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# Associations between psychopathic traits and brain activity during instructed false responding

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Abstract:

Lying is one of the characteristic features of psychopathy, and has been recognized in clinical and diagnostic descriptions of the disorder, yet individuals with psychopathic traits have been found to have reduced neural activity in many of the brain regions that are important for lying. In this study, we examine brain activity in sixteen individuals with varying degrees of psychopathic traits during a task in which they are instructed to falsify information or tell the truth about autobiographical and non-autobiographical facts, some of which was related to criminal behavior. We found that psychopathic traits were primarily associated with increased activity in the anterior cingulate, various regions of the prefrontal cortex, insula, angular gyrus, and the inferior parietal lobe when participants falsified information of any type. Associations tended to be stronger when participants falsified information about criminal behaviors. Although this study was conducted in a small sample of individuals and the task used has limited ecological validity, these findings support a growing body of literature suggesting that in some contexts, individuals with higher levels of psychopathic traits may demonstrate heightened levels of brain activity.

Keywords: psychopathy, deception, autobiographical, fMRI, criminal behavior

1. Introduction

Individuals with psychopathic traits are described as frequently deceiving others and are thought to be skilled at doing so (Hare, 2003). Deception has been defined as a deliberate act that is intended to foster in another person a belief or understanding which the deceiver considers false (Zuckerman et al., 1981). Lying, or making a statement that is believed by the liar to be false, is one way to deceive. The process of lying involves the inhibition of true responses and the production of deceptive ones (Abe et al., 2007). It also involves complex socio-cognitive processes such as taking the perspective of another person, reading his or her intentions, moral decision-making, monitoring one's own behavior, and likely emotion regulation (Abe et al., 2007; Lisofsky et al., 2014). The present study focuses on the basic process of falsifying responses. Brain imaging studies in which participants are instructed to lie under certain conditions show that the process of inhibiting the truth and producing a lie is associated with brain activity in various regions of the prefrontal cortex and the anterior cingulate (e.g., Abe et al., 2007; Kozel et al., 2005; Nunez et al., 2005; Ofen et al., 2017). For example, Abe et al. (2007) found that the DLPFC and the frontopolar cortex were active when falsifying responses, but not when participants were trying to deceive an interrogator. These regions are involved in working memory, maintaining attention, inhibiting prepotent responses, and conflict monitoring (Aron et al., 2007; Kerns et al., 2004; Rossi et al., 2009) – processes necessary to intentionally inhibit the truth (i.e., the automatic, prepotent response) in order to lie. The frontopolar cortex has also been associated with switching between alternatives (Boorman et al., 2009; Sylvester et al., 2003). The anterior cingulate has been implicated in several studies involving falsifying information or malingering (Kozel et al., 2005; Lee et al., 2005; Mohamed et al., 2006) and is involved in directed attention, conflict processing, and inhibitory control (Gasquoine, 2013).

Notably, psychopathic traits have been associated with reduced neural activity in many of these regions during various tasks (Yang and Raine, 2009). Because psychopathy is associated with more frequent (i.e., practiced) and possibly skilled lying, yet reduced neural activity in brain regions associated

with the process of falsifying information, it is unclear whether psychopathy would be associated with increased or reduced neural activity when participants falsify information.

ERP studies have examined brain functioning during the process of response inhibition – one important component of falsifying information – in relation to psychopathy, but have found mixed results. Kiehl et al. (2000) found that psychopathic individuals showed abnormalities in the generation of two characteristic ERP components, the N2 and P3, generated by the anterior cingulate and adjacent regions, and suggested that the neural processes involved in response inhibition are abnormal in these individuals. However, Munro et al. (2007) found no relationship between psychopathic traits and the generation of these ERP components during response inhibition.

Two previous studies have examined brain activity during the process of falsifying information in relation to psychopathic traits (Fullam et al., 2009; Nunez et al., 2005). Both studies assessed psychopathy using a self-report measure and found that various aspects of psychopathy were associated with reduced neural activity when participants were instructed to lie versus tell the truth. However, in both of these studies, participants were instructed to lie about relatively mundane information (e.g., "Do you own a laptop computer?"). We sought to build on these studies by asking participants to lie about something of greater personal consequence – one's own criminal behavior – which may be more closely related to lying in the real world.

Although Fullam et al. (2009) and Nunez et al. (2005) identified reduced neural activity during the process of falsifying information, one recent study found that psychopathy was associated with *increased* activity in frontoparietal regions during two processes that are likely important in the process of falsifying information – interference suppression and response inhibition, two components of inhibitory self-control (Rodman et al., 2016). Thus, it is possible that individuals with psychopathic traits may show increased neural activity when falsifying information. The goal of the present study was to clarify the relationship between psychopathic traits and brain activity during the process of falsifying information, a central cognitive component of lying.

In the present study, we specifically examined brain activity in regions that have consistently been associated with the process of falsifying information in previous studies in order to examine how activity in these regions was associated with psychopathic traits. Regions included the anterior cingulate, dorsolateral prefrontal cortex (DLPFC), insula, inferior parietal lobe (e.g., angular/supramarginal gyrus), frontopolar cortex, orbitofrontal/ventromedial prefrontal cortex, and temporal pole (Abe et al., 2007; Kozel et al., 2005; Kozel et al., 2004; Lee et al., 2005; Nunez et al., 2005).

Although the ERP and fMRI research is mixed, we hypothesized that psychopathy would be associated with reduced neural activity in these brain regions during the process of falsifying information because of the larger body of evidence suggesting associating psychopathy with reduced neural activity in these regions. We also hypothesized that correlations would be strongest for the aspect of psychopathy that involves frequent lying and conning.

## 2. Methods

*2.1. Participants*. Participants were 16 adults (2 females) recruited from temporary employment agencies in the greater Los Angeles area (mean age = 30.2; 40% Caucasian, 40% African American, 13.3% Asian). Samples from this community have been found to show relatively higher rates of psychopathy and violence perpetration (Raine et al., 2000). Participants were excluded if they were under 18 years of age; nonfluent in English; claustrophobic; or had a pacemaker, metal implants, or history of epilepsy. The principal investigator obtained a certificate of confidentiality from the Secretary of Health pursuant to Section 303(a) of Public Health Act 42. Participants were informed that any information they might provide about uninvestigated crimes could not be subpoenaed by any court. All participants provided informed consent. Data for this study was collected in 2006 and 2007.

*2.2. Stimuli and Design.* The fMRI task was adapted from previous studies (Fullam et al., 2009; Spence et al., 2001). A 2x2x2 design was used to examine lying (selecting a false response) versus telling the truth in response to a series of yes/no questions that varied in (1) autobiographical versus non-autobiographical content, and (2) criminal versus non-criminal content, resulting in eight conditions

(lie/truth × autobiographical/non-autobiographical × criminal/non-criminal). Table 1 contains sample questions. Twenty-four questions were presented in each of the four categories. Participants were instructed to respond truthfully or falsely to the questions using a button box. Questions were presented for four seconds each and were grouped into blocks of four questions each. At the beginning of each block, a screen appeared for two seconds instructing the participant either to lie or tell the truth about the following set of questions. Each block was followed by a four second fixation period. The task was divided into two runs. The structure of the task is depicted in Figure 1.

[INSERT TABLE 1 AND FIGURE 1 HERE]

*2.3. Psychopathy and IQ Assessment.* Psychopathic traits were assessed using the PCL-R: 2nd Edition (Hare, 2003), which is supplemented by seven sources of collateral data (described in Glenn et al., 2011). Psychopathy has been found to be dimensional in nature (Edens et al., 2006). The PCL-R has previously been used to assess psychopathic traits in community samples (Coid et al., 2009; Gao et al., 2011; Neumann and Hare, 2008).The PCL-R consists of 20 items and reflects four facets of psychopathy: Facet 1 represents interpersonal features such as glibness, superficial charm and pathological lying; Facet 2 represents affective features such as lack of empathy, guilt, and remorse; Facet 3 represents lifestyle features such as impulsivity, risk-taking, and sensation seeking, and Facet 4 represents antisocial behavior. Ratings were made by a Ph.D. clinical graduate student who received systematic training on the administration and scoring of the PCL-R. Means, standard deviations, and ranges for psychopathy total and facet scores can be found in Table 2. The two females' scores were 32 and 26.3. Subtests of the Wechsler Adult Intelligence Scale-Revised (Wechsler, 1981) were used to estimate verbal, performance, and total IQ.

*2.4. MRI data acquisition.* Functional images were acquired on a Siemens 3T Trio scanner using an echo planar imaging (EPI) sequence with the following parameters: repetition time (TR) = 2000 ms, echo time (TE) = 60 ms, matrix = 64 × 64, field of view (FOV) = 192 mm, slice thickness = 3.5 mm, gap = 0 mm,

32 axial slices. The duration of each of the two EPI scans was 11 minutes, 20 seconds. These were followed by an 8-minute T1-weighted magnetization prepared rapid gradient echo (MPRAGE) structural scan (256 × 256 matrix, 1 × 1 × 1 mm voxel size).

*2.5. fMRI image analysis.* Image preprocessing was conducted using SPM8 and involved slice timing correction, image realignment and unwarping, normalization into a standard stereotactic space using the Montreal Neurologic Institute (MNI) template, and spatial smoothing with an 8 mm full width at half maximum Gaussian kernel. Data from one participant was excluded because of failure to complete the task.

A fixed effects model was used to analyze individual participant data. For each participant a General Linear Model was set up by specifying the onsets and durations (16 s) of the task blocks. The spatial realignment parameters were added to the design matrix as conditions of no interest. Resulting box-car functions were convolved with the canonical hemodynamic response function. To remove low-frequency scanner drifts, data were high-pass filtered with a frequency cutoff at 128 seconds.

To improve power when examining differences in task-related activity for lying versus telling the truth in response to the questions, we first defined a (GLM) for each participant with only two conditions – lie and truth. For comparisons between lie and truth conditions, second-level estimation was conducted. Statistical non-parametric mapping (SnPM) was used to correct for multiple comparisons (Nichols, 2014; Nichols and Holmes, 2002). This method enables us to address issues originating from multiple comparisons in fMRI analysis with greater confidence that the false positive rates are controlled appropriately (Eklund et al., 2016). Because SnPM does not require parametric assumption, this method is more robust against possible error associated with inflated false positives compared to parametric fMRI analysis methods (Nichols and Holmes, 2002). A clusterwise threshold of $p < .05$ controlling for family-wise error (FWE) and cluster-forming threshold of $p < 0.001$ after applying SnPM was used and 5,000 permutations were performed to examine areas in which brain activity differed in the lie and truth conditions in the group as a whole. It should be noted that the focus of the present study was to identify

regions in which brain activity was associated with psychopathy scores. Thus, we only briefly report main effects for the whole group.

After examining main effects, correlation analyses were performed to examine brain regions in which activity was correlated with psychopathy scores (total and facet scores). We utilized the 'MultiSub: Simple Regression (correlation); single covariate of interest, one scan per subject' method provided by SnPM. Each participant's PCL:R score was entered to the SnPM analysis model as the single covariate. Correlational analyses were restricted to a priori regions of interest. These included regions previously associated with falsifying information (the anterior cingulate [BA 32], DLPFC [BA 8/9], the inferior parietal lobe (e.g., angular/supramarginal gyrus [BA 40]), the frontopolar cortex [BA 10], and the orbitofrontal/ventromedial prefrontal cortex [BA 11] (Abe et al., 2007; Lee et al., 2005), including those associated with falsifying information about autobiographical events (Fullam et al., 2009; Nunez et al., 2005)). These regions were selected based on previous associations with the process of falsifying information, not because of associations with psychopathy. The regions of interest were created using Talairach Daemon (TD) anatomic label masks from the WFU PickAtlas (http://fmri.wfubmc.edu/downloads/WFU_PickAtlas_User_Manual_v3.0.pdf) (Lancaster et al., 1997; Lancaster et al., 2000; Maldjian et al., 2004; Maldjian et al., 2003). Using SnPM, the statistical threshold was $p < 0.05$ (FWE corrected) for voxel-wise comparisons, which was found to provide more valid correction results based on permutations compared to default correction methods provided by analysis tools such as SPM, FSL, AFNI (Eklund et al., 2016). In addition, we also applied thresholds at $p < 0.01$ and $p < 0.05$ (uncorrected) that correspond to r - .45 and r = .60, respectively, for exploratory purposes.

Because of the correlational nature of our study, it was not feasible to interpret interaction effects (for a more detailed explanation, see supplementary materials). Thus, we examined correlations between psychopathy scores and brain activity for the eight specific contrasts (e.g. autobiographical lie > autobiographical truth, autobiographical lie > nonautobiographical lie, etc.).

## 3. Results

Psychopathy total and facet scores were not correlated with verbal, performance, or full scale IQ and none of these correlations approached significance (all $p > 0.49$; total psychopathy and full scale IQ: $r = 0.01$, $p = 0.97$). Therefore, IQ was not used as a covariate. An overview of the significant associations between psychopathy scores (total and facet) and brain activity for all contrasts can be found in Table 3.

*3.1. Lie > truth contrast*

We first examined differences in activity between blocks in which participants were instructed to lie versus tell the truth. Consistent with prior studies utilizing similar tasks (Fullam et al., 2009), we found clusters of activation in the right DLPFC (Brodmann's area (BA) 8), frontopolar cortex (BA 10) and the right inferior parietal lobule, including the supramarginal gyrus and angular gyrus (BA 40) when lying versus telling the truth (full details can be found in Table S1). No voxels were significantly more active when participants were instructed to tell the truth versus lie.

Next we examined correlations between psychopathy scores and brain activity for the lie > truth contrast within the a priori ROIs. Table 4 lists regions in which psychopathy scores (total and facet) were correlated with brain activity within the ROIs. Total psychopathy scores were positively associated with activity in the frontopolar cortex, supramarginal gyrus, and lateral frontal cortex (Figure 2). There were no areas within the ROIs in which psychopathy scores were significantly negatively associated with activity. Activity in the frontopolar cortex and supramarginal gyrus was positively correlated with each of the four facets of psychopathy. Facet 4, which reflects antisocial behavior, was also positively correlated with activity in the orbitofrontal/ventromedial prefrontal cortex and anterior cingulate cortex. Facets 1 and 2, the Interpersonal/Affective facets, were negatively correlated with activity in the left DLPFC, and Facet 2 was negatively correlated with activity in the orbitofrontal cortex (see Table 3 and Table S2).

