Dear Author,

Please, note that changes made to the HTML content will be added to the article before publication, but are not reflected in this PDF.

Note also that this file should not be used for submitting corrections.

XML-IS

Our reference: PSY 8414 P-authorquery-vx

AUTHOR QUERY FORM

ELSEVIER	**Journal: PSY** **Article Number: 8414**	**Please e-mail or fax your responses and any corrections to:** **E-mail: corrections.essd@elsevier.macipd.com** **Fax: +44 1392 285878**

Dear Author,

Please check your proof carefully and mark all corrections at the appropriate place in the proof (e.g., by using on-screen annotation in the PDF file) or compile them in a separate list. Note: if you opt to annotate the file with software other than Adobe Reader then please also highlight the appropriate place in the PDF file. To ensure fast publication of your paper please return your corrections within 48 hours.

For correction or revision of any artwork, please consult http://www.elsevier.com/artworkinstructions.

Any queries or remarks that have arisen during the processing of your manuscript are listed below and highlighted by flags in the proof. Click on the Q link to go to the location in the proof.

Location in article	Query / Remark: click on the Q link to go Please insert your reply or correction at the corresponding line in the proof
Q1	Please confirm that given names and surnames have been identified correctly and are presented in the desired order.
Q2	Please check the hierarchy of the section headings.
Q3	Grant numbers for Grant sponsors "Welsh Office of Research and Development for Health and Social Care" and "Virtual Institute for the study of Severe Personality Disorder" are missing from the acknowledgement section. Please check
Q4	The country name has been inserted for the 'a' and 'b' affiliation. Please check, and correct if necessary.

Thank you for your assistance.

Please check this box or indicate your approval if you have no corrections to make to the PDF file ☐

Contents lists available at ScienceDirect

Psychiatry Research

journal homepage: www.elsevier.com/locate/psychres

Highlights

Executive function in psychopathy: The tower of London, Brixton spatial anticipation and the Hayling sentence completion tests

Ruth Bagshaw [a], Nicola S. Gray [b], Robert J. Snowden [c]

[a] Caswell Clinic, Abertawe Bro Morgannwg University NHS Trust, Bridgend CF31 4LN, UK
[b] Ty Catrin, Pastoral Healthcare, Cardiff and School of Medicine, Swansea University, UK
[c] School of Psychology, Cardiff University, Cardiff CF10 3AT, UK

- Psychopaths had small planning times on the Tower of London.
- Psychopaths had more rule breaking errors on the Brixton spatial anticipation test.
- Results are consistent with OFC, but not DLPFC, dysfunction in psychopathy.

http://dx.doi.org/10.1016/j.psychres.2014.07.031

Psychiatry Research ■ (■■■■) ■■■–■■■

Contents lists available at ScienceDirect

Psychiatry Research

journal homepage: www.elsevier.com/locate/psychres

Executive function in psychopathy: The tower of London, Brixton spatial anticipation and the Hayling sentence completion tests

Q1 Ruth Bagshaw[a], Nicola S. Gray[b], Robert J. Snowden[c,*]

[a] Caswell Clinic, Abertawe Bro Morgannwg University NHS Trust, Bridgend CF31 4LN, UK
Q4 [b] Ty Catrin, Pastoral Healthcare, Cardiff and School of Medicine, Swansea University, UK
[c] School of Psychology, Cardiff University, Cardiff CF10 3AT, UK

ARTICLE INFO

Article history:
Received 18 April 2013
Received in revised form
14 July 2014
Accepted 15 July 2014

Keywords:
Psychopathy
PCL-R
Executive function
Tower of London
Hayling test
Brixton test

ABSTRACT

Executive dysfunction in those high on traits of psychopathy has often been reported, with many disagreements as to the nature of the dysfunction. We aimed to see if tests of planning and rule acquisition/adherence would discriminate those high on psychopathic traits. A battery of executive function tests (Tower of London, Brixton Spatial Anticipation, and Hayling Sentence Completion Tasks) was given to 28 British male prisoners. Psychopathy was measured using the Psychopathy Checklist-Revised. High psychopathy was related to reduced planning in the Tower of London test and poor rule-adherence on the Brixton Test. Other tests of executive function were not related to psychopathy. The results appear supportive of the notion that function of the orbitofrontal cortex (OFC) is dysfunctional in psychopathy whilst that of the dorsolateral prefrontal cortex (DLPFC) is normal and suggest that impulsivity in those high on psychopathy traits impedes planning and rule following. We suggest the adapted Tower of London test and the Brixton Test could be useful objective measures of this type of impulsivity in offenders which could help identify key treatment goals.

Q2 1. Introduction

The notion that there may be neuropsychological deficits, and in particular deficits in executive functions related to the frontal lobes,[1] in those with antisocial and criminal traits has a long history (Harlow, 1848). The link between psychopathy and possible frontal lobe dysfunction arose from observations of similarities between individuals with acquired frontal lobe damage and those with psychopathy. This led to the coining of the terms 'pseudo-psychopathy' (Blumer and Benson, 1975) and 'acquired sociopathy' (Damasio et al., 1987) that describe personality and behaviour changes that follow injury to the frontal lobes, involving reduced inhibition of responses, mood instability and reduced social reciprocity.

Early findings from studies of executive function in psychopathy were equivocal, with some studies reporting a range of deficits amongst psychopaths in performance on common neuropsychological tests. A number of studies, however, reported no differences between psychopathic offenders and either normal individuals or people with other clinical conditions (see Brower and Price, 2001; Hare, 1984; Hart et al., 1990; Morgan and Lilienfeld, 2000).

The lack of consistent findings could be explained by two important variables that were not always carefully considered in previous research: (1) variance in the definitions of psychopathy, (2) poor sensitivity and/or specificity of the tests.

