the mean and standard errors of the percentage correct target trials (PCTT), the percentage correct responses to Go trials in the PGNG per difficulty level. c) Bar graph depicting the mean and standard errors of the percentage correctly inhibited trials (PCIT) in the PGNG per difficulty level. Only the levels 2 and 3 of the PGNG involve an inhibitory component.

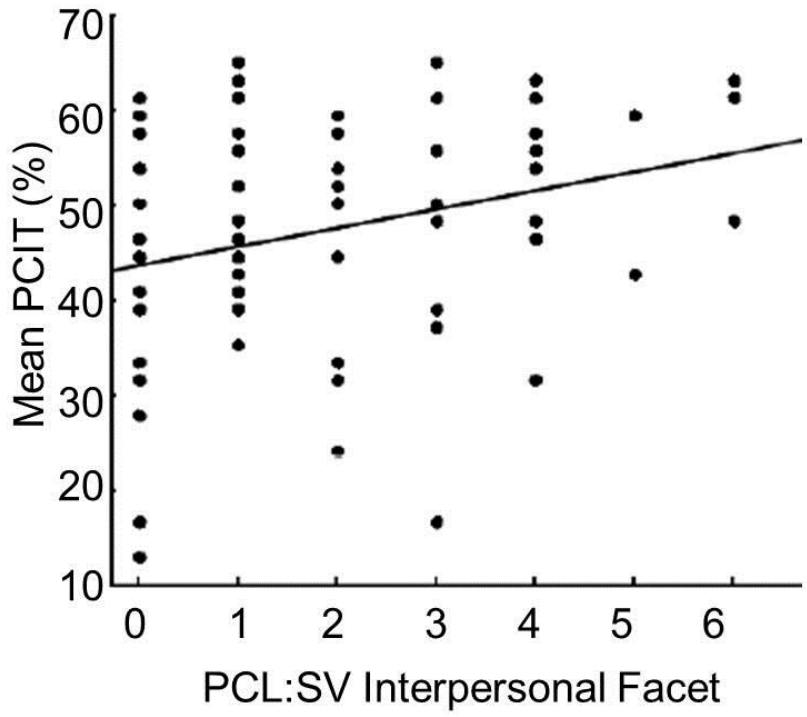

Figure 2. Scatterplot of the significant relationship between the interpersonal facet of the PCL:SV (Facet 1) and inhibitory accuracy, as measured by the mean percentage of correctly inhibited trials (PCIT) across levels 2 and 3. The line represents the least squares fit to the data.

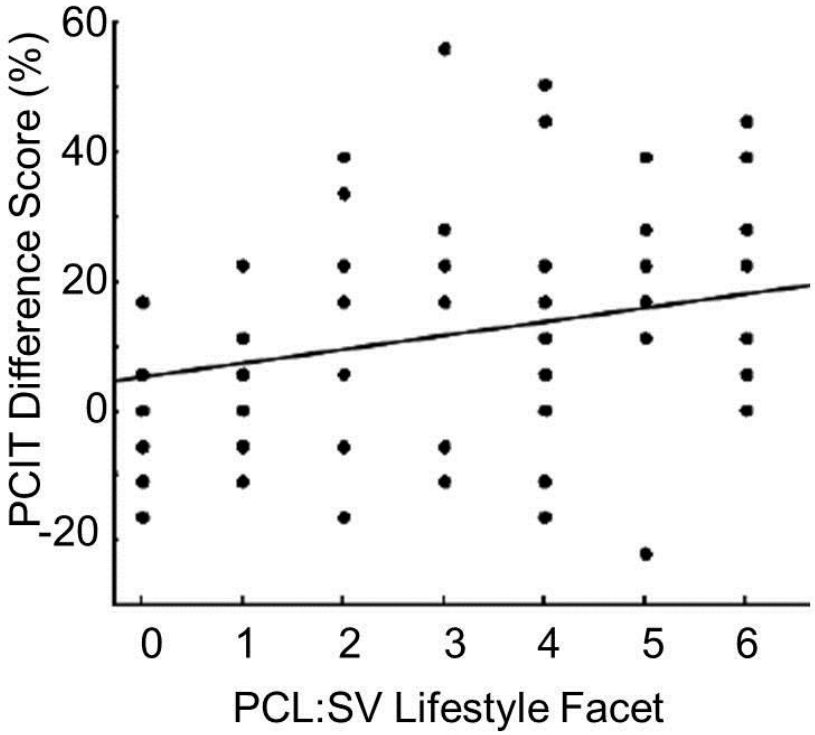

Figure 3. Scatterplot of the significant interaction between the lifestyle facet (Facet 3) of the PCL:SV and difficulty level on inhibitory accuracy, plotted as the decrease in performance from level 2 to level 3 (Difference score; calculated as level 2 minus level 3 percentage correctly inhibited trials). The line represents the least squares fit to the data.