[INSERT TABLES 3 AND 4 AND FIGURE 2 HERE]

*3.2. Contrasts involving autobiographical versus non-autobiographical information*

Next we examined the contrasts involving lying or telling the truth about autobiographical compared to non-autobiographical information. We first examined areas that were associated with

psychopathy when participants were instructed to lie about autobiographical versus non-autobiographical information (autobiographical lie > non-autobiographical lie). Total psychopathy scores were positively associated with activity in the dorsolateral and dorsomedial prefrontal cortex, frontopolar cortex, supramarginal gyrus, and anterior cingulate cortex (Table 5). There were no ROIs in which activity was negatively associated with total psychopathy scores. All facets were associated with increased activity in the DLPFC and frontopolar cortex, with stronger associations for the Lifestyle and Antisocial facets. Facets 3 and 4 were also associated with activity in the bilateral supramarginal gyrus. Although there were no negative associations with total psychopathy scores, a few negative associations were observed with facet scores, though these relationships were weaker.

[INSERT TABLE 5 HERE]

We next examined areas that were associated with psychopathy when participants were instructed to lie versus tell the truth about autobiographical information. Total psychopathy scores were positively correlated with activity in the lateral part of the frontal lobe bilaterally, the insula, the frontopolar cortex, and supramarginal gyrus (Table 6, Figure 3). Total psychopathy scores were negatively associated with activity in the orbitofrontal cortex, angular gyrus, and DLPFC, though these effects were weaker. Positive associations were observed between Facets 1, 2, and 3 and the bilateral lateral frontal lobe and bilateral insula. Facets 2, 3, and 4 were positively associated with activity in the frontopolar cortex and all facets were correlated with activity in the supramarginal gyrus. All facets were negatively associated with activity in the orbitofrontal cortex.

[INSERT TABLE 6 AND FIGURE 3 HERE]

Results for the remaining two contrasts (autobiographical truth > non-autobiographical truth and non-autobiographical lie > non-autobiographic truth) are presented in Tables S3 and S4. When lying versus telling the truth about non-autobiographical information, psychopathy was positively correlated with activity in the frontopolar cortex and supramarginal gyrus. When telling the truth about autobiographical versus non-autobiographical information, psychopathy positively associated with

activity in the frontopolar cortex, but negatively associated with activity in the dorsal anterior cingulate and insula. These negative associations were primarily driven by negative relationships with Facet 2.

*3.3. Contrasts involving criminal versus non-criminal information*

We also examined differences in activity between blocks in which participants responded to criminal versus non-criminal information, regardless of whether they lied or told the truth. The bilateral cuneus was more active when participants responded to criminal versus non-criminal information (cluster-forming $p < 0.001$; cluster-level $p < 0.05$ FWE). No significant activations were found for the contrast non-criminal > criminal.

Next we examined correlations between psychopathy scores and brain activity for the criminal > non-criminal contrast within the a priori ROIs. Table S5 lists regions in which psychopathy scores were correlated with brain activity within the ROIs (also summarized in Table 2). Regions include the frontopolar cortex and anterior cingulate.

We then examined contrasts involving lying or telling the truth about criminally relevant information versus information that was not criminal in nature. We first examined areas that were associated with psychopathy when participants were instructed to lie about criminal versus non-criminal information. Total psychopathy scores were positively associated with activity in the anterior cingulate and dorsal prefrontal cortex, orbitofrontal cortex, insula, and frontopolar cortex. No negative associations were observed with total psychopathy scores (Table 7). All facets were positively associated with activity in the insula, orbitofrontal and frontopolar cortex, though associations tended to be stronger for Facets 3 and 4. Facet 3 was positively associated with activity in each of the regions associated with the total score. None of the facets were negatively associated with activity in the ROIs.

[INSERT TABLE 7 HERE]

Next we examined areas associated with psychopathy when participants were instructed to lie versus tell the truth about criminal information. Total psychopathy scores were positively associated with activity in the anterior cingulate, lateral and dorsolateral prefrontal cortex, insula, and frontopolar cortex

(Table 8; Figure 4). No negative associations were observed with total psychopathy scores. Positive associations were observed between Facets 2 and 3 and the anterior cingulate, insula, and lateral and dorsolateral prefrontal cortex. Facet 4 was associated with increased activity in the frontopolar cortex. None of the facets were negatively associated with activity in the ROIs.

[INSERT TABLE 8 AND FIGURE 4 HERE]

Results for the remaining two contrasts (criminal truth > non-criminal truth and non-criminal lie > non-criminal truth) are presented in Tables S6 and S7. When lying versus telling the truth about non-criminal information, psychopathy was positively associated with activity in the frontopolar cortex and anterior cingulate, and negatively associated with activity in the DLPFC. Activity in the frontopolar cortex was positively associated with all facets of psychopathy. Activity in the angular gyrus demonstrated the strongest relationship with Facet 1. Activity in the DLPFC was negatively associated with Facets 2 and 3. When telling the truth about criminal versus non-criminal information, psychopathy was negatively associated with activity in the DLPFC, and this was primarily driven by Facets 2 and 3.

## 4. Discussion

Although previous studies have often found psychopathy to be associated with reduced levels of neural activity during various tasks (Koenigs, 2012; Yang and Raine, 2009), the present study adds to a growing literature suggesting that there are contexts in which psychopathic individuals may demonstrate increased neural activity (Glenn et al., 2009; Müller et al., 2003; Rodman et al., 2016), even in regions such as the orbitofrontal cortex, which is commonly described as demonstrating reduced activity in psychopathic individuals (Koenigs, 2012; Yang and Raine, 2009). In this study, participants were instructed to lie and tell the truth about different categories of information (e.g., personally relevant, criminally relevant). Across different conditions, we primarily observed positive associations between psychopathy scores and neural activity in regions of interest in the prefrontal cortex, anterior cingulate, insula, angular gyrus, and inferior parietal lobe.

Regardless of information type, when participants were instructed to lie versus tell the truth, we found that psychopathy was positively correlated with activity in the frontopolar cortex, as well as the supramarginal gyrus. Interestingly, in every contrast we examined, activity in the frontopolar cortex was positively associated with psychopathy scores. This suggests that its associations with psychopathy are not specific to the process of falsifying information, as it was also correlated with psychopathy for contrasts comparing different types of lying (e.g., autobiographical versus non-autobiographical lies, criminal versus non-criminal lies), and for responding to criminal versus non-criminal information. This may reflect the wide range of functions of the frontopolar cortex. For example, this region has been found to be active when participants switch between alternatives (Boorman et al., 2009; Sylvester et al., 2003), a process likely important in falsifying information compared to telling the truth. The region of the frontopolar cortex that we found to be active when participants lied about autobiographical versus non-autobiographical information (MNI: 36, 64, 6) has also been found to be active during the process of retrieving information for recognition memory (Herron et al., 2004) and for the retrieval of overlapping navigational memories in different contexts (Brown and Stern, 2014). The positive correlation between activity in this region and psychopathy may indicate that these individuals engage in more processing related to retrieving information when falsifying information about autobiographical events, or may engage in more processing related to manipulating information when falsifying information in general. On one hand, individuals higher in psychopathy may be more practiced at lying, or find lying to be less novel, and thus are better able to recruit brain regions that facilitate the process. However, it is also possible that increased activity in the frontopolar cortex could reflect *less* efficient functioning. Karim et al. (2010) used transcranial direct current stimulation (tDCS) to inhibit the frontopolar cortex and found that it resulted in *improvements* in lying abilities on the Guilty Knowledge Test. They suggest that the frontopolar cortex is involved in socioemotional judgments, and so activity in this region may represent moral conflict; inhibiting this region with tDCS and relieving the person from this moral conflict may result in the individual being able to "deceive unhinderedly" (Karim et al., 2010). Thus, one possibility is

that psychopathic individuals, who may have committed more of the crimes that were asked about, may have more moral conflict during the task compared to individuals scoring low in psychopathy. Individuals higher in psychopathy may also have weak memories when evaluating some questions, such that they require increased processing to recall the event (Ofen et al., 2017), whereas individuals lower in psychopathy may know immediately that they have not committed specific acts.

When participants were instructed to lie versus tell the truth (regardless of information type) we also observed increased activity in the supramarginal gyrus in individuals scoring higher in psychopathy. The supramarginal gyrus has been also found to be active when participants are instructed to lie versus tell the truth about both episodic memories and personal beliefs (Ofen et al., 2017). The specific region of the supramarginal gyrus that we found to be associated with psychopathy (MNI: -44, -48, 36) has previously been associated with withholding movement initiation, or proactive inhibition (Jaffard et al., 2008). Similar to the frontopolar cortex, increased activity in this region in individuals with higher levels of psychopathic traits during the process of falsifying information may reflect more efficient processing in these individuals who may engage in frequent lying behavior. This would be in line with neuropsychological research suggesting that in psychopathy, many aspects of executive functioning appear to be preserved, and in some cases enhanced (Baskin-Sommers et al., 2015; Sellbom and Verona, 2007).

When lying versus telling the truth about autobiographical information specifically, psychopathy was positively correlated with activity in the lateral prefrontal cortex and insula. When lying versus telling the truth about autobiographical information, we would expect there to potentially be more involvement of emotion (Fink et al., 1996; Vogeley and Fink, 2003), particularly because half of the content also involves questions related to criminal activity. The lateral prefrontal cortex has been associated with goal directed attention (Asplund et al., 2010) and with controlling the flow of information in other brain regions and networks during the performance of cognitive tasks (Cole et al., 2013). Melcher, Born, and Gruber (2011) found that activity in this specific area of the lateral prefrontal cortex

that was correlated with psychopathy (MNI: -36, 4, 28) was enhanced during a cognitive interference task (Stroop task) after participants were primed with emotionally negative and arousing images. They suggest that individuals in a negative affective state have to exert enhanced control efforts to resolve cognitive interference. One possibility, though speculative, is that the autobiographical questions in the task may have elicited more negative affect in the individuals scoring higher in psychopathy (e.g., perhaps they have engaged in more of the criminal behaviors asked about, which may have been negative experiences), and therefore these individuals required more cognitive control processing to respond falsely to the autobiographical information. Consistent with this idea, activity in the lateral prefrontal cortex was also associated with psychopathy when participants lied versus told the truth about criminal information.

Activity in the insula has been associated with the imagination of self-generated behavior (Farrer et al., 2003; Farrer and Frith, 2002; Lee and Reeve, 2013). This may suggest that individuals scoring higher in psychopathy are engaging in more self-reflection about behaviors they have done in the past. Similar to our speculation above, this may be because they have engaged in more of the criminal-related behaviors that were asked about, and are therefore imagining specific events. Indeed, we found positive correlations between psychopathy and activity in the insula for both the criminal versus non-criminal lie contrast, and the criminal lie versus truth contrast.

When falsifying responses about autobiographical versus *non*-autobiographical information we would expect there to be more processing related to retrieving information about the self, and also more involvement of emotional processing. During this contrast, we found increased activity in the DLPFC in individuals scoring higher in psychopathy. This region (MNI: 40, 36, 38) has been identified as one of the primary regions involved in successful response inhibition (Steele et al., 2013). Although lying about both types of information would involve response inhibition, it may be that individuals scoring higher in psychopathy require more processing to inhibit responses about autobiographical information. Another possibility is that, as discussed above, individuals higher in psychopathic traits may be more practiced at lying about autobiographical information, and may be better able to recruit the DLPFC to facilitate the

process. We also found positive correlations between psychopathy and DLPFC activity when participants were lying about criminal compared to non-criminal information, in which individuals scoring higher in psychopathy may also be more practiced.

Falsifying responses about criminal relative to non-criminal information may involve retrieval of salient emotional memories for individuals who have committed some of the crimes asked about, and may elicit little response from individuals who have not engaged in any of the behaviors. For this contrast, we found that psychopathy was associated with increased activity in the anterior cingulate. This same region was also associated with psychopathy when lying versus telling the truth about criminal information, and in general for responding to criminal versus non-criminal information. The anterior cingulate has been associated with a number of executive functions that are likely important in the process of falsifying information, including conflict monitoring and cognitive control (Gasquoine, 2013). This region of the anterior cingulate specifically (MNI: 20, 36, 22) has previously been found to be active during inhibitory processing in the Stroop task (Gruber and Yurgelun-Todd, 2005). Thus, the rationale for increased activity in this region may be similar to that for the lateral prefrontal cortex and DLPFC – that individuals higher in psychopathy may be more practiced at lying and better able to recruit regions involved in cognitive control. Although speculative, another possibility is that individuals scoring higher in psychopathy may have committed more of the crimes that were asked about, and therefore may have more information to process when thinking about these events (e.g., recalling details of the event) than someone who had not committed the crime and required little effort to recall the truth. Although we do not have response time data available that might help us to further explore this idea, social-cognitive models for understanding lying suggest that one of the first steps of the lying process is that truths are searched for and retrieved from long term memory and transferred to working memory – a process requiring cognitive resources (Walczyk et al., 2014).

In contrast to the current findings, however, Crowley et al. (2010) found *reduced* activity in this same region of the anterior cingulate (MNI: 22, 36, 28) in adolescent boys with conduct problems during

a decision-making task involving inhibitory control. Although speculative, it may be that increases in neural activity are specific to the process of lying, in which individuals with higher levels of psychopathic traits may be more practiced, rather than general tasks that involve inhibitory control.

Interestingly, this region of the anterior cingulate has also been found to be active when participants are asked to think about hypothetical personal situations (e.g., respond to questions as you would if you had woken up this morning as a member of the opposite sex) (Tamir and Mitchell, 2011), which is similar to the instruction to falsify information about oneself. This may give some insight as to why we see correlations for this region primarily in the criminally-relevant contrasts. It may be that participants higher in psychopathy are recalling specific scenarios in time when asked about crimes they may have committed, whereas those lower in psychopathy may not have an association with a prior event.