1.1. Variance in definition of psychopathy

The definition of antisocial behaviour has not been consistent across studies. Of importance is the distinction between antisocial personality disorder and that of psychopathy. Distinctions have been made at various levels between these groups (Hare and Neumann, 2008; Hart and Hare, 1996) and there may be reasons to suspect that there may be both similarities and differences in their underlying aetiologies and neurophysiological correlates. Thus, deficits found in people with antisocial personality disorder may, or may not, be found in people with psychopathy, and vice versa.

It has been suggested that there are subfactors to the overall concept of psychopathy. The Psychopathy Checklist Revised (PCL-R: Hare, 2003) is a well validated measure of psychopathy that is often used in both research and clinical/forensic settings. Studies of the PCL-R reveal a factor structure showing that two moderately correlated factors define psychopathy. Factor 1 describes affective and interpersonal deficits such as lack of empathy, pathological

* Corresponding author.
E-mail address: snowden@cardiff.ac.uk (R.J. Snowden).

[1] The terms "executive function" and "frontal lobe function" have become nearly synonymous (see Alvarez and Emory, 2006).

http://dx.doi.org/10.1016/j.psychres.2014.07.031
0165-1781/

lying, lack of remorse, and manipulativeness. Factor 2 describes behavioural and lifestyle deficits such as impulsivity, criminality, and poor behavioural controls. Many previous studies have shown that these two factors can have quite different relationships to outcome measures (see Snowden and Gray, 2010; Vanman et al., 2003). Hence, there may be different patterns of executive function impairment associated with the two factors of psychopathy and studies should examine which aspects of psychopathy are related to any posited executive function impairments.

1.2. Sensitivity and specificity of selected tests

Many commonly used tests of executive function are designed to be used with people with marked clinical problems such as dementia or traumatic brain injury. They are, therefore, designed to measure quite profound loss of function and may not have the sensitivity to detect more subtle, lifelong deficits that might be more characteristic of people with psychopathy.

There has been much debate as to whether many tests of executive function are merely tests of intelligence, especially fluid intelligence (de Frias et al., 2006; Rabbitt and Lowe, 2000). The relationship between intelligence and psychopathy was originally thought to be negligible (Hare, 2003; Walsh et al., 2004). However, more recent studies have shown that different sub-facets of psychopathy may well have relationships with measured IQ. For example, Vitacco et al. (2008) show that the components of psychopathy related to an impulsive lifestyle and to antisocial behaviours are inversely related to IQ score, whilst those related to interpersonal style are positively related (see also Copestake et al., 2013). Hence, some of the "executive function" deficits described in previous studies may reflect differences in intelligence as many studies did not provide an independent measure of intelligence. Therefore, we also took measures of IQ in order to see if any executive function impairments found could be accounted for by general intelligence.

Many of the early tests of executive function in psychopaths used general test batteries. Most tests of executive function involve multiple areas of the frontal lobes and associated neural pathways. Lapierre et al., (1995) administered a relatively large battery of well-established neuropsychological tests to prison inmates. They found significant differences, and large effect sizes, between psychopathic and non-psychopathic inmates on commission errors for the Go/NoGo task (i.e., responding when they were meant to withhold the response) and for the qualitative score on the Porteus Maze Test (i.e., breaking the rules of the maze, such as going over the 'walls' of the maze) but not for several other neuropsychological tests (for instance, the Wisconsin Card Sort Test). They suggest that the tasks that tap into poor impulse control are affected in those with psychopathic traits and relate this to possible orbitofrontal and/or ventromedial areas of the frontal cortex. Others have also provided support for the notion that tasks that are sensitive to dysfunction in orbitofrontal cortex are often affected in those with psychopathic traits. (Blair et al., 2006; Gao et al., 2009; Mitchell et al., 2002; Yang and Raine, 2009), and this has been extended to community samples using psychometrically defined traits of psychopathy (Snowden et al., 2013)

Impulsivity is a cardinal feature of psychopathy, reflected in several items on the PCL-R, for example, Item 10, Poor Behavioural Controls, and Item 14 Impulsivity as well as other items describing aspects of lifestyle impulsivity (see, for example, Hart and Dempster, 1997). However, not all psychopaths self-report that they are impulsive (Snowden and Gray, 2011), and many of their crimes appear instrumental and planned (Woodworth and Porter, 2002). Clearly, a better understanding of the nature of impulsivity and its possible dysfunction in psychopathy is needed. Current, however, it appears that tests that are more specific to functions such as planning, impulsivity and rule-breaking are likely to be affected in psychopathy, whilst other executive functions (such as working memory and response interference) are not affected.

1.3. Aims of the study

Researchers and clinicians need tests that are sensitive indices of the specific impairments associated with psychopathy. Level of risk, and understanding the factors associated with risk, including neuropsychological function, are of particular interest in the assessment, treatment and management of people with psychopathy. Further elaboration of the pattern of deficits associated with psychopathy in closed testing conditions may support the identification of more individualised treatment targets, management strategies and outcome measurement. Given the limited range of neuropsychological tasks that have so far been studied in psychopathic offenders, we decided to test a battery of neuropsychological tasks commonly used in clinical settings but not previously or extensively reported in studies of psychopathy.

We identified three tasks that we thought might be suitable proxy measures for impulsivity, namely: planning impulsivity (Tower of London Test), inhibition of a prepotent response (Hayling Test), and adherence to rules (Brixton Test). We hypothesised that those high on traits of psychopathy would perform worse on these tests but would not show impairments on tests associated with more general aspects of executive function.

1.4. Adapted tower of London test

The Tower of London Test was designed to measure deficits in planning associated with frontal lobe lesions (Shallice, 1982). In the adapted version of the Tower of London (Andres and Van der Linden, 2001) the task additionally contains a "misleading condition". In this misleading condition, moving the first bead into the apparently correct final position is an erroneous strategy that effectively blocks the correct solution to the problem, requiring the respondent to back track to the original start position, therefore leading to increased errors on the task. In addition, a facilitative condition allows the first bead to be correctly placed in its final position requiring the participant to plan ahead in order to discriminate between these two conditions and achieve the optimal solution. A proneness to respond impulsively to the misleading conditions on the first move would be expected to increase the number of moves taken to solve the problem in the misleading trials. Problems in considering consequences and acting impulsively are traits associated with psychopathy (Hare, 2003) that may reflect deficits in evaluating the value of choices and inhibiting inclinations to immediate reward. These individuals would not plan sufficiently in the Tower of London Test and would be likely to succumb to the immediate option of moving a bead directly to its final position regardless of whether this was likely to be a correct or misleading option. This should be manifest in shorter planning times, and in a greater number of moves in the misleading trials.