The finding of increased activity in individuals scoring higher in psychopathic traits during the process of falsifying information is consistent with findings from a recent study by Rodman et al. (2016) in which psychopathy scores in an incarcerated sample predicted increased activity within a distributed frontoparietal network during tasks that assessed components of inhibitory self-control: interference suppression and response inhibition – two skills that are likely important in the process of falsifying information. Regions demonstrating increased activity included the frontopolar cortex, temporoparietal junction, and DLPFC.

Contrary to hypotheses, associations tended to be weaker for the interpersonal facet (Facet 1), which involves pathological lying, and stronger for the lifestyle and antisocial facets, which tend to be more reflective of externalizing behaviors in general. One exception to this is that when lying versus telling the truth about noncriminal information, Facet 1 was positively associated with activity in the angular gyrus and frontopolar cortex. One possible explanation for the stronger associations with the lifestyle and antisocial facets is that individuals who are more impulsive and disinhibited may require more effort to perform the task, which relies on the ability to inhibit responses.

Although the majority of brain regions demonstrated positive correlations with psychopathy, a few negative correlations were observed. Interestingly, the orbitofrontal cortex was *positively* correlated with psychopathy scores for the contrasts involving criminal information, but was *negatively* associated with psychopathy scores (total and all facets) when participants lied versus told the truth about autobiographical information. The region of the OFC demonstrating *positive* correlations in contrasts involving criminal information (MNI: 28, 42, -6) has been found to be active when participants attend to a perpetual stimulus in order to replace a representation in working memory (i.e., participants replaced a word being held in working memory with a different word) (Rudner et al., 2005). One possibility is that individual higher in psychopathy may have a stronger representation of an event (e.g., stealing something) that they are updating during the process of falsifying information. Another possibility is that activity in this region may reflect more anxiety about lying about criminal information. In a previous study of deception, activity in the orbitofrontal/ventromedial prefrontal cortex was associated with more anxiety about deceiving the interrogator (Abe et al., 2007). The fact that we observe positive correlations between psychopathy and functioning in the orbitofrontal cortex when falsifying information about criminal behavior specifically could reflect increased anxiety in individuals who may have previously committed some of these crimes. Future studies could help to clarify whether this is the case by assessing anxiety via self-report or physiological measures during the process of deception.

In contrast, Abe et al. (2007) found that the process of falsifying responses was associated with activation in more lateral regions. The region of the OFC that we found to demonstrate *negative* correlations when participants lied versus told the truth about autobiographical information was more lateral. This specific region (MNI: 42, 48, -14) has been found to be active in a task involving word reversal and rhyme judgment, which may reflect its involvement in the more elemental aspect of falsifying information that involves mental reversal of words (Rudner et al., 2005). It is unclear why individuals scoring higher in psychopathy would show less activity in this region specifically in the contrast involving autobiographical information. It should be emphasized that for all of the regions

discussed, we are unable to determine the specific process that is resulting in the observed alterations in neural activity.

*4.1. Limitations*

Like many prior studies of lying using fMRI (Lee et al., 2002; Nunez et al., 2005; Ofen et al., 2017), our task involved instructing participants to lie, and thus is not necessarily indicative of the process of lying in real-world situations. Obeying an instruction to provide inaccurate responses is fundamentally different from being internally motivated to deceive, and spontaneously behaving in such a way to achieve a deceptive goal. There were no consequences for telling a lie in this study, which likely reduced the emotional salience that may typically accompany lying. The task also did not require that the participant monitor his own behavior and that of the listener while lying, as would happen in a face-to-face interaction. This type of real-world lying is very difficult to operationalize in a laboratory setting, and even more so in a brain imaging study; this limitation applies to most extant research in this area. In addition to the limited ecological validity of the task, we did not have a way to ascertain whether participants were actually telling the truth or lying, and it is possible that there are differences between people scoring high and low in psychopathy in how closely they followed instructions in the task. This is a problem that occurs in many brain imaging studies in which participants are required to follow instructions. In studies examining psychopathy – a construct associated with antisocial behavior – failure to comply may be especially problematic. Finally, the sample size in the present study was small. To account for this, we have done a few things: (1) we used ROI analyses to reduce the number of tests conducted, (2) we have utilized a more sensitive method (SnPM) to correct for multiple comparisons in order to avoid Type 2 error, and (3) we have tried to interpret general trends in our data rather than focusing on specific single findings.

Overall, our findings provide information about the neural correlates of the cognitive aspect of lying – falsifying information – in relation to psychopathic traits. Unlike prior neuroimaging studies of psychopathy which have focused on tasks involving the processing of emotion-related stimuli and have

demonstrated reduced levels of neural activity (Decety et al., 2013; Harenski et al., 2010; Marsh and Cardinale, 2012), our study suggests that, in some contexts, individuals scoring higher in psychopathic traits demonstrate increased levels of neural activity. Future studies involving more ecologically valid and interactive experimental paradigms will likely help to further our understanding of how the brains of individuals with psychopathic traits may function differently during deception in real-world contexts.

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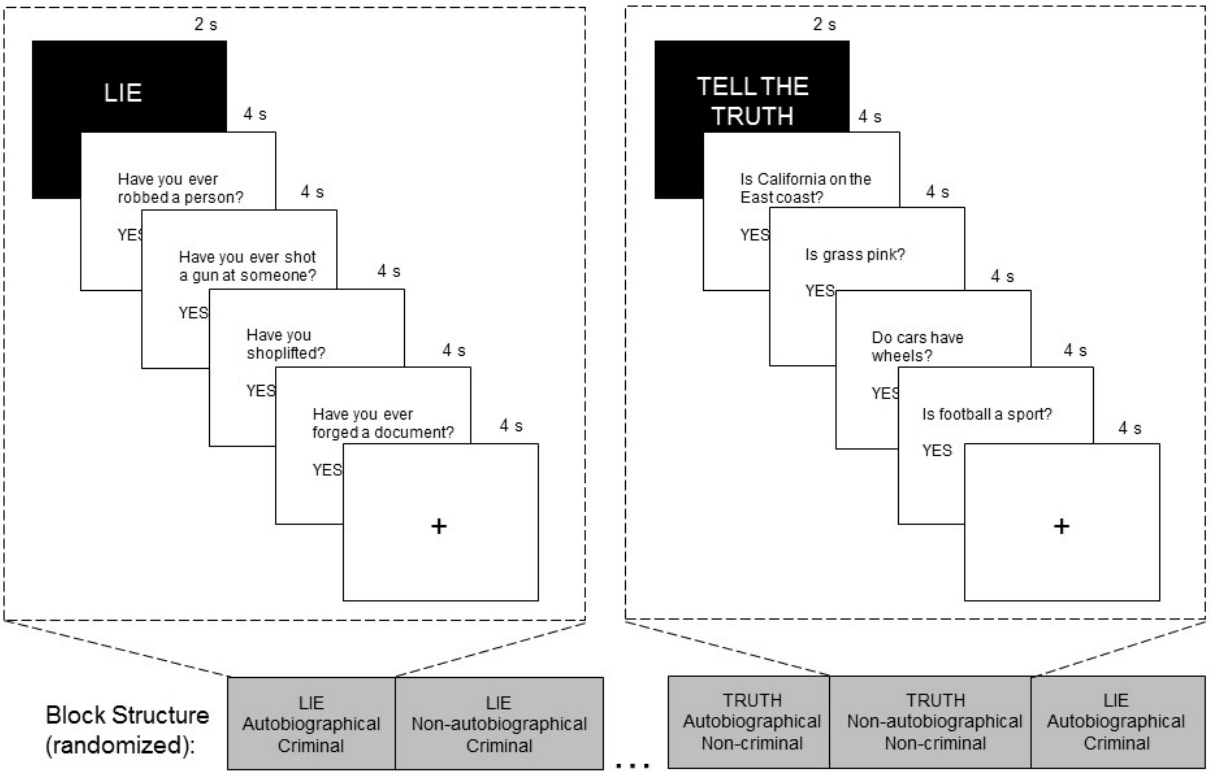


**Figure 1.** Schematic of task structure. In separate blocks, participants were instructed to lie or tell the truth about each type of question. Participants indicated "yes" by pressing the left button and "no" by pressing the right button on a button box. The 16-second period in which participants answered the four questions was modeled for each block.

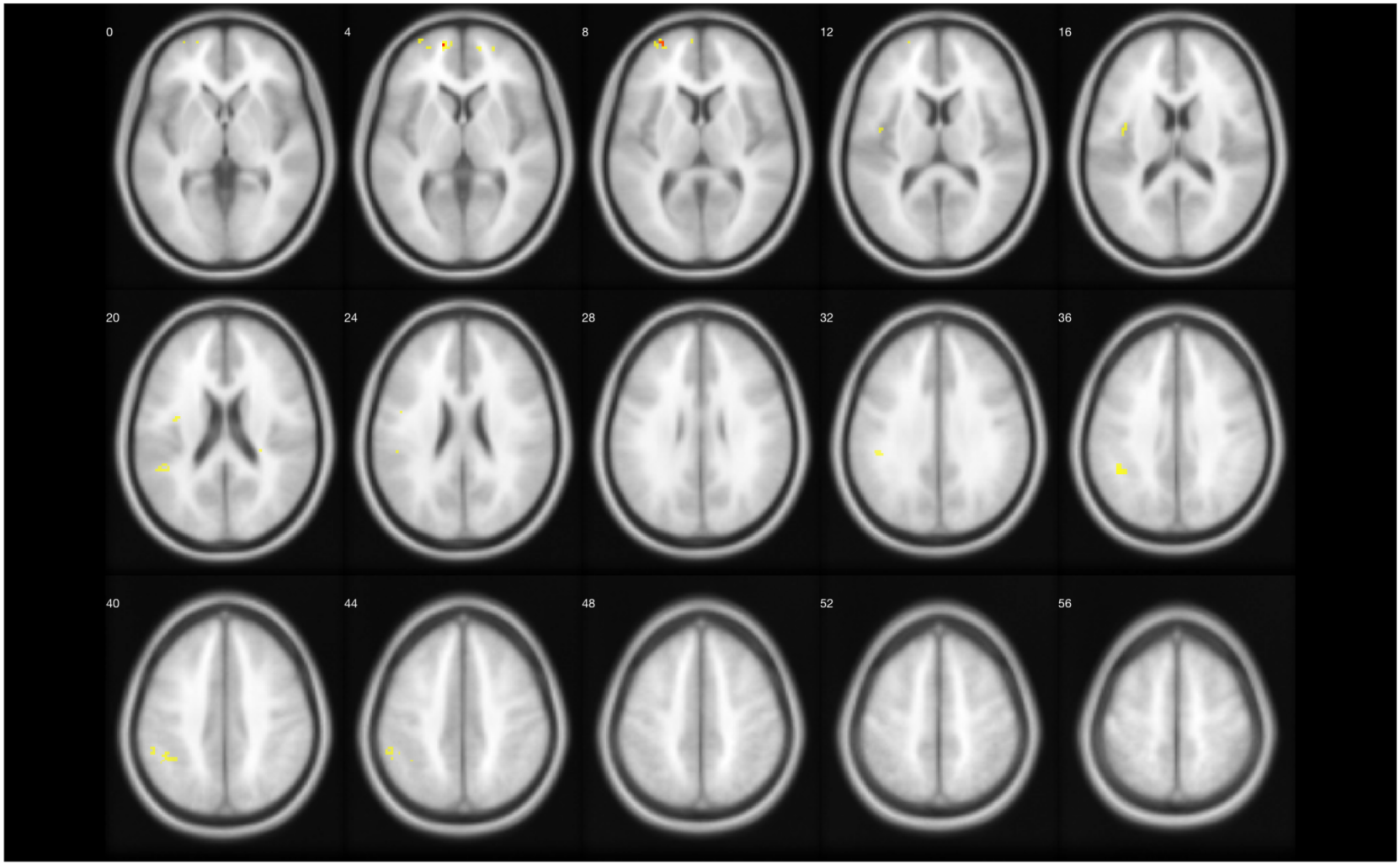


**Figure 2**. Brain areas in which total psychopathy scores were positively associated with activity during the contrast lie versus truth (Table 4).
Yellow: $p < 0.05$ uncorrected voxel-wise
Orange and red: $p < 0.01$ uncorrected voxel-wise

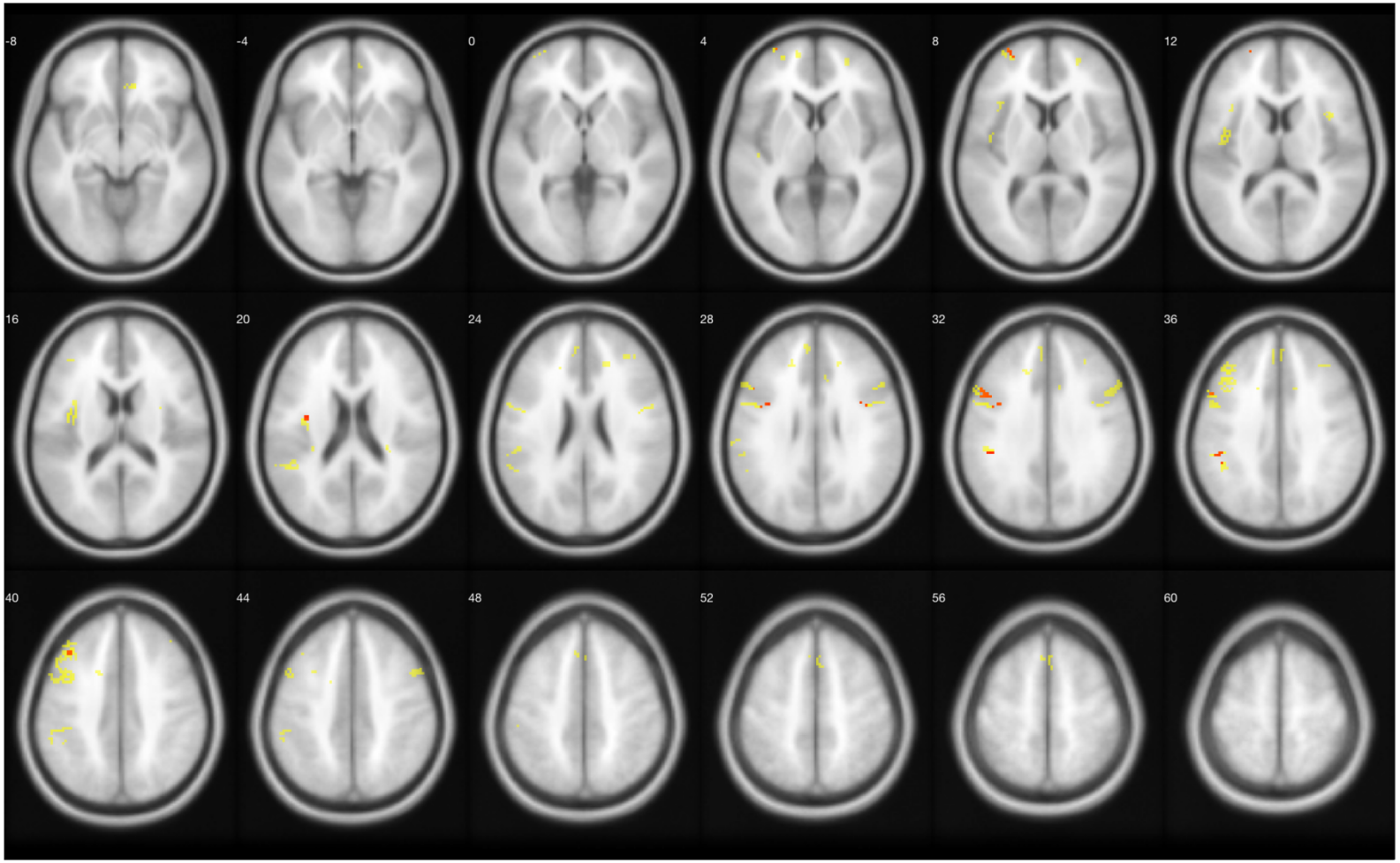


**Figure 3**. Brain areas in which total psychopathy scores were positively associated with activity during the contrast autobiographical lie versus autobiographical truth (Table 6).
Yellow: $p < 0.05$ uncorrected voxel-wise
Orange and red: $p < 0.01$ uncorrected voxel-wise

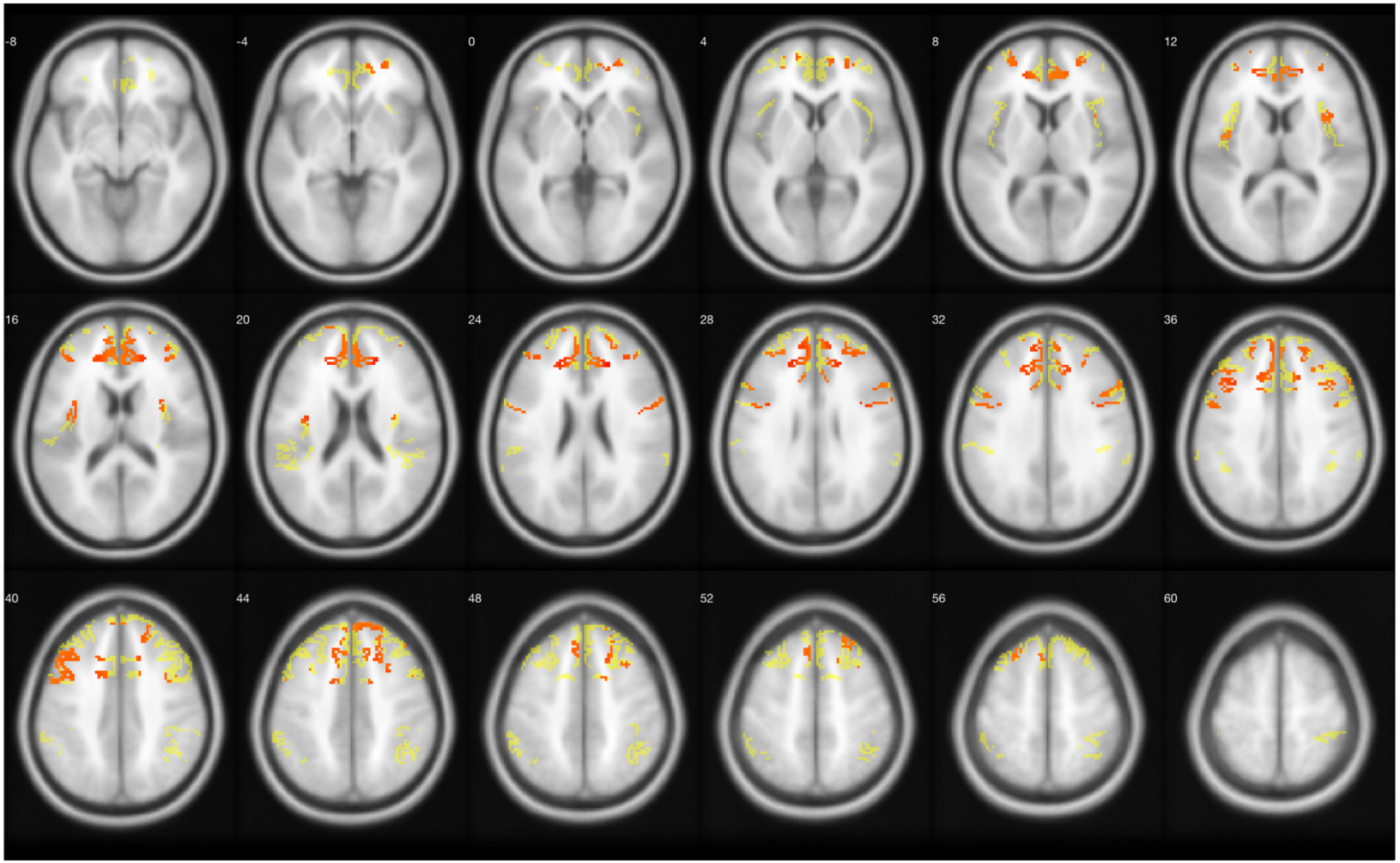


**Figure 4**. Brain areas in which total psychopathy scores were positively associated with activity for the contrast criminal lie versus criminal truth (Table 8).
Yellow: $p < 0.05$ uncorrected voxel-wise
Orange and red: $p < 0.01$ uncorrected voxel-wise

Table 1. Sample questions from each category. Participants were instructed to lie or tell the truth about each type of question, resulting in eight conditions for the task.

| | Autobiographical | Non-autobiographical |
|---|---|---|
| Criminal | Have you ever robbed a person? | Is it a crime to break into someone's house? |
| Non-criminal | Did you drive a car to get here today? | Is California on the East Coast? |

Table 2. Descriptive statistics for the PCL-R.

| | Mean | SD | Range |
|---|---|---|---|
| Total PCL-R | 22.7 | 8.8 | 7.4 - 35 |
| Facet 1 (transformed) | 6.2 | 2.6 | 1.25 – 8.75 |
| Facet 2 (transformed) | 7.1 | 3.3 | 0 – 10 |
| Facet 3 | 6.5 | 2.3 | 2 – 10 |
| Facet 4 | 4.0 | 2.6 | 0 – 9 |

*Note*. Facets 1 and 2 can range from 0 to 8 whereas Facets 3 and 4 can range from 0 to 10. In order to allow for direct comparisons of means and ranges across facets, we transformed scores on Facets 1 and 2 to a 0 to 10 scale.

Table 3. Overview of the significant associations with psychopathy total and facet scores for each contrast.

| | Lie vs. truth | Criminal vs. non-criminal | Autobiographical lie vs. non-autobiographical lie | Autobiographical lie vs. autobiographical truth | Non-autobiographical lie vs. non-autobiographical truth | Criminal lie vs. non-criminal lie | Criminal lie vs. criminal truth | Non-criminal lie vs. non-criminal truth |
|---|---|---|---|---|---|---|---|---|
| **Total Psychopathy** | | | | | | | | |
| *Positive associations* | | | | | | | | |
| Anterior cingulate | | + | + | + | | | + | |
| Lateral frontal cortex | + | | | + | | + | + | |
| Insula | + | | | + | + | + | + | + |
| DLPFC | | | + | + | | | + | |
| DLPFC / Anterior cingulate | | | | | | + | | |
| Orbitofrontal cortex | | | + | | | + | + | |
| Frontopolar cortex | + | + | + | + | + | + | + | + |
| Supramarginal gyrus | + | | + | + | + | | + | + |
| Dorsomedial PFC | | | + | + | | | | |
| Inferior frontal gyrus | | | | + | | + | | |
| Temporal pole | | + | + | | | + | + | |
| Angular gyrus | | | + | | | | + | + |
| Inferior parietal lobe | | | | | | | + | |
| Postcentral gyrus | | | + | | | + | + | |
| Ventromedial PFC | | | | | | + | + | |
| *Negative associations* | | | | | | | | |
| Orbitofrontal cortex | | | | - | | | | - |
| Angular gyrus | | | | - | | | | - |
| DLPFC | | - | | - | | | | - |
| Insula | | | | | - | | | |
| Dorsomedial PFC | | | | | | | | - |
| Anterior cingulate | | | | | | | | - |
| Frontopolar cortex | | | | | | | | - |
| Postcentral gyrus | | | | | | | | - |
| | | | | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Interpersonal (Facet 1)** | | | | | | | | |
| *Positive associations* | | | | | | | | |
| Lateral frontal cortex | + | | | + | | + | | |
| DLPFC | | | + | + | + | | + | + |
| Insula | + | | | + | + | + | + | |
| Anterior cingulate | | + | | + | | + | + | |
| Angular gyrus | + | | | | | | | + |
| Superior parietal lobule | + | | | | | | | |
| Supramarginal gyrus | + | | | + | + | | + | + |
| Frontopolar cortex | + | + | + | | | + | + | + |
| Orbitofrontal cortex | | | | + | | + | + | |
| Dorsomedial PFC | | | | | | | + | |
| Temporal pole | | + | | | + | | | + |
| Postcentral gyrus | | | | | | | | + |
| *Negative associations* | | | | | | | | |
| Temporal pole | | | - | | | | | |
| Frontopolar cortex | | | | - | | | | |
| DLPFC | - | | | - | | | | |
| Angular gyrus | | | - | | | | | |
| Supramarginal gyrus | | | - | | | | | |
| Orbitofrontal cortex | | | - | - | | | | |
| | | | | | | | | |
| **Affective (Facet 2)** | | | | | | | | |
| *Positive associations* | | | | | | | | |
| Lateral frontal cortex | + | | + | + | | + | + | |
| Insula | + | | | + | | + | + | + |
| DLPFC | | | + | + | | + | | |
| Frontopolar cortex | + | + | + | + | + | + | + | + |
| Supramarginal gyrus | + | | | + | + | | | + |
| Angular gyrus | | | + | | | | + | |
| Orbitofrontal cortex | | | + | | | + | + | |
| Anterior cingulate | | + | | + | | + | + | |
| Dorsomedial PFC | | | + | | | + | + | |
| Temporal pole | | | | | | + | | |
| Ventrolateral PFC | | | | | | + | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Superior parietal lobule | + | | | | | | | |
| Postcentral gyrus | | | | | | | | + |
| *Negative associations* | | | | | | | | |
| Orbitofrontal cortex | - | | | - | | | | - |
| DLPFC | - | - | | | - | | | - |
| Ventrolateral PFC | | | - | | | | | - |
| Frontopolar cortex | | | | - | | | | - |
| Temporal pole | | | - | | | | | |
| Insula | | | | | - | | | |
| Supramarginal gyrus | | | | | - | | | |
| Anterior cingulate | | | | | | | | - |
| Medial PFC | | | | | | | | - |
| Lateral PFC | | | | | | | | - |
| Angular gyrus | | - | | | | | | |
| **Lifestyle (Facet 3)** | | | | | | | | |
| *Positive associations* | | | | | | | | |
| DLPFC | + | | + | + | | + | + | |
| Anterior cingulate | | + | | + | | + | + | |
| Lateral PFC | | | | + | | + | + | |
| Orbitofrontal cortex | | | + | | | + | + | |
| Insula | + | | + | + | | + | + | + |
| Dorsomedial PFC | | | + | + | | + | | |
| Angular gyrus | | | | + | | | + | + |
| Supramarginal gyrus | | | + | + | + | + | + | + |
| Frontopolar cortex | + | + | + | + | + | + | | + |
| Temporal pole | | | + | | | + | + | |
| Postcentral gyrus | | | + | | | | | + |
| Supramarginal gyrus | + | | | | | | | |
| Ventrolateral PFC | | | | | | + | + | |
| *Negative associations* | | | | | | | | |
| Orbitofrontal cortex | | | | - | | | | - |
| Insula | | | | | - | | | |
| DLPFC | | | | | | | | - |
| Frontopolar cortex | | | | | | | | - |
| Ventrolateral PFC | | | | | | | | - |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Dorsomedial PFC | | | | | | | | - |
| Anterior cingulate | | | | | | | | - |
| Angular gyrus | | | | | | | | - |
| | | | | | | | | |
| **Antisocial (Facet 4)** | | | | | | | | |
| *Positive associations* | | | | | | | | |
| Orbitofrontal cortex | + | | | | ± | + | + | |
| Frontopolar cortex | + | + | + | + | + | + | + | + |
| Lateral PFC | + | | | + | | + | + | |
| Insula | + | | + | + | + | + | + | |
| Temporal pole | | | + | | | + | | |
| Angular gyrus | | | + | + | | | + | |
| Supramarginal gyrus | + | | + | | + | + | + | |
| DLPFC | | | + | + | | + | | |
| Dorsomedial PFC | + | | + | + | + | | | |
| Anterior cingulate | + | + | + | + | + | | | |
| Ventrolateral PFC | | | | | + | + | + | |
| Ventromedial PFC | + | | | | | | | |
| Middle frontal gyrus | + | | | | | | | |
| *Negative associations* | | | | | | | | |
| Angular gyrus | | | | - | | | | - |
| Orbitofrontal cortex | | | - | - | | | | - |
| Temporal pole | - | | | - | | | | |
| Inferior parietal lobule | | | | | - | | | |
| Insula | | | | | - | | | - |
| Anterior cingulate | | | | | | | | - |
| DLPFC | | | | | | | | - |
| Frontopolar cortex | | | | | | | | - |

*Note.* This table is intended to provide an easier comparison of associations from the different contrasts. Between the different contrasts, associations for each region do not represent the exact same coordinates, but are found within the specified brain region. For specific coordinates, see Tables 4-8, S4 and S6. Black shading indicates significance at $p < 0.05$ after FWE correction. Dark gray shading indicates significance at $p < 0.01$ uncorrected for voxel-wise comparison. Light grey shading indicates significant at $p < 0.05$ uncorrected for voxel-wise comparison.