There has only been one previous attempt to examine the performance of psychopathic individuals on the adapted Tower of London Test. Pham et al. (2003) found that psychopathic individuals did not differ from non-psychopathic individuals on planning time, nor did they differ on the facilitative trials. However, they note that psychopathic individuals took longer to complete the problem and made more errors on the misleading trials.

Please cite this article as: Bagshaw, R., et al., Executive function in psychopathy: The tower of London, Brixton spatial anticipation and the Hayling sentence completion tests. Psychiatry Research (2014), http://dx.doi.org/10.1016/j.psychres.2014.07.031

1.5. The Brixton spatial anticipation test

The Brixton Spatial Anticipation Test (Burgess and Shallice, 1996) is a visual analogue of the Wisconsin Card Sort Test (WCST) that relies on inductive reasoning. It contains both the components of acquiring the new rule each time the rule changes (and hence not perseverating on the old rule), and also maintaining the rule once acquired (rule adherence).

It has been suggested that impulsivity leading to excessively rapid responding could be responsible, in some patients, for the higher number of rule adherence errors (Burgess and Shallice, 1996; Miller and Milner, 1985). Such rule adherence errors had been observed in a small scale, unpublished service evaluation by one of the authors that showed that individuals with impulse control disorders commonly produced rule adherence errors and often verbalised a strategy of trying to 'beat the system' by changing their response before the rule changes. This behaviour appears analogous to the reward discounting behaviour of psychopathic individuals on the Iowa Gambling task which is mediated by the OFC (van Honk et al., 2002). We predicted that there will be positive correlation between rule adherence errors and PCL-R score but that there would be no impairment in learning the rule in the first instance and no deficits in persevertive responding. At present there has been no previous investigation into the relationship between the Brixton test and psychopathy.

1.6. The Hayling sentence completion test

The Hayling test (Burgess and Shallice, 1996) requires the participant to complete sentences with a semantically sensible word (Part A), or with a semantically nonsensical word (Part B). The Hayling test is believed to rest on the ability to inhibit a prepotent response. We predicted that those high in psychopathy would not be able to inhibit this prepotent response and would show a greater number of errors on this task showing deficits of disinhibition. Whilst this test has been examined in several populations, such as those with mood disorders (Frangou et al., 2005), suicidal behaviour (Raust et al., 2007), brain injured patients (Odhuba et al., 2005), and patients with Alzheimer's disease (Belleville et al., 2006), to name but a few, we could find no record of it being administered to those with psychopathy.

2. Method

2.1. Participants

Participants were 29 male prisoners aged between 25 and 54 years and recently admitted to the assessment wing of HMP Grendon in the UK. They had an average of 34 convictions (range 3 to 138) which extended from prolific burglary, to sexual offences and homicide. One participant was withdrawn due to the presence of a seizure disorder for which he required medication. All participants reported themselves as drug free and had undertaken drug screening tests within the six weeks prior to inclusion in the study. All drug screening tests were negative. Twenty eight participants were included in the data analysis, and their details are described in Table 1. An index offence is the offence(s) for which the inmate is currently serving a prison sentence. Thirteen participants had index offences involving serious violence, including homicide, assault and robbery. Seven participants had index offences involving serious sexual assaults against adults including rape. Four participants had index offences involving sexual assaults against children.

One participant was not able to complete the full assessment battery due to the session over-running and all prisoners on the wing returning to their cells for a period known as 'lock down'. This participant did not complete the adapted Tower of London Test. Thus, 27 data sets were used in the analysis of the adapted Tower of London Test and 28 data sets were included in all other analyses.

Table 1
Participant characteristics.

Characteristic	Mean	S.D.	Range
Age (years)	35.14	6.86	25–54
PCL-R total score (0–40)	23.42	9.73	5–39
Factor 1 (0–16)	9.14	4.30	2–16
Factor 2 (0–18)	11.10	5.06	0–18
Full scale IQ	90.5	16.56	65–119
Verbal IQ	84.86	17.37	55–119
Performance IQ	98.04	16.42	72–129
Total adult convictions	34.64	28.98	3–138

HMP Grendon provides a therapeutic community approach for offenders with personality disorders who have committed serious crimes (see Hobson and Shine, 1998). One of the criteria for admission to the community is that the inmate must not be taking any psychotropic medication, and that they are free from drug-related problems. All inmates are regularly tested for drug use and any that are found to fail such tests are removed from the treatment programme. Thus although our sample size was modest (though in keeping with similar studies of this nature – e.g. (Lapierre et al., 1995; Mitchell et al., 2002; Pham et al., 2003) we had the advantage of studying a population that had a wide range of PCL-R scores and was relatively unaffected by the influence of current medication or illegal drugs on executive function.

2.2. Ethics

Ethical approval was obtained from both HMP Grendon's Research Assessment Group and Cardiff University Ethics Committee. All participants were judged by the Responsible Clinician of the prison to be suitable to be approached and invited to participate and able to give informed consent. None of the staff of the prison were directly involved in the study and assessments were not observed by any prison staff. All participants gave written informed consent to participate in the study.

2.3. Materials

2.3.1. Psychopathy checklist-revised (PCL-R)

Psychopathy was measured using the PCL-R (Hare, 2003) The PCL-R contains 20 items that are rated by a clinician after a full file review and interview with the patient. Total scores range from 0 to 40. A large body of evidence suggests that the PCL-R consists of 2 factors relating to Interpersonal and Affective components (Factor 1) and Lifestyle and Antisocial components (Factor 2).