Table 4. Brain regions associated with psychopathy scores for the contrast lie vs. truth.

| | BA | x | y | z | T |
|---|---|---|---|---|---|
| Total Psychopathy | | | | | |
| *Positive associations* | | | | | |
| **Frontopolar cortex** | **10** | **-28** | **62** | **8** | **3.01** |
| | | **-14** | **60** | **4** | **2.75** |
| | | -22 | 62 | 10 | 2.57 |
| | | 8 | 64 | 14 | 2.17 |
| | | 24 | 58 | 2 | 2.17 |
| Supramarginal gyrus | 40 | -44 | -48 | 36 | 2.58 |
| | | -54 | -42 | 42 | 2.05 |
| Insula | 13 | -36 | -6 | 22 | 2.57 |
| Lateral frontal cortex | 9 | -46 | -2 | 24 | 1.93 |
| *Negative associations* | | | | | |
| None | | | | | |
| | | | | | |
| Interpersonal (Facet 1) | | | | | |
| *Positive associations* | | | | | |
| **Angular gyrus** | **40** | **-46** | **-50** | **40** | **2.69** |
| Insula | 13 | 28 | -32 | 18 | 2.53 |
| | | -60 | -44 | 20 | 2.08 |
| Superior parietal lobule | 40 | 50 | -40 | 60 | 2.45 |
| Supramarginal gyrus | 40 | -66 | -42 | 22 | 2.31 |
| Frontopolar cortex | 10 | -34 | 62 | 8 | 2.15 |
| | | -36 | 60 | 14 | 1.84 |
| Lateral frontal cortex | 9 | -46 | 2 | 24 | 2.09 |
| | | 48 | 0 | 24 | 2.08 |
| *Negative associations* | | | | | |
| DLPFC | 10 | -32 | 56 | 28 | -2.18 |
| | | | | | |
| Affective (Facet 2) | | | | | |
| *Positive associations* | | | | | |
| **Frontopolar cortex** | **10** | **-28** | **62** | **6** | **2.97** |
| | | -12 | 64 | 6 | 2.62 |
| | | -22 | 64 | 10 | 2.26 |
| | | 6 | 64 | 14 | 2.06 |
| | | 24 | 58 | 2 | 1.78 |
| | | 22 | 56 | -6 | 2.15 |
| **Supramarginal gyrus** | **40** | **-44** | **-48** | **36** | **2.67** |
| | | -62 | -50 | 22 | 2.08 |
| Insula | 13 | -36 | -6 | 22 | 2.47 |
| Superior parietal lobule | 40 | 52 | -36 | 60 | 1.97 |
| Lateral frontal cortex | 9 | -46 | -2 | 24 | 1.89 |
| | | | | | |
| *Negative associations* | | | | | |
| Orbitofrontal cortex | 11 | 44 | 46 | -14 | -1.81 |
| DLPFC | 10 | -32 | 58 | 24 | -1.85 |
| | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| Lifestyle (Facet 3) | | | | | |
| *Positive associations* | | | | | |
| **Supramarginal gyrus** | **40** | **-44** | **-46** | **36** | **2.82** |
| | | 36 | -50 | 44 | 2.24 |
| Frontopolar cortex | 10 | -14 | 60 | 4 | 2.62 |
| | | -28 | 62 | 6 | 2.59 |
| | | -22 | 66 | 10 | 2.35 |
| | | 8 | 64 | 14 | 2.21 |
| | | 40 | 60 | 12 | 2.07 |
| | | 22 | 56 | -6 | 1.94 |
| Insula | 13 | -46 | -46 | 18 | 2.47 |
| DLPFC | 9 | -50 | 4 | 34 | 2.02 |
| | | 52 | 18 | 26 | 1.94 |
| | | | | | |
| *Negative associations* | | | | | |
| None | | | | | |
| | | | | | |
| Antisocial (Facet 4) | | | | | |
| *Positive associations* | | | | | |
| **Frontopolar cortex** | **10, 11, 32** | **-14** | **60** | **4** | **4.13** |
| | **10, 11, 32** | **16** | **56** | **2** | **3.42** |
| | 10 | -26 | 62 | -6 | 1.96 |
| **Orbitofrontal cortex** | **11** | **24** | **50** | **-14** | **2.81** |
| **Insula** | **13** | **-38** | **-2** | **18** | **2.74** |
| Anterior cingulate | 9, 32 | 20 | 34 | 24 | 2.49 |
| | 32 | -2 | 40 | -4 | 1.87 |
| Ventromedial PFC | 11,32 | -4 | 40 | -18 | 2.36 |
| Dorsomedial PFC | 9, 10, 32 | -10 | 40 | 28 | 2.28 |
| | | 14 | 48 | 10 | 2.22 |
| Middle frontal gyrus | 10 | 34 | 40 | 10 | 2.11 |
| Supramarginal gyrus | 40 | -60 | -64 | 32 | 1.92 |
| Lateral PFC | 10 | -36 | 38 | 14 | 1.88 |
| *Negative associations* | | | | | |
| Temporal pole | 38 | **-34** | **20** | **-30** | **-3.21** |
| | | **32** | **16** | **-28** | **-2.66** |

*Note*. Bold indicates that associations were significant at $p < 0.01$ uncorrected for voxel-wise comparison.

Table 5. Brain regions associated with psychopathy (total and facet) scores for the contrast autobiographical lie vs. non-autobiographical lie.

| | BA | x | y | z | T |
|---|---|---|---|---|---|
| Total psychopathy | | | | | |
| *Positive associations* | | | | | |
| **DLPFC** | **8, 9** | **40** | **36** | **38** | **3.34** |
| **Frontopolar cortex** | **10** | **36** | **64** | **6** | **2.96** |
| **Dorsomedial PFC** | **8** | **4** | **42** | **46** | **2.94** |
| | | **-16** | **30** | **58** | **2.84** |
| | | **2** | **22** | **56** | **2.70** |
| | | **-2** | **40** | **46** | **2.69** |
| | | -2 | 20 | 58 | 2.42 |
| **Supramarginal gyrus** | **40** | **62** | **-56** | **24** | **2.82** |
| | | -44 | -32 | 32 | 2.38 |
| Angular gyrus | 40 | 46 | -66 | 44 | 2.61 |
| Anterior cingulate | 32 | -8 | 8 | 52 | 2.24 |
| Postcentral gyrus | 40 | 38 | -30 | 50 | 2.12 |
| Orbitofrontal cortex | 11 | 24 | 52 | -10 | 2.05 |
| | 10 | 22 | 56 | -8 | 1.81 |
| Temporal pole | 38 | -42 | 20 | -22 | 2.03 |
| *Negative associations* | | | | | |
| None | | | | | |
| | | | | | |
| Interpersonal (Facet 1) | | | | | |
| *Positive associations* | | | | | |
| Frontopolar cortex | 9 | 28 | 52 | 38 | 2.29 |
| | 10 | 40 | 54 | 24 | 1.80 |
| | 10 | 42 | 56 | 18 | 1.78 |
| DLPFC | 8 | 32 | 18 | 58 | 2.27 |
| | 9 | 58 | 20 | 30 | 2.13 |
| | 9 | -56 | 12 | 38 | 1.98 |
| *Negative associations* | | | | | |
| **Temporal pole** | **38** | **52** | **16** | **-16** | **-2.80** |
| | | -32 | 8 | -22 | -2.40 |
| Angular gyrus | 40 | -54 | -62 | 42 | -2.33 |
| Supramarginal gyrus | 40 | -60 | -62 | 30 | -2.11 |
| Orbitofrontal cortex | 11 | 42 | 36 | -14 | -1.86 |
| | | | | | |
| Affective (Facet 2) | | | | | |
| *Positive associations* | | | | | |
| **DLPFC** | **8, 9** | **34** | **30** | **50** | **3.41** |
| | 9 | -44 | 32 | 42 | 2.34 |
| | 10 | 40 | 40 | 28 | 2.29 |
| | 8, 9 | -54 | 12 | 42 | 2.24 |
| **Lateral PFC** | **9** | **54** | **0** | **26** | **2.68** |
| Frontopolar cortex | 10 | 18 | 66 | 22 | 2.48 |
| | | 2 | 54 | 8 | 2.02 |

| | | | | | |
|---|---|---|---|---|---|
| Dorsomedial PFC | 8 | 4 | 42 | 46 | 2.47 |
| | | 2 | 22 | 56 | 2.36 |
| | | -2 | 40 | 46 | 2.34 |
| Orbitofrontal cortex | 11 | 24 | 52 | -10 | 2.12 |
| Angular gyrus | 40 | 60 | -56 | 26 | 1.92 |
| *Negative associations* | | | | | |
| Temporal pole | 38 | -32 | 8 | -24 | -2.26 |
| Ventrolateral PFC | 10 | 46 | 54 | -6 | -1.89 |
| | | | | | |
| | | | | | |
| Lifestyle (Facet 3) | | | | | |
| *Positive associations* | | | | | |
| **DLPFC** | **8, 9, 10, 32** | **38** | **34** | **36** | **5.21** |
| | 9 | 36 | 4 | 28 | 1.89 |
| | 9 | -46 | 2 | 36 | 1.80 |
| **Dorsomedial PFC** | **8** | **-16** | **30** | **56** | **3.98** |
| | **8, 9, 10, 32** | **-2** | **20** | **56** | **3.76** |
| **Supramarginal gyrus** | **40** | **-54** | **-30** | **32** | **3.48** |
| | **40** | **62** | **-56** | **24** | **3.19** |
| **Temporal pole** | **38** | **-44** | **20** | **-24** | **3.45** |
| **Frontopolar cortex** | **10** | **36** | **64** | **6** | **3.05** |
| | 10, 32 | -14 | 54 | 2 | 2.42 |
| | 10 | -28 | 56 | -2 | 2.40 |
| | 9 | -30 | 50 | 36 | 2.09 |
| | 10 | 10 | 52 | 16 | 1.88 |
| **Postcentral gyrus** | **40** | **38** | **-30** | **50** | **2.82** |
| Insula | 13 | 26 | 20 | -10 | 2.63 |
| | | -40 | 24 | 8 | 2.46 |
| Orbitofrontal cortex | 11 | 24 | 52 | -10 | 2.21 |
| | 11 | 24 | 26 | -14 | 2.18 |
| *Negative associations* | | | | | |
| None | | | | | |
| | | | | | |
| Antisocial (Facet 4) | | | | | |
| *Positive associations* | | | | | |
| **Supramarginal gyrus** | **40** | **62** | **-52** | **24** | **3.89** |
| **Frontopolar cortex** | **10** | **36** | **64** | **6** | **3.28** |
| | | **-4** | **66** | **10** | **2.84** |
| | | 2 | 66 | 12 | 2.27 |
| **DLPFC** | **8, 9** | **28** | **42** | **44** | **3.03** |
| | 8, 9 | -28 | 40 | 44 | 2.54 |
| | 9 | -32 | 46 | 34 | 2.36 |
| | 9 | 52 | 0 | 26 | 1.98 |
| **Dorsomedial PFC** | **8** | **4** | **42** | **48** | **2.72** |
| | 8 | -2 | 40 | 46 | 2.56 |
| | 8, 32 | 2 | 14 | 54 | 2.09 |
| | 8 | -16 | 30 | 58 | 2.08 |

| | | | | | |
|---|---|---|---|---|---|
| **Supramarginal gyrus** | **40** | **-44** | **-32** | **32** | **2.67** |
| | 40 | 38 | -30 | 50 | 2.48 |
| Angular gyrus | 40 | 44 | -66 | 44 | 2.52 |
| Anterior cingulate | 32 | -8 | 8 | 52 | 2.43 |
| Insula | 13 | 36 | -22 | 22 | 2.15 |
| | | -36 | -18 | 22 | 2.09 |
| Temporal pole | 38 | -44 | 20 | -24 | 1.89 |
| *Negative associations* | | | | | |
| Orbitofrontal cortex | 11 | 42 | 50 | -14 | -2.13 |
| | | -38 | 34 | -14 | -1.88 |

*Note*. Bold indicates that associations were significant at $p < 0.01$ uncorrected for voxel-wise comparison.