PCL-Rs were completed by one of two individual raters. The rates were trained and supervised on the PCL-R by NSG, an experienced trainer of the PCL-R. From this larger sample we obtained PCL-R ratings from two independent raters for a subsample of 17 offenders. Interclass correlations were very high (R_{total}=0.98; $R_{Factor1}$= 0.98; $R_{Factor2}$=0.97). The 28 participants for whom we collected neuropsychological data were part of a larger research sample.

2.3.2. Wechsler abbreviated scale for intelligence (WASI)

The WASI (Wechsler, 1999) was used to measure general intellectual ability. The four subtest version was used in this study, comprising tests of vocabulary, abstract verbal reasoning (Similarities test), visuospatial/ constructional skills (Block Design test)

Please cite this article as: Bagshaw, R., et al., Executive function in psychopathy: The tower of London, Brixton spatial anticipation and the Hayling sentence completion tests. Psychiatry Research (2014), http://dx.doi.org/10.1016/j.psychres.2014.07.031

and abstract non verbal reasoning (Matrix Reasoning test). The four subtest version allows the calculation of Verbal, Performance and Full Scale IQ.

2.3.3. Adapted tower of London test

The version of the Tower of London Test we used is based on Shallice (1982) and uses three beads and three unequally sized posts that can support one, two or three beads, respectively. The beads are placed in a starting configuration and the respondent has to move the beads one at a time to produce a target configuration whilst maintaining rules about only moving one bead at a time and only onto a post that has a space available. In this study we tested four levels of task difficulty: 3, 4, 5 and 6-move conditions. We also included the facilitative and the misleading conditions of Andres and Van der Linden (2001).

The adapted Tower of London provides three measures; (1) Planning time - the time from presentation of the item to the first move being initiated; (2) Errors - the number of moves in excess of the minimum possible to achieve the solution, and; (3) Action time - the time taken to complete the task once the first move is initiated. In the present study we were only interested in the Planning Time for most of the conditions, but also for the number of moves in the misleading condition.

2.3.4. The Brixton spatial anticipation test

The Brixton test (Burgess and Shallice, 1997) involves detecting a series of abstract rules that predict the location of a target circle in an array of ten circles across 50 trials. The rule governing where the target circle appears next changes unpredictably. Respondents have to detect and apply the new rule until it changes again.

We operationalised two types of errors on the Brixton test. Rule detection errors were counted as those errors following a rule change. Rule adherence errors were counted as errors that followed two or more consecutive correct responses where the rule had not changed.

2.3.5. The Hayling sentence completion test

The Hayling test (Burgess and Shallice, 1997) requires the participant to complete sentences with a semantically sensible word (Part A), or with a semantically nonsensical word (Part B). Hence, in part B the participant has to withhold a prepotent response and generate a new response. The dependent measures are the time taken to initiate a response in Parts A and B and the number of errors made. The number of errors are used to produce a scaled score (from 10–1) where the fewest errors are given the largest score.

2.4. Procedure

Participants undertook a single testing session with the first author during which the neuropsychological test battery was administered. The information sheet that had been provided at the time of recruitment was re-presented prior to the commencement of testing and any questions were answered. Prison officers were able to observe the testing session from outside the room and participants were able to terminate or pause the session if they wished to.

The test battery was administered in a specified order (WASI, Hayling, Brixton, and Tower of London), with an attempt to alternate verbal and visuospatial tasks. Participants were offered a break at the half way point to counter any effects of fatigue. Some other neuropsychological tests were also administered but are not presented here.

2.5. Statistical analysis

There is now good evidence that psychopathy as defined by the PCL-R should be regarded as a dimension rather than a taxon (Edens et al., 2006; Walters et al., 2007). Hence, we did not group our participants into psychopathic versus non-psychopathic for the main analyses but chose to use a correlational analysis that preserves the dimensional nature of the psychopathy construct (see MacCallum et al., 2002).

All variables were inspected for the assumptions of a normal distribution. Data from the PCL-R, the Tower of London, and the Brixton test were deemed not to violate the assumptions of normality. However, the data from the Hayling Test showed a strong positive skew for the RT data and a distinct bimodal distribution (that reflected an overabundance of both minimum and maximum scores). These were not eliminated by data transformations. Hence, analyses that involved data from the Hayling test used non-parametric statistics (i.e., Spearman's rank correlation). Correlations were compared by the techniques described by Steiger (1980).

3. Results

3.1. Psychopathy and IQ

The descriptive statistics for psychopathy and IQ scores are shown in Table 1. Psychopathy was not significantly related to IQ ($r = -0.04$; ns). This finding is consistent with other studies (Vitacco et al., 2005) that have found no association between psychopathy and intelligence. Further examination of all relationships between IQ (Total, Verbal and Performance) and PCL-R (Total, Factor 1, and Factor 2) all showed small correlations

Table 2
Mean or median planning time (s) on the tower of London, and correlation with PCL-R total score. $N=27$.

Tower of London	Mean (S.D.) or median (quartile range)	PCL-R total	Factor 1 *[unique variance]*	Factor 2 *[unique variance]*
3 Move	3.96 (2.11)	−0.32*	−0.29 (−0.17)	−0.30 (−0.17)
4 Move	3.73 (2.97)	−0.53**	−0.57** (−0.48**)	−0.35* (−0.07)
5 Move	3.86 (2.56)	−0.46**	−0.58** (−0.54**)	−0.25 (−0.09)
6 Move	5.24 (4.58)	−0.54 **	−0.63** (−0.58**)	−0.32 (−0.02)
Brixton rule Detection	13.61 (4.89)	−0.39*	−0.33 (−0.14)	−0.39* (−0.26)
Brixton rule Adherence	5.50 (2.64)	0.39*	0.33* (0.16)	0.35* (0.21)
Hayling part A (s)	6.0 (5–10)	0.02	0.02	0.02
Hayling part B (s)	8.5 (6–28)	−0.10	−0.12	−0.09
Hayling part B (Errors scaled score)	6.0 (1.25–7.0)	−0.18	−0.09	−0.32

Note:
* $p < 0.05$.
** $p < 0.01$.

Please cite this article as: Bagshaw, R., et al., Executive function in psychopathy: The tower of London, Brixton spatial anticipation and the Hayling sentence completion tests. Psychiatry Research (2014), http://dx.doi.org/10.1016/j.psychres.2014.07.031

($rs < |0.10|$) and none were significant. Nevertheless, we also (where possible) repeated the analysis while partialling out the effects of IQ in order to rule out any separate association between IQ and performance on the tests of executive function.

3.2. Tower of London and psychopathy

Table 2 shows the correlations between the TOL scores and levels of psychopathy. It is noticeable that all the correlations relating to PCL-R and planning time were negative and many were significant and of a "large" effect size (Cohen, 1992). We repeated this analysis while partialling out the effects of IQ. The results changed very little.[2]

We had also hypothesised that a failure to plan would lead to a greater number of moves in the misleading 5-move condition. PCL-R scores correlated significantly with number of moves in the misleading condition ($r=0.45$, $p < 0.05$), further, as expected, number of moves was not related to psychopathy in the facilitating condition ($r=-0.04$, *ns*).

Given the strong effect of PCL-R score on the planning time we attempted to examine which aspects of psychopathy were associated with this reduced planning time An examination of each of the factors of psychopathy showed that both Factor 1 and Factor 2 appeared to be negatively related to planning time, with some hint that Factor 1 showed slightly greater effects. For the 5-move problem the correlations differed significantly ($p < 0.05$). We also examined the unique variance accounted for by each factor and these are shown in italics. The relationship between Factor 1 and poor planning time remained, but was much reduced for Factor 2. The correlations differed for the 4, 5 and 6 move problems ($ps < 0.05$).

3.3. Brixton spatial anticipation test and psychopathy

The results of this test are presented in Table 2. Overall performance was in the "moderate average" range as defined by the manual. As hypothesised, total PCL-R score was positively related to the number of rule adherence errors, producing a "moderate" effect size (Cohen, 1992). Though not hypothesised, there was a significant negative relationship between PCL-R score and the number of rule detection errors, which means those with a high PCL-R score acquired the change of rule of how the counter moved faster than those with low scores.

Examination at the level of the factors of the PCL-R did not reveal any specific pattern. Both Factor 1 and Factor 2 were positively correlated with the Rule Adherence errors with similar effect sizes. Both Factor 1 and Factor 2 were negatively correlated with the rule detection errors with similar effect sizes.

3.4. Hayling sentence completion test and psychopathy

The results of this test are presented in Table 2. Performance on Parts A and B was in the "average" range, while errors on Part B was in the "low average" range as defined by the manual. No results relating performance to psychopathy achieved a satisfactory level of statistical significance. However, we do note that Factor 2 appears to have a moderate negative correlation that approached significance ($p=0.051$) with the number of errors scaled score (suggesting that those with high Factor 2 scores had difficulty in withholding the prepotent response).

[2] Results of these supplementary analyses are not shown but are available from the corresponding author.

4. Discussion

In this sample of male prisoners we were able to show substantial dysfunction in planning on the adapted Tower of London test as a function of psychopathy total score. Those with a high psychopathy score appear to spend little time planning how to complete the problem, especially as the problem gets more difficult. This 'impulsive' behaviour in turn also led to a greater number of errors in completing the task under conditions where there appears to be an obvious first move but this move is actually disadvantageous. For the Brixton Spatial Anticipation task, we found that psychopathy did not lead to any impairment in acquiring the rules but that it was associated with later rule breaking after the rule was acquired. No significant results emerged from the Hayling test.

4.1. Tower of London and psychopathy

Our results using the Tower of London test are not in agreement with those of Pham et al. (2003). They were unable to demonstrate any changes in planning time on a 5-move version of this task in those high on psychopathy, but did note that the psychopathic group made more errors when exposed to the misleading condition– a result that we also found. The reasons for the differences between the studies is unclear, though we note that Pham et al. report possible confounds, such as the control group having a higher IQ score than the psychopathic group, and the psychopathic group had more drug use than the controls. Both of these confounding factors may have served to slow their psychopathic groups' planning and thus reduce any sign of the impulsive behaviour we demonstrate here. Clearly further studies are needed to resolve this issue.

Several aspects of frontal lobe function have been implicated in the Tower of London task (Carlin et al., 2000; Unterrainer et al., 2004; Wagner et al., 2006) as well as other cortical areas. Principal amongst these areas is the dorsolateral prefrontal cortex (DLPC), and, therefore, if psychopathy is associated with dysfunction in this area, we might expect deficits in the Tower of London Test. In past research using the Tower of London Test, damage to the frontal regions has been associated with longer planning times (Carlin et al., 2000). However, our results indicate smaller planning times not larger ones. Hence, one could interpret this faster planning time as indicative of either a different type of executive function deficit, or even as evidence of an executive function strength! The latter hypothesis seems unlikely to be the correct interpretation as decreased planning time in psychopathic individuals appears to be accompanied by an increase in the number of errors and a failure to modify this behaviour in light of negative consequences. Instead, our findings suggest that the psychopathic individuals acted in an 'impulsive' manner, commencing the problem without formulating a plan of how to solve the task or discriminating between two conditions affecting placement of the first bead. Lack of planning and behavioural impulsivity are specific items on the PCL-R. However, these items load on Factor 2 and our results show a stronger association with Factor 1. A possible explanation of this could be the crucial role of interpersonal and affective deficits in psychopathy that may be implicated in deficient response modulation (Newman et al., 1987). This theory suggests that impulsive behaviour reflects difficulties in the automatic switching of attention which then interferes with the ability to assimilate unattended events and potentially relevant information while engaged in the organisation and implementation of goal directed behaviour. It is thought to be an attentional deficit that reduces behavioural inhibition once behavioural activation is occurring (see Hart and Dempster, 1997). Our results may offer support for the model of deficient response modulation in

Please cite this article as: Bagshaw, R., et al., Executive function in psychopathy: The tower of London, Brixton spatial anticipation and the Hayling sentence completion tests. Psychiatry Research (2014), http://dx.doi.org/10.1016/j.psychres.2014.07.031

psychopathy (Newman et al., 1987; Wallace et al., 1999; Lorenz and Newman, 2002). Planning time on the Tower of London Test and the number of moves for the misleading condition, may therefore prove to be a useful neuropsychological indicator of the executive functions underpinning deficient response modulation in those high on traits of psychopathy.