Table 6. Brain regions associated with psychopathy (total and facet) scores for the contrast autobiographical lie vs. autobiographical truth.

| | BA | x | y | z | T |
|---|---|---|---|---|---|
| Total psychopathy | | | | | |
| *Positive associations* | | | | | |
| **Lateral frontal cortex** | **9** | **-36** | **4** | **28** | **3.31** |
| | | **-46** | **12** | **30** | **3.01** |
| | | 48 | 16 | 28 | 2.41 |
| | | -30 | 12 | 42 | 1.96 |
| **Insula** | **13** | **-34** | **-6** | **22** | **3.38** |
| | | 42 | 12 | 14 | 2.23 |
| **Frontopolar cortex** | **10** | **-22** | **62** | **10** | **3.20** |
| | | -30 | 62 | 0 | 2.34 |
| | | -14 | 60 | 4 | 2.17 |
| | | 24 | 54 | 6 | 2.06 |
| **Supramarginal gyrus** | **40** | **-44** | **-34** | **32** | **3.19** |
| | | **-44** | **-42** | **36** | **2.74** |
| **Inferior frontal gyrus** | **9** | **34** | **4** | **28** | **2.88** |
| Anterior cingulate | 32 | 12 | 34 | -8 | 2.46 |
| | | 18 | 34 | 24 | 2.02 |
| | | -16 | 12 | 38 | 1.91 |
| DLPFC | 9 | 30 | 36 | 30 | 2.26 |
| | 10 | 40 | 40 | 20 | 2.07 |
| Dorsomedial PFC | 9 | -4 | 40 | 34 | 2.22 |
| | 8 | 2 | 20 | 54 | 2.20 |
| | 9 | 2 | 40 | 36 | 2.07 |
| | 8 | -4 | 24 | 56 | 2.03 |
| *Negative associations* | | | | | |
| Orbitofrontal cortex | 11 | 42 | 48 | -14 | -2.38 |
| Angular gyrus | 40 | 40 | -58 | 42 | -1.87 |
| DLPFC | 10 | -32 | 58 | 26 | -1.83 |
| | | | | | |
| Interpersonal (Facet 1) | | | | | |
| *Positive associations* | | | | | |
| **Lateral PFC** | **8, 9** | **-62** | **4** | **24** | **3.23** |
| | **9** | **46** | **-2** | **24** | **2.88** |
| DLPFC | 8 | 30 | 12 | 42 | 2.41 |
| | 9 | -54 | 20 | 38 | 2.35 |
| | 8 | -28 | 12 | 42 | 1.94 |
| **Insula** | **13** | **-36** | **-6** | **22** | **2.79** |
| | | **28** | **-32** | **18** | **2.79** |
| Frontopolar cortex | 10 | -34 | 62 | 8 | 2.37 |
| | 10 | -36 | 60 | 14 | 2.05 |
| Supramarginal gyrus | 40 | -42 | -32 | 32 | 2.36 |
| | 40 | -44 | -42 | 36 | 2.22 |
| Anterior cingulate | 32 | -16 | 10 | 48 | 2.18 |
| | 10, 32 | 12 | 34 | -10 | 2.03 |
| | 32 | 16 | 8 | 38 | 2.02 |

| | | | | | |
|---|---|---|---|---|---|
| Orbitofrontal cortex | 11 | 24 | 42 | -10 | 2.17 |
| *Negative associations* | | | | | |
| Frontopolar cortex | 10 | -32 | 56 | 28 | -2.41 |
| | 10 | 22 | 62 | 18 | -2.01 |
| | 10 | -4 | 60 | 16 | -1.81 |
| Orbitofrontal cortex | 11 | 42 | 50 | -14 | -1.88 |
| DLPFC | 8 | 20 | 32 | 58 | -1.81 |
| | | | | | |
| Affective (Facet 2) | | | | | |
| *Positive associations* | | | | | |
| **Lateral PFC** | **9** | **-36** | **4** | **28** | **3.53** |
| | **8, 9** | **-46** | **10** | **30** | **2.77** |
| | 9 | 36 | 4 | 28 | 2.53 |
| **Insula** | **13** | **-34** | **-6** | **22** | **3.46** |
| | | 42 | 10 | 12 | 2.01 |
| **Frontopolar cortex** | **10** | **-30** | **64** | **4** | **3.10** |
| | 10 | -38 | 60 | 2 | 2.46 |
| **Supramarginal gyrus** | **40** | **-44** | **-34** | **32** | **2.93** |
| | 40 | -44 | -42 | 36 | 2.41 |
| Anterior cingulate | 10, 32 | 12 | 34 | -10 | 2.49 |
| DLPFC | 9 | -54 | 20 | 38 | 2.17 |
| | 8 | -28 | 12 | 42 | 1.84 |
| *Negative associations* | | | | | |
| Frontopolar cortex | 10 | -32 | 58 | 26 | -2.35 |
| Orbitofrontal cortex | 11 | 42 | 48 | -14 | -2.31 |
| | | | | | |
| Lifestyle (Facet 3) | | | | | |
| *Positive associations* | | | | | |
| **Lateral PFC** | **8, 9** | **-48** | **12** | **32** | **4.13** |
| | **9** | **-38** | **4** | **28** | **3.58** |
| | **9** | **48** | **16** | **28** | **3.43** |
| | **9** | **36** | **4** | **30** | **3.39** |
| | **9** | **-54** | **26** | **34** | **3.10** |
| | 8 | 28 | 12 | 42 | 1.99 |
| **Angular gyrus** | **40** | **-44** | **-34** | **32** | **3.97** |
| **Frontopolar cortex** | **10** | **-28** | **62** | **8** | **3.54** |
| | **10** | **40** | **40** | **24** | **3.24** |
| | 10 | -14 | 58 | 4 | 2.38 |
| | 9, 10 | -38 | 40 | 24 | 2.32 |
| | 10 | -36 | 60 | 14 | 2.30 |
| | 10 | 24 | 54 | 6 | 2.10 |
| **Dorsomedial PFC/ Anterior cingulate** | **8, 9, 10, 32** | **4** | **18** | **52** | **3.08** |
| | **9, 10, 32** | **-6** | **48** | **26** | **2.84** |
| **Insula** | **13** | **-34** | **-6** | **22** | **3.05** |
| | | 28 | -32 | 20 | 2.59 |
| **Anterior cingulate** | **8, 32** | **-4** | **22** | **46** | **2.69** |
| | **32** | **-16** | **12** | **38** | **2.65** |
| | 10, 32 | 12 | 34 | -8 | 2.48 |

| | | | | | |
|---|---|---|---|---|---|
| | 32 | -12 | 22 | 26 | 2.46 |
| | 10, 32 | 8 | 50 | -4 | 2.04 |
| DLPFC | 9 | 22 | 44 | 36 | 2.27 |
| | 8 | -22 | 16 | 48 | 1.84 |
| Supramarginal gyrus | 40 | 62 | -32 | 38 | 2.23 |
| *Negative associations* | | | | | |
| Orbitofrontal cortex | 11 | 42 | 48 | -14 | -1.91 |
| | | | | | |
| Antisocial (Facet 4) | | | | | |
| *Positive associations* | | | | | |
| **Frontopolar cortex** | **10** | **-22** | **62** | **10** | **4.18** |
| | **10** | **-28** | **62** | **8** | **3.77** |
| | **10** | **24** | **56** | **8** | **3.09** |
| | **10** | **-14** | **60** | **4** | **2.75** |
| | 10, 32 | 14 | 56 | 4 | 2.46 |
| | 10 | 40 | 40 | 22 | 2.32 |
| **Insula** | **13** | **-36** | **-6** | **22** | **2.71** |
| | | 42 | 12 | 14 | 2.06 |
| Lateral PFC | 9 | 50 | 18 | 26 | 2.54 |
| | 9 | -46 | 12 | 30 | 2.30 |
| | 9 | -40 | 26 | 38 | 2.30 |
| Angular gyrus | 40 | -46 | -36 | 36 | 2.50 |
| Anterior cingulate | 9, 32 | -18 | 38 | 26 | 2.30 |
| | 9 | -6 | 48 | 26 | 2.29 |
| | 9, 32 | 20 | 36 | 24 | 2.27 |
| | 10, 32 | 12 | 34 | -8 | 2.15 |
| Dorsomedial PFC | 9 | 4 | 48 | 34 | 2.20 |
| DLPFC | 9 | 34 | 34 | 34 | 1.91 |
| *Negative associations* | | | | | |
| Angular gyrus | 40 | 46 | -64 | 42 | -2.38 |
| | 40 | -42 | -66 | 48 | -1.88 |
| Orbitofrontal cortex | 11 | 42 | 48 | -14 | -2.13 |
| Temporal pole | 38 | -32 | 8 | -22 | -2.10 |

*Note*. Bold indicates that associations were significant at $p < 0.01$ uncorrected for voxel-wise comparison.

Table 7. Brain regions associated with psychopathy (total and facet) scores for the contrast criminal lie vs. non-criminal lie.

| | BA | x | y | z | T |
|---|---|---|---|---|---|
| Total psychopathy | | | | | |
| *Positive associations* | | | | | |
| **Dorsal PFC / Anterior cingulate** | **8, 9, 10, 11, 32** | **18** | **36** | **22** | **3.89** |
| | | **-10** | **48** | **26** | **3.72** |
| | 32 | 16 | 12 | 38 | 2.07 |
| | 32 | 18 | 6 | 50 | 1.98 |
| | 8 | 4 | 24 | 50 | 1.77 |
| **Orbitofrontal cortex** | **10, 11** | **28** | **42** | **-6** | **3.73** |
| | **11** | **-24** | **28** | **-12** | **2.73** |
| **Insula** | **13** | **-44** | **24** | **10** | **3.42** |
| | | **42** | **12** | **12** | **3.34** |
| **Frontopolar cortex** | **10,11** | **-28** | **56** | **8** | **3.26** |
| **Lateral frontal cortex** | **9** | **44** | **-4** | **26** | **3.15** |
| | | **36** | **4** | **28** | **2.74** |
| | | -36 | 4 | 28 | 2.63 |
| Inferior frontal gyrus | 10 | 54 | 42 | 0 | 2.47 |
| | | -52 | 42 | 0 | 1.93 |
| DLPFC | 9 | -30 | 50 | 36 | 2.21 |
| | 8 | -28 | 12 | 42 | 2.15 |
| | 8 | -20 | 28 | 58 | 2.13 |
| | 9 | -54 | 20 | 38 | 2.10 |
| Ventromedial PFC | 10 | 10 | 56 | -6 | 2.18 |
| Postcentral gyrus | 40 | 64 | -22 | 20 | 1.91 |
| **Temporal pole** | **38** | **50** | **0** | **-12** | **2.73** |
| *Negative associations* | | | | | |
| None | | | | | |
| | | | | | |
| Interpersonal (Facet 1) | | | | | |
| *Positive associations* | | | | | |
| Lateral PFC | 9 | -48 | 16 | 28 | 2.15 |
| | 9 | -48 | 34 | 36 | 2.14 |
| Frontopolar cortex | 10 | -38 | 58 | 14 | 1.97 |
| Anterior cingulate | 32 | -6 | 24 | -8 | 1.97 |
| Orbitofrontal cortex | 11 | 38 | 36 | -12 | 1.79 |
| Insula | 13 | -36 | -6 | 20 | 2.21 |
| | | 28 | 20 | -4 | 1.94 |
| *Negative associations* | | | | | |
| None | | | | | |
| | | | | | |
| Affective (Facet 2) | | | | | |
| *Positive associations* | | | | | |
| **Frontopolar cortex** | **10** | **-46** | **46** | **16** | **3.10** |
| | 10, 32 | -20 | 50 | 2 | 1.98 |

| | | | | | |
|---|---|---|---|---|---|
| **Orbitofrontal cortex** | **10, 11** | **28** | **42** | **-6** | **2.93** |
| | **11** | **-30** | **42** | **-6** | **2.85** |
| **Insula** | **13** | **42** | **12** | **12** | **2.91** |
| | | -34 | 4 | 18 | 2.63 |
| **Anterior cingulate** | **9, 10, 32** | **18** | **36** | **22** | **2.83** |
| | **8, 9, 10, 32** | **-18** | **42** | **16** | **2.82** |
| | 32 | 4 | 32 | -6 | 2.28 |
| | 32 | -16 | 10 | 40 | 2.15 |
| | 32 | 10 | 16 | 30 | 1.84 |
| Lateral PFC | 9 | 44 | -4 | 26 | 2.56 |
| | 9 | -52 | 28 | 36 | 2.55 |
| | 9 | -36 | 4 | 28 | 2.13 |
| Temporal pole | 38 | 50 | 0 | -12 | 2.33 |
| Ventrolateral PFC | 10 | 54 | 40 | 0 | 2.19 |
| DLPFC | 9 | 34 | 32 | 34 | 2.18 |
| | 9 | -18 | 48 | 36 | 2.15 |
| Dorsomedial PFC | 9 | 12 | 48 | 26 | 2.04 |
| *Negative associations* | | | | | |
| None | | | | | |
| | | | | | |
| Lifestyle (Facet 3) | | | | | |
| *Positive associations* | | | | | |
| **Orbitofrontal cortex** | **10, 11** | **28** | **42** | **-6** | **4.14** |
| | **11** | **-26** | **38** | **-6** | **3.08** |
| | **11** | **-24** | **30** | **-12** | **2.94** |
| **Anterior cingulate** | **8, 9, 10, 11, 32** | **18** | **36** | **22** | **4.05** |
| | **8, 9, 10, 11, 32** | **-4** | **32** | **-6** | **3.96** |
| **Lateral PFC** | **9** | **44** | **-4** | **26** | **3.61** |
| | | -36 | 4 | 28 | 2.47 |
| **Insula** | **13** | **42** | **12** | **12** | **3.39** |
| | | **-44** | **24** | **10** | **3.33** |
| **Frontopolar cortex** | **10** | **-24** | **52** | **8** | **3.11** |
| **DLPFC** | **9** | **30** | **32** | **34** | **2.70** |
| | 9 | -30 | 50 | 36 | 2.50 |
| | 8 | -28 | 12 | 42 | 2.26 |
| | 8 | -16 | 30 | 54 | 2.25 |
| | 9 | -54 | 20 | 38 | 2.16 |
| **Ventrolateral PFC** | **10** | **54** | **40** | **0** | **2.70** |
| | | -52 | 42 | 0 | 1.78 |
| Temporal pole | 38 | 50 | 0 | -12 | 2.34 |
| Supramarginal gyrus | 40 | 64 | -22 | 20 | 2.05 |
| | | 54 | -30 | 24 | 1.96 |
| Anterior cingulate | 32 | 16 | 4 | 42 | 1.96 |
| Dorsomedial PFC | 8 | 8 | 36 | 50 | 1.89 |
| | | 14 | 38 | 54 | 1.80 |
| *Negative associations* | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| None | | | | | |
| | | | | | |
| Antisocial (Facet 4) | | | | | |
| *Positive associations* | | | | | |
| **Orbitofrontal cortex** | **8, 9, 10, 11, 32** | **-12** | **34** | **-10** | **5.16** |
| | **11** | **-24** | **28** | **-12** | **3.79** |
| | **11** | **34** | **38** | **-12** | **3.14** |
| **Frontopolar cortex** | **8, 9, 10, 11, 32** | **6** | **60** | **16** | **4.58** |
| **Insula** | **13** | **42** | **12** | **12** | **3.73** |
| | | **-44** | **24** | **10** | **3.57** |
| **Temporal pole** | **38** | **50** | **0** | **-12** | **3.35** |
| | | -54 | 0 | -8 | 2.14 |
| **Supramarginal gyrus** | **40** | **66** | **-24** | **18** | **3.11** |
| | 40 | -56 | -26 | 14 | 2.16 |
| | 40 | 50 | -30 | 32 | 2.16 |
| | 40 | -62 | -24 | 30 | 1.84 |
| **DLPFC** | **9** | **-30** | **50** | **36** | **2.95** |
| **Lateral PFC** | **9** | **-36** | **4** | **28** | **2.88** |
| | **9** | **36** | **4** | **28** | **2.86** |
| Ventrolateral PFC | 10 | -52 | 42 | 0 | 2.18 |
| *Negative associations* | | | | | |
| None | | | | | |

*Note*. Underline indicates that associations were significant at $p < 0.05$ after FWE correction. Bold indicates that associations were significant at $p < 0.01$ uncorrected for voxel-wise comparison.