4.2. Brixton spatial anticipation test and psychopathy

Psychopathic individuals appear to have no problems in learning the rule that governs the movement of the circle or switching when this rule changes. Indeed, those with higher psychopathy scores appears to be able to switch rules better as they made fewer errors on this part of the task. This is consistent with the many reports of intact performance for psychopathic offenders on similar tasks that require rule learning and switching to new rules, such as the Wisconsin Card Sort Test (Ishikawa et al., 2001; Lapierre et al., 1995) and is thought to be indicative of intact function in the DLPFC (Milner, 1963; Monchi et al., 2001). On the other hand, we found that psychopathy was associated with an increase in rule adherence errors (breaking an already acquired rule before it has changed). While such errors could be due to factors such as poor working memory, there is no evidence from other paradigms of such memory deficits in psychopathy (Hansen et al., 2007; Sreenivasan et al., 2008). Instead, it appears that these rule adherence errors are evidence of faulty judgement of the value of the choice and impaired inhibitory control of inclinations to take an immediate reward whereby the person attempts to pre-empt the possible change of rule and fails to modify their behaviour in light of negative consequences. Several participants in this present study verbalised a strategy of trying to anticipate the next rule change and 'beat the system'. Such rule-breaking behaviour in psychopathic individuals has also been observed on the Porteus-maze task (Lapierre et al., 1995; Pham et al., 2003; Roussy and Toupin, 2000), and appears similar to the risky decision making of psychopathic individuals on the Iowa Gambling task (Losel and Schmucker, 2004; Mitchell et al., 2002; van Honk et al., 2002) where they appear to continue to choose from the losing packs of cards despite their knowledge that this is a poor strategy overall. Both these types of qualitative errors on the Porteus Maze and risky decision making on the Iowa Gambling task are thought to be indicators of orbitofrontal cortex (OFC) dysfunction, and we speculate that rule adherence errors on the Brixton Test may also be indicative of this. However, to date there have been no neuropsychological or neuroimaging studies that can confirm or refute this hypothesis.

Interestingly, the association between rule adherence and the PCL-R did not show the same Factor 1 association as the Tower of London test. We think this may be because the task provides a less immediately primed impulsive response opportunity and is a less complex task overall. The Deficient Response Modulation model would suggest that in such a case the attentional load would be lower, therefore the reduction in behavioural inhibition would be lower and therefore, the mediating role of affective traits in psychopathy would be less marked.

4.3. Limitations

Given the specialised nature of the population under study, the size of our sample was only modest (though in keeping with similar studies of this nature – e.g., Lapierre et al., 1995; Mitchell et al., 2002; Pham et al., 2003). Nevertheless, due to the large effect sizes manifest on the adapted Tower of London Test and Brixton Spatial Anticipation Test, we were able to demonstrate highly significant results and therefore the issue of sample size is not a concern for these tests. However, our small sample size may have led to Type II errors. We note that for the Hayling test the correlation with PCL-R Factor 2 score was of a moderate size (Cohen, 1992) but was not significant. Clearly, if these correlations were to be replicated with a larger sample size they would reach statistical significance.

Our sample only consisted of incarcerated males. In previous research successful psychopathic individuals appear to show some differences in autonomic nervous system function as compared to unsuccessful (i.e. convicted and incarcerated) psychopathic individuals (Ishikawa et al., 2001). There also appears to be some difference in neuropsychological function between male and female psychopaths (Vitale and Newman, 2001). Hence, it would be of interest to assess whether the findings in the present population generalise to these other groups.

The populations that are normally studied in order to understand psychopathy are often associated with substance use problems, and this raises the question of the extent to which any findings might be a result of, or associated with, substance abuse as opposed to psychopathy per se. One advantage of the current sample is that they were maintained in a drug and alcohol-free state and were free of any psychotropic medication (according to the strict rules of the institution). However, this may not remedy any long term effects of previous substance misuse (Bolla et al., 2003). We further note substance-use problems have been shown to have significant effects on rule detection errors on the Brixton Test (Reay et al., 2006), results that were not present as a function of psychopathy in the present study. Hence, we believe we can rule out any current or recent use of substances as a contributory factor to the present findings.

5. Conclusion

We have demonstrated that amongst this group of incarcerated offenders with histories of violent or prolific offending, psychopathy is associated with: poor planning on a complex task (Tower of London), and the inability to adhere to a rule (Brixton Test). The Adapted Tower of London Test and the Brixton Test may be useful additions to the clinical and research armoury of neuropsychological tests for assessing psychopathy-related deficits. Q3

Acknowledgement

Thanks to the staff and inmates at HMP Grendon for their assistance. This work was supported by grant from the Welsh Office of Research and Development for Health and Social Care and the Virtual Institute for the study of Severe Personality Disorder.

References

Alvarez, J.A., Emory, E., 2006. Executive function and the frontal lobes: a meta-analytic review. Neuropsychology Review 16, 17–42.

Andres, P., Van der Linden, M., 2001. Supervisory attentional system in patients with focal frontal lesions. Journal of Clinical and Experimental Neuropsychology 23, 225–239.

Belleville, S., Rouleau, N., Van der Linden, M., 2006. Use of the Hayling task to measure inhibition of prepotent responses in normal aging and Alzheimer's disease. Brain and Cognition 62, 113–119.

Blumer, D., Benson, D.F., 1975. Personality changes with frontal and temporal lesions. In: Benson, D.F., Blumer, D. (Eds.), Psychiatric Aspects of Neurologic Disease. Grune and Stratton, New York, pp. 155–157 (pp).

Blair, K.S., Newman, C., Mitchell, D.G.V., Richell, R.A., Leonard, A., Morton, J., 2006. Differentiating among prefrontal substrates in psychopathy: neuropsychological test findings. Neuropsychology 20, 153–165.

Bolla, K.I., Eldreth, D.A., London, E.D., Kiehl, K.A., Mouratidis, M., Contoreggi, C., 2003. Orbitofrontal cortex dysfunction in abstinent cocaine abusers performing a decision-making task. Neuroimage 19, 1085–1094.

Brower, M.C., Price, B.H., 2001. Neuropsychiatry of frontal lobe dysfunction in violent and criminal behaviour: a critical review. Journal of Neurology Neurosurgery and Psychiatry 71, 720–726.
Burgess, P.W., Shallice, T., 1996. Response suppression, initiation and strategy use following frontal lobe lesions. Neuropsychlogia 34, 263–273.
Burgess, P.W., Shallice, T., 1997. The Hayling and Brixton TestsThames Valley Test Company, Thurston, England.
Carlin, D., Bonerba, J., Phipps, M., Alexander, G., S., M., G., J., 2000. Planning impairments in frontal lobe dementia and frontal lobe lesion patients. Neuropsychologia 38, 655–665.
Cohen, J., 1992. A power primer. Psychological Bulletin 112, 155–159.
Copestake, S., Gray, N.S., Snowden, R.J., 2013. Emotional intelligence and psychopathy: a comparison of trait and ability measures. Emotion 13 (4), 691–702.
Damasio, A., Tranel, D., Damasio, H., 1987. Individuals with sociopathic behavior caused by frontal damage fail to respond autonomically to social stimuli. Behavioral Brain Research 41, 81–94.
de Frias, C.M., Dixon, R.A., Strauss, E., 2006. Structure of four executive functioning tests in healthy older adults. Neuropsychology 20, 206–214.
Edens, J.F., Marcus, D.K., Liliienfield, S.O., Polythress, N.G., 2006. Psychopathic, not psychopathic: taxometric evidence for the dimensional structure of psychopathy. Journal of Abnormal Psychology 115, 131–144.
Frangou, S., Haldane, M., Roddy, D., Kumari, V., 2005. Evidence for deficit in tasks of ventral, but not dorsal, prefrontal executive function as an endophenotypic marker for bipolar disorder. Biological Psychiatry 58, 838–839.
Gao, Y., Glenn, A.L., Schug, R.A., Yang, Y., Raine, A., 2009. The neurobiology of psychopathy: a neurodevelopmental perspective. Canadian Journal of Psychiatry-Revue Canadienne De Psychiatrie 54, 813–823.
Hansen, A.L., Johnsen, B.H., Thornton, D., Waage, L., Thayer, J.F., 2007. Facets of psychopathy, heart rate variability and cognitive function. Journal of Personality Disorders 21, 568–582.
Hare, R.D., 1984. Performance of psychopaths on cognitive tasks related to frontal lobe function. Journal of Abnormal Psychology 93, 133–140.
Hare, R.D., 2003. The Hare psychopathy checklist - revised (PCL-R), 2nd Edition Multi-Health Systems, Toronto.
Hare, R.D., Neumann, C.S., 2008. Psychopathy as a clinical and empirical construct. Annual Review of Clinical Psychology 4, 217–246.
Harlow, J.M., 1848. Passage of an iron rod through the head. Boston Medical and Surgical Journal 39, 369–393.
Hart, S.D., Dempster, R.J., 1997. Impulsivity and psychopathy. In: Webster, C.D., Jackson, M.A. (Eds.), In Impulsivity: Theory Assessment and TreatmentGuildford Press, New York, pp. 212–232.
Hart, S.D., Forth, A.E., Hare, R.D., 1990. Performance of criminal psychopaths on selected neuropsychological tests. Journal of Abnormal Psychology 99, 374–379.
Hart, S.D., Hare, R.D., 1996. Psychopathy and antisocial personality disorder. Current Opinion in Psychiatry 9, 129–132.
Hobson, J., Shine, J., 1998. Measurement of psychopathy in a UK prison population referred for long-term psychotherapy. British Journal of Criminology 38, 504–515.
Ishikawa, S.S., Raine, A., Lencz, T., Bihrle, S., Lacasse, L., 2001. Autonomic stress reactivity and executive functions in successful and unsuccessful criminal psychopaths from the community. Journal of Abnormal Psychology 110, 423–432.
Lapierre, D., Braun, C.M.J., Hodgins, S., 1995. Ventral frontal deficits in psychopathy: neuropsychological test findings. Neuropsychologia 33, 139–151.
Losel, F., Schmucker, M., 2004. Psychopathy, risk taking, and attention: a differentiated test of the somatic marker hypothesis. Journal of Abnormal Psychology 113, 522–529.
Lorenz, A.R., Newman, J.P., 2002. Deficient response modulation and emotion processing in low anxious caucasian psychopathic offenders: results from a lexical decision task. Emotion 2 (2), 91–104.
MacCallum, R.C., Zhang, S.B., Preacher, K.J., Rucker, D.D., 2002. On the practice of dichotomization of quantitative variables. Psychological Methods 7, 19–40.
Miller, L., Milner, B., 1985. Cognitive risk-taking after frontal or temporal lobectomy.2. The synthesis of phonemic and semantic information. Neuropsychologia 23, 371–379.
Milner, B., 1963. Effects of different brain lesions on card sorting: the role of the frontal lobes. Archives of Neurology 9, 90–100.
Mitchell, D.G.V., Colledge, E., Leonard, A., Blair, R.J.R., 2002. Risky decisions and response reversal: is there evidence of orbitofrontal cortex dysfunction in psychopathic individuals? Neuropsychologia 40, 2013–2022.
Monchi, O., Petrides, M., Petre, V., Worsley, K., Dagher, A., 2001. Wisconsin card sorting revisited: distinct neural circuits participating in different stages of the task identified by event-related functional magnetic resonance imaging. Journal of Neuroscience 21, 7733–7741.