Table 8. Brain regions associated with psychopathy (total and facet) scores for the contrast criminal lie vs. criminal truth.

| | BA | x | y | z | T |
|---|---|---|---|---|---|
| Total psychopathy | | | | | |
| *Positive associations* | | | | | |
| **Anterior cingulate** | **8, 9, 10, 11, 32** | **20** | **36** | **22** | **4.54** |
| **Lateral PFC** | **9** | **36** | **4** | **28** | **4.26** |
| | | **-36** | **4** | **28** | **4.01** |
| | | **40** | **40** | **22** | **3.38** |
| **Insula** | **13** | **-34** | **-6** | **22** | **4.28** |
| | | **32** | **6** | **18** | **3.58** |
| **DLPFC** | **8, 9, 10, 32** | **-34** | **20** | **34** | **4.12** |
| **Frontopolar cortex** | **10, 11** | **24** | **50** | **4** | **3.21** |
| Inferior parietal lobule | 40 | -58 | -42 | 48 | 2.59 |
| Angular gyrus | 40 | 42 | -52 | 52 | 2.56 |
| Temporal pole | 38 | -46 | -46 | 18 | 2.42 |
| Orbitofrontal cortex | 11 | -26 | 38 | -6 | 2.33 |
| | | 24 | 34 | -12 | 1.81 |
| Supramarginal gyrus | 40 | -44 | -48 | 34 | 2.21 |
| Ventromedial PFC | 10 | 10 | 56 | -6 | 2.15 |
| Postcentral gyrus | 40 | 62 | -30 | 18 | 1.88 |
| *Negative associations* | | | | | |
| None | | | | | |
| | | | | | |
| Interpersonal (Facet 1) | | | | | |
| *Positive associations* | | | | | |
| **DLPFC** | **8, 9, 32** | **30** | **12** | **42** | **3.11** |
| | **9** | **36** | **4** | **32** | **2.84** |
| | **8, 9, 10, 32** | **-42** | **16** | **54** | **2.67** |
| | 9 | -38 | 4 | 32 | 2.40 |
| | 9 | -20 | 38 | 36 | 2.09 |
| | 10 | 32 | 42 | 28 | 1.77 |
| **Insula** | **13** | **-34** | **-6** | **22** | **3.07** |
| | | 40 | -40 | 20 | 2.07 |
| Anterior cingulate | 32 | -14 | 4 | 42 | 3.00 |
| | | 16 | 4 | 46 | 2.40 |
| | | 10 | 22 | 26 | 2.13 |
| | | -12 | 24 | 26 | 2.07 |
| | 9, 32 | 6 | 38 | 20 | 1.88 |
| Supramarginal gyrus | 40 | -58 | -42 | 48 | 2.36 |
| | | 52 | -36 | 60 | 2.05 |
| | | 56 | -32 | 54 | 2.00 |
| Orbitofrontal cortex | 11 | 24 | 38 | -6 | 2.21 |
| Dorsomedial PFC | 9 | -4 | 44 | 38 | 2.09 |
| | 8 | -20 | 30 | 56 | 1.92 |

| | | | | | |
|---|---|---|---|---|---|
| Frontopolar cortex | 10 | -20 | 48 | 0 | 1.81 |
| *Negative associations* | | | | | |
| None | | | | | |
| | | | | | |
| Affective (Facet 2) | | | | | |
| *Positive associations* | | | | | |
| **Lateral PFC** | **9** | **36** | **4** | **28** | **4.09** |
| | **9** | **-36** | **4** | **28** | **3.82** |
| | **8, 9, 10, 32** | **40** | **2** | **28** | **3.77** |
| | **8, 9, 10, 32** | **-40** | **20** | **34** | **3.72** |
| | **9, 10** | **34** | **40** | **22** | **2.79** |
| **Insula** | **13** | **-34** | **-6** | **22** | **4.05** |
| | | **32** | **4** | **18** | **3.36** |
| **Angular gyrus** | **40** | **-52** | **-52** | **50** | **2.89** |
| | **40** | **42** | **-42** | **40** | **2.69** |
| | 40 | -44 | -48 | 34 | 2.02 |
| | 40 | 38 | -38 | 60 | 2.02 |
| Orbitofrontal cortex | 10, 11 | 26 | 54 | -2 | 2.62 |
| | 11 | -26 | 38 | -6 | 2.38 |
| | 10, 32 | 20 | 50 | 2 | 2.30 |
| | 10, 32 | -18 | 44 | -2 | 2.06 |
| Anterior cingulate | 10, 32 | 2 | 36 | -2 | 2.11 |
| Frontopolar cortex | 10 | -14 | 62 | 24 | 2.03 |
| Dorsomedial PFC | 8 | -18 | 46 | 44 | 1.80 |
| *Negative associations* | | | | | |
| None | | | | | |
| | | | | | |
| Lifestyle (Facet 3) | | | | | |
| *Positive associations* | | | | | |
| **Anterior cingulate** | **8, 9, 10, 11, 32** | **20** | **36** | **24** | **5.04** |
| **DLPFC** | **9** | **36** | **4** | **32** | **4.85** |
| **Lateral PFC** | **8, 9, 10, 11, 32** | **-42** | **40** | **24** | **4.74** |
| | **9** | **-36** | **4** | **28** | **4.44** |
| | 40 | -64 | -24 | 22 | 1.99 |
| **Insula** | **13** | **-34** | **0** | **18** | **4.11** |
| | | **32** | **6** | **18** | **3.74** |
| **Angular gyrus** | **40** | **46** | **-46** | **46** | **3.52** |
| | 40 | 54 | -56 | 32 | 2.04 |
| **Supramarginal gyrus** | **40** | **-62** | **-24** | **30** | **3.20** |
| DLPFC | 9 | -30 | 50 | 36 | 2.35 |
| Temporal pole | 38 | 50 | -2 | -8 | 2.15 |
| Orbitofrontal cortex | 11 | 24 | 34 | -12 | 2.05 |
| | 10 | -10 | 56 | -6 | 1.89 |
| Ventrolateral PFC | 10 | -52 | 42 | 0 | 1.81 |
| *Negative associations* | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| None | | | | | |
| | | | | | |
| Antisocial (Facet 4) | | | | | |
| *Positive associations* | | | | | |
| **Frontopolar cortex** | **8, 9, 10, 11, 32** | **8** | **62** | **16** | **4.83** |
| | **8, 9, 10, 11, 32** | **-22** | **62** | **10** | **4.58** |
| | **10** | **-26** | **58** | **8** | **3.89** |
| **Lateral PFC** | **9** | **-36** | **4** | **28** | **3.51** |
| | **9** | **36** | **4** | **28** | **3.23** |
| | 9 | -54 | 20 | 38 | 2.64 |
| **Insula** | **13** | **-34** | **0** | **18** | **3.24** |
| | | **32** | **6** | **18** | **3.14** |
| **Angular gyrus** | **40** | **52** | **-48** | **46** | **3.06** |
| **Supramarginal gyrus** | **40** | **-66** | **-26** | **30** | **2.71** |
| | 40 | -44 | -48 | 34 | 2.33 |
| | 40 | -64 | -24 | 22 | 2.18 |
| Orbitofrontal cortex | 11 | -44 | 34 | -14 | 2.48 |
| | 11 | 46 | 44 | -10 | 1.96 |
| Ventrolateral PFC | 10 | 50 | 42 | 0 | 2.26 |
| | 10 | -52 | 42 | 0 | 2.15 |
| *Negative associations* | | | | | |
| None | | | | | |

*Note*. Underline indicates that associations were significant at $p < 0.05$ after FWE correction. Bold indicates that associations were significant at $p < 0.01$ uncorrected for voxel-wise comparison.

Supplementary Materials for Glenn, A.L., Han, H. Yang, Y. Raine, A. & Schug, R.A. Associations between psychopathic traits and brain activity during instructed false responding.

Supplementary Methods:

Because of the correlation nature of our study, it was not feasible to first conduct higher-level interactions before examining simple contrasts. The interaction analyses (e.g., lie x autobiographical) would have reflected regions in which psychopathy scores were correlated with the interaction term (F-value). Within each significant region, we would need to figure out how that interaction term was arrived upon for each individual (e.g., what the plot of activity for the lie x autobiographical interaction looks like), and it is likely that these interactions would be different for each person. Thus, we did not think that interaction analyses would provide useful information. Follow-up tests examining simple contrasts (of the type presented in the current study) reflect a different correlation test that is not related to the correlation test that would have been conducted in an interaction analysis.

Supplementary Results:

Table S1. Brain areas active for the contrast lie versus truth across the whole sample (main effect). A voxel-wise threshold of $p < 0.05$ FWE and a cluster-wise threshold of $p < 0.001$ after applying SnPM was used and 5,000 permutations were performed.

| | BA | x | y | z | T | k |
|---|---|---|---|---|---|---|
| DLPFC | 8,9 | 40 | 18 | 50 | 4.82 | 313 |
| Frontopolar cortex | 10 | 40 | 56 | 14 | 4.57 | 134 |
| Inferior parietal lobule | 40 | 50 | -44 | 50 | 4.42 | 162 |

Table S2. Overview of the strongest associations with psychopathy total and facet scores for each contrast.