Morgan, A.B., Lilienfeld, S.O., 2000. A meta-analytic review of the relation between antisocial behavior and neuropsychological measures of executive function. Clinical Psychology Review 20, 113–136.
Newman, J.P., Patterson, C.M., Kosson, D.S., 1987. Response perseveration in psychopaths. Journal of Abnormal Psychology 96 (2), 145–148.
Odhuba, R.A., van den Broek, M.D., Johns, L.C., 2005. Ecological validity of measures of executive functioning. British Journal of Clinical Psychology 44, 269–278.
Pham, T.H., Vanderstukken, O., Philippot, P., Vanderlinden, M., 2003. Selective attention and executive functions deficits among criminal psychopaths. Aggressive Behavior 29, 393–405.
Rabbitt, P., Lowe, C., 2000. Patterns of cognitive ageing. Psychological Research-Psychologische Forschung 63, 308–316.
Raust, A., Slama, F., Mathieu, F., Roy, I., Chenu, A., Koncke, D., 2007. Prefrontal cortex dysfunction in patients with suicidal behavior. Psychological Medicine 37, 411–419.
Reay, J.L., Hamilton, C., Kennedy, D.O., Scholey, A.B., 2006. MDMA polydrug users show process-specific central executive impairments coupled with impaired social and emotional judgement processes. Journal of Psychopharmacology 20, 385–388.
Roussy, S., Toupin, J., 2000. Behavioral inhibition deficits in juvenile psychopaths. Aggressive Behavior 26, 413–424.
Shallice, T., 1982. Specific impairments in planning. Philosophical Transactions of the Royal Society B 298, 199–209.
Snowden, R.J., Gray, N.S., 2010. Temperament and character as a function of psychopathy: relationships between the psychopathy checklist - revised and the temperament and character inventory in a sample of personality disordered serious or repeat offenders. Journal of Forensic Psychiatry & Psychology 21, 815–833.
Snowden, R.J., Gray, N.S., 2011. Impulsivity and psychopathy: associations between the barrett impulsivity scale and the psychopathy checklist revised. Psychiatry Research 187 (3), 414–417.
Snowden, R.J., Gray, N.S., Pugh, S., Atkinson, G., 2013. Executive function as a function of sub-clinical psychopathy. Personality and Individual Differences 55 (7), 801–804.
Sreenivasan, S., Walker, S.C., Weinberger, L.E., Kirkish, P., Garrick, T., 2008. Four-facet PCL-R structure and cognitive functioning among high violent criminal offenders. Journal of Personality Assessment 90, 197–200.
Steiger, J.H., 1980. Tests for comparing elements of a correlation matrix. Psychological Bulletin 87, 245–251.
Unterrainer, J.M., Rahm, B., Kaller, C.P., Leonhart, R., Quiske, K., Hoppe-Seyler, K., 2004. Planning abilities and the tower of London: is this task measuring a discrete cognitive function? Journal of Clinical and Experimental Neuropsychology 26, 846–856.
van Honk, J., Hermans, E.J., Putman, P., Montagne, B., Schutter, D.L.G., 2002. Defective somatic markers in subclinical psychopathy. NeuroReport 13, 1025–1027.
Vanman, E.J., Mejia, V.Y., Dawson, M.E., Schell, A.M., Raine, A., 2003. Modification of the startle reflex in a community sample: do one or two dimensions of psychopathy underlie emotional processing? Personality and Individual Differences 35, 2007–2021.
Vitacco, M., Neumann, C.S., Jackson, R.L., 2005. Testing of a four-factor model of psychopathy: associations with gender, ethnicity, intelligence and violence. Journal of Consulting and Clinical Psychology 73 (3), 466–476.
Vitacco, M.J., Neumann, C.S., Wodushek, T., 2008. Differential relationships between the dimensions of psychopathy and intelligence. Criminal Justice and Behavior 35, 48–55.
Vitale, J.E., Newman, J.P., 2001. Response perseveration in psychopathic women. Journal of Abnormal Psychology 110, 644–647.
Wagner, G., Koch, K., Reichenbach, J.R., Sauer, H., Schloesser, R.G.M., 2006. The special involvement of the rostrolateral prefrontal cortex in planning abilities: an event-related fMRI study with the tower of London paradigm. Neuropsychologia 44, 2337–2347.
Wallace, J.F., Vitale, J.E., Newman, J.P., 1999. Response modulation deficits implications of the diagnosis and treatment of psychopathy. Journal of Cognitive Psychotherapy 13 (1), 55–70.
Walsh, Z., Swogger, M.T., Kosson, D.S., 2004. Psychopathy, IQ, and violence in european american and african american county jail inmates. Journal of Consulting and Clinical Psychology 72, 1165–1169.
Walters, G.D., Gray, N.S., Jackson, R.L., Sewell, K.W., Rogers, R., Taylor, J., 2007. A taxometric analysis of the psychopathy checklist: screening version (PCL: SV): further evidence of dimensionality. Psychological Assessment 19, 330–339.
Wechsler, D., 1999. Wechsler Abbreviated Scale of Intelligence (WASI). Harcourt Assessment, San Antonio, TX.
Woodworth, M., Porter, S., 2002. In cold blood: characteristics of criminal homicides as a function of psychopathy. Journal of Abnormal Psychology 111, 436–455.
Yang, Y., Raine, A., 2009. Prefrontal structural and functional brain imaging findings in antisocial, violent, and psychopathic individuals: a meta-analysis. Psychiatry Research-Neuroimaging 174, 81–88.

Please cite this article as: Bagshaw, R., et al., Executive function in psychopathy: The tower of London, Brixton spatial anticipation and the Hayling sentence completion tests. Psychiatry Research (2014), http://dx.doi.org/10.1016/j.psychres.2014.07.031