| | Lie vs. truth | Criminal vs. non-criminal | Autobiographical lie vs. non-autobiographical lie | Autobiographical lie vs. autobiographical truth | Non-autobiographical lie vs. non-autobiographical truth | Criminal lie vs. non-criminal lie | Criminal lie vs. criminal truth | Non-criminal lie vs. non-criminal truth |
|---|---|---|---|---|---|---|---|---|
| | r | r | r | r | r | r | r | r |
| **Total Psychopathy** | | | | | | | | |
| *Positive association* | | | | | | | | |
| Anterior cingulate | | 0.51 | 0.53 | 0.56 | | | **0.78** | |
| Lateral frontal cortex | 0.47 | | | **0.68** | | **0.66** | **0.76** | |
| Insula | 0.58 | | | **0.68** | 0.45 | **0.69** | **0.76** | 0.55 |
| DLPFC | | | **0.68** | 0.53 | | 0.52 | **0.75** | |
| DLPFC / Anterior cingulate | | | | | | **0.73** | | |
| Orbitofrontal cortex | | | 0.49 | | | **0.72** | 0.54 | |
| Frontopolar cortex | **0.64** | **0.65** | **0.63** | **0.66** | **0.65** | **0.67** | **0.66** | **0.73** |
| Supramarginal gyrus | 0.58 | | **0.62** | **0.66** | **0.61** | | 0.52 | 0.49 |
| Dorsomedial PFC | | | **0.63** | 0.52 | | | | |
| Inferior frontal gyrus | | | | **0.62** | | 0.57 | | |
| Temporal pole | | 0.49 | 0.49 | | | **0.60** | 0.56 | |
| Angular gyrus | | | 0.59 | | | | 0.58 | **0.61** |
| Inferior parietal lobe | | | | | | | 0.58 | |
| Postcentral gyrus | | | 0.51 | | | 0.47 | 0.46 | 0.58 |
| Ventromedial PFC | | | | | | 0.52 | 0.51 | |
| *Negative association* | | | | | | | | |
| Orbitofrontal cortex | | | | -0.55 | | | | -0.61 |
| Angular gyrus | | | | -0.46 | | | | -0.48 |
| DLPFC | | -0.49 | | -0.45 | | | | **-0.63** |
| Insula | | | | | -0.46 | | | |
| Dorsomedial PFC | | | | | | | | **-0.63** |
| Anterior cingulate | | | | | | | | -0.56 |
| Frontopolar cortex | | | | | | | | -0.44 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Postcentral gyrus | | | | | | | | 0.50 |
| | | | | | | | | |
| **Interpersonal (Facet 1)** | | | | | | | | |
| *Positive association* | | | | | | | | |
| Lateral frontal cortex | 0.50 | | | **0.67** | | 0.51 | | |
| DLPFC | | | 0.53 | 0.56 | 0.51 | | **0.65** | |
| Insula | 0.57 | | | 0.61 | 0.51 | 0.52 | **0.65** | **0.65** |
| Anterior cingulate | | 0.53 | | 0.52 | | 0.48 | **0.64** | |
| Angular gyrus | **0.60** | | | | | | | **0.81** |
| Superior parietal lobule | 0.56 | | | | | | | |
| Supramarginal gyrus | 0.54 | | | 0.55 | **0.68** | | 0.55 | **0.64** |
| Frontopolar cortex | 0.51 | 0.49 | 0.54 | | | 0.48 | 0.45 | **0.76** |
| Orbitofrontal cortex | | | | 0.52 | | 0.44 | 0.52 | |
| Dorsomedial PFC | | | | | | | 0.50 | |
| Temporal pole | | **0.56** | | | 0.55 | | | 0.58 |
| Postcentral gyrus | | | | | | | | 0.48 |
| *Negative association* | | | | | | | | |
| Temporal pole | | | **-0.61** | | | | | |
| Frontopolar cortex | | | | -0.56 | | | | |
| DLPFC | -0.52 | | | -0.45 | | | | |
| Angular gyrus | | | -0.54 | | | | | |
| Supramarginal gyrus | | | -0.51 | | | | | |
| Orbitofrontal cortex | | | -0.46 | -0.46 | | | | |
| | | | | | | | | |
| **Affective (Facet 2)** | | | | | | | | |
| *Positive association* | | | | | | | | |
| Lateral frontal cortex | 0.46 | | **0.60** | **0.70** | | 0.58 | **0.75** | |
| Insula | 0.57 | | | **0.69** | | 0.63 | 0.**75** | |
| DLPFC | | | **0.69** | .52 | | .52 | | |
| Frontopolar cortex | **0.64** | 0.54 | 0.57 | **0.65** | **0.61** | **0.65** | 0.49 | **0.72** |
| Supramarginal gyrus | **0.60** | | | **0.63** | **0.66** | | | **0.66** |
| Angular gyrus | | | 0.47 | | | | **0.63** | |
| Orbitofrontal cortex | | | 0.51 | | | **0.63** | 0.59 | |
| Anterior cingulate | | **0.60** | | 0.57 | | **0.62** | 0.51 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Dorsomedial PFC | | | 0.57 | | | 0.49 | 0.45 | |
| Temporal pole | | | | | | 0.54 | | |
| Ventrolateral PFC | | | | | | 0.52 | | |
| Superior parietal lobule | 0.48 | | | | | | | |
| Postcentral gyrus | | | | | | | | **-0.64** |
| *Negative association* | | | | | | | | |
| Orbitofrontal cortex | **-0.64** | | | -0.54 | | | | -0.57 |
| DLPFC | **-0.60** | -0.52 | | | -0.49 | | | **-0.64** |
| Ventrolateral PFC | | | -0.46 | | | | | **-0.62** |
| Frontopolar cortex | | | | -0.55 | | | | **-0.72** |
| Temporal pole | | | -0.53 | | | | | |
| Insula | | | | | -0.51 | | | |
| Supramarginal gyrus | | | | | | | | |
| Anterior cingulate | | | | | -0.45 | | | **-0.61** |
| Medial PFC | | | | | | | | -0.45 |
| Lateral PFC | | | | | | | | -0.44 |
| Angular gyrus | | -0.52 | | | | | | |
| **Lifestyle (Facet 3)** | | | | | | | | |
| *Positive association* | | | | | | | | |
| DLPFC | 0.49 | | **0.82** | 0.53 | | **0.60** | **0.80** | |
| Anterior cingulate | | 0.46 | | **0.60** | | **0.75** | **0.81** | |
| Lateral PFC | | | | **0.75** | | **0.71** | **0.80** | |
| Orbitofrontal cortex | | | 0.52 | | | **0.75** | 0.49 | |
| Insula | 0.57 | | 0.59 | **0.65** | | **0.68** | **0.75** | 0.54 |
| Dorsomedial PFC | | | **0.74** | **0.65** | | 0.46 | | |
| Angular gyrus | | | | **0.74** | | | **0.70** | 0.51 |
| Supramarginal gyrus | | | **0.69** | 0.53 | | 0.49 | **0.66** | 0.53 |
| Frontopolar cortex | 0.59 | 0.58 | **0.66** | **0.70** | **0.61** | **0.65** | | **0.74** |
| Temporal pole | | | **0.69** | | | 0.54 | 0.51 | |
| Postcentral gyrus | | | **0.62** | | | | | 0.45 |
| Supramarginal gyrus | **0.62** | | | | 0.56 | | | |
| Ventrolateral PFC | | | | | | **0.60** | 0.45 | |
| *Negative association* | | | | | | | | |
| Orbitofrontal cortex | | | | -0.47 | | | | **-0.60** |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Insula | | | | | -0.48 | | | |
| DLPFC | | | | | | | | **-0.75** |
| Frontopolar cortex | | | | | | | | **-0.65** |
| Ventrolateral PFC | | | | | | | | -0.58 |
| Dorsomedial PFC | | | | | | | | -0.57 |
| Anterior cingulate | | | | | | | | -0.49 |
| Angular gyrus | | | | | | | | -0.47 |
| | | | | | | | | |
| **Antisocial (Facet 4)** | | | | | | | | |
| *Positive association* | | | | | | | | |
| Orbitofrontal cortex | **0.61** | | | | 0.51 | **0.82** | 0.57 | |
| Frontopolar cortex | **0.75** | **0.67** | **0.67** | **0.76** | **0.79** | **0.79** | **0.80** | **0.65** |
| Lateral PFC | 0.46 | | | 0.58 | | **0.62** | **0.70** | |
| Insula | **0.61** | | 0.51 | 0.60 | 0.54 | **0.72** | **0.67** | |
| Temporal pole | | | 0.46 | | | **0.68** | | |
| Angular gyrus | | | 0.57 | 0.57 | | | **0.65** | |
| Supramarginal gyrus | 0.47 | | **0.73** | | 0.51 | **0.65** | **0.60** | |
| DLPFC | | | **0.64** | 0.47 | | **0.63** | | |
| Dorsomedial PFC | 0.53 | | **0.60** | 0.52 | 0.60 | | | |
| Anterior cingulate | 0.57 | **0.62** | 0.56 | 0.54 | 0.49 | | | |
| Ventrolateral PFC | | | | | 0.47 | 0.52 | 0.53 | |
| Ventromedial PFC | 0.55 | | | | | | | |
| Middle frontal gyrus | 0.51 | | | | | | | |
| *Negative association* | | | | | | | | |
| Angular gyrus | | | | -0.55 | | | | |
| Orbitofrontal cortex | | | -0.51 | -0.50 | | | | **-0.65** |
| Temporal pole | **-0.66** | | | -0.50 | | | | |
| Inferior parietal lobule | | | | | -0.46 | | | |
| Insula | | | | | -0.45 | | | **-0.70** |
| Anterior cingulate | | | | | | | | **-0.68** |
| DLPFC | | | | | | | | **-0.66** |
| Frontopolar cortex | | | | | | | | **-0.61** |

*Note.* This table provides the association coefficients for the associations in Table 3. As noted by Yarkoni (2009), in studies with small sample sizes, association sizes can be inflated such that a true association that is only moderate in size appears to be large. Thus, it is highly unlikely that

these association coefficients are actually this high. Between the different contrasts, associations for each region do not represent the exact same coordinates, but are found within the specified brain region. Underline indicates that associations were significant at $p < 0.05$ after FWE correction. Bold values indicate associations that were significant at $p < 0.01$ uncorrected for voxel-wise comparison.

Table S3. Brain regions associated with psychopathy (total and facet) scores for the contrast autobiographical truth vs. non-autobiographical truth.

| | BA | x | y | z | T |
|---|---|---|---|---|---|
| Total Psychopathy | | | | | |
| *Positive association* | | | | | |
| **Frontopolar cortex** | **10** | **22** | **66** | **12** | **3.06** |
| | 10 | -22 | 60 | 2 | 2.33 |
| | 10 | -6 | 58 | -6 | 2.12 |
| | 10 | 24 | 58 | 4 | 1.85 |
| **Medial PFC** | **10, 32** | **-4** | **60** | **8** | **2.93** |
| | 10, 32 | 12 | 58 | 4 | 2.34 |
| Dorsomedial PFC | 9 | 14 | 54 | 42 | 2.50 |
| | 8 | 16 | 50 | 46 | 2.48 |
| | 8, 9 | -10 | 48 | 46 | 2.24 |
| | 8 | -20 | 46 | 46 | 1.94 |
| Supramarginal gyrus | 40 | -54 | -56 | 48 | 2.40 |
| | 40 | 48 | -64 | 42 | 2.37 |
| | 40 | 40 | -48 | 34 | 1.87 |
| | 40 | -56 | -58 | 32 | 1.79 |
| Ventrolateral PFC | 10 | 32 | 56 | -8 | 1.95 |
| | | | | | |
| *Negative association* | | | | | |
| **Anterior cingulate** | **32** | **10** | **16** | **36** | **-3.14** |
| | **32** | **-14** | **12** | **38** | **-2.86** |
| **Insula** | **13** | **38** | **-10** | **18** | **-2.67** |
| | 13 | -50 | 12 | 10 | -2.27 |
| DLPFC | 8, 9 | 58 | 12 | 38 | -2.46 |
| | 9 | -56 | 20 | 34 | -2.43 |
| | 9 | -54 | 20 | 38 | -2.00 |
| Lateral PFC | 9 | -60 | 4 | 24 | -2.13 |
| Supramarginal gyrus | 40 | -44 | -30 | 46 | -2.10 |
| | 40 | 56 | -24 | 16 | -1.88 |
| Interpersonal (Facet 1) | | | | | |
| *Positive association* | | | | | |
| Dorsomedial PFC | 8 | -16 | 30 | 58 | 2.29 |
| | 8 | 16 | 48 | 48 | 2.20 |
| | 8 | -4 | 48 | 48 | 1.80 |
| Frontopolar cortex | 10 | 24 | 66 | 14 | 1.98 |
| Ventrolateral PFC | 10 | -22 | 56 | -6 | 1.78 |
| | | | | | |
| *Negative association* | | | | | |
| **Anterior cingulate** | **32** | **10** | **16** | **36** | **-3.47** |
| | **2** | **-14** | **10** | **40** | **-3.25** |
| Insula | 13, 38 | 38 | -10 | 18 | -2.58 |
| | | -44 | -4 | 12 | -2.15 |
| | | -42 | 2 | -10 | -2.08 |
| Lateral PFC | 9 | -62 | 4 | 24 | -2.42 |

| | | | | | |
|---|---|---|---|---|---|
| Supramarginal gyrus | 40 | -50 | -34 | 54 | -2.35 |
| | | -66 | -26 | 28 | -2.12 |
| | | 56 | -26 | 28 | -2.00 |
| DLPFC | 8, 9 | 58 | 16 | 38 | -2.26 |
| | 9 | -44 | 10 | 32 | -1.96 |
| | | | | | |
| Affective (Facet 2) | | | | | |
| *Positive association* | | | | | |
| **Frontopolar cortex** | **10** | **20** | **66** | **10** | **3.28** |
| | | -4 | 62 | 8 | 2.12 |
| | | -20 | 62 | -2 | 1.93 |
| | | 30 | 64 | 4 | 1.80 |
| Supramarginal gyrus | 40 | 42 | -66 | 44 | 1.77 |
| *Negative association* | | | | | |
| **Anterior cingulate** | **32** | **12** | **16** | **34** | **-4.08** |
| | | **-14** | **12** | **38** | **-3.39** |
| | **9, 32** | -14 | 24 | 34 | -2.43 |
| **Insula** | **13** | **36** | **-12** | **18** | **-2.93** |
| | | -42 | -4 | 10 | -2.33 |
| **DLPFC** | **9** | **-46** | **12** | **32** | **-2.79** |
| | | -42 | 14 | 34 | -2.43 |
| | **8, 9** | 42 | 38 | 42 | -2.40 |
| **Lateral PFC** | **9** | **-60** | **4** | **24** | **-2.76** |
| | | 36 | 4 | 28 | -1.89 |
| Supramarginal gyrus | 40 | -44 | -30 | 46 | -2.11 |
| | | 56 | -24 | 16 | -1.98 |
| | | -52 | -36 | 56 | -1.92 |
| | | 60 | -24 | 28 | -1.90 |
| | | | | | |
| Lifestyle (Facet 3) | | | | | |
| *Positive association* | | | | | |
| **Frontopolar cortex** | **10** | **-4** | **62** | **10** | **3.32** |
| | | **22** | **68** | **12** | **3.01** |
| | | -20 | 62 | 0 | 2.00 |
| | | -4 | 58 | -6 | 1.96 |
| | | 30 | 64 | 4 | 1.91 |
| | | 12 | 68 | 12 | 1.87 |
| **Dorsomedial PFC** | **9, 10** | **14** | **54** | **42** | **2.68** |
| | **8, 9** | **-10** | **48** | **46** | **2.68** |
| | 8 | 16 | 50 | 46 | 2.65 |
| | 8 | -22 | 40 | 50 | 2.15 |
| | 9, 10 | -14 | 60 | 32 | 2.11 |
| Supramarginal gyrus | 40 | -52 | -60 | 48 | 2.52 |
| | | 48 | -64 | 42 | 2.04 |
| | | 65 | -52 | 22 | 1.88 |
| *Negative association* | | | | | |
| **DLPFC** | **9** | **-56** | **20** | **34** | **-3.07** |
| | | **-54** | **20** | **38** | **-2.88** |
| | | 58 | 14 | 38 | -2.38 |

| | | | | | |
|---|---|---|---|---|---|
| | | 42 | 38 | 42 | -2.26 |
| Anterior cingulate | 32 | 10 | 18 | 32 | -2.60 |
| | | -14 | 12 | 38 | -2.35 |
| Supramarginal gyrus | 40 | 64 | -28 | 34 | -1.90 |
| | | -50 | -30 | 46 | -1.83 |
| Insula | 13 | -44 | 8 | 0 | -1.86 |
| | | | | | |
| Antisocial (Facet 4) | | | | | |
| *Positive association* | | | | | |
| **Frontopolar cortex** | **9, 10, 11, 32** | **-4** | **60** | **10** | **4.41** |
| | **10** | **-22** | **60** | **2** | **3.26** |
| | **9, 10, 11, 32** | **2** | **62** | **10** | **3.14** |
| | **8, 9, 10, 11** | **22** | **66** | **14** | **3.05** |
| | **8, 9, 10** | **-14** | **60** | **32** | **2.73** |
| | 10 | -32 | 62 | 4 | 2.22 |
| | 9, 10 | -26 | 56 | 32 | 2.00 |
| | 10 | -22 | 56 | -6 | 1.95 |
| | 10 | 12 | 34 | -10 | 1.79 |
| | 10 | -42 | 52 | 4 | 1.77 |
| **Supramarginal gyrus** | **40** | **48** | **-64** | **42** | **3.16** |
| | | **-54** | **-52** | **50** | **3.15** |
| | | -44 | -48 | 34 | 2.38 |
| | | 40 | -48 | 34 | 2.22 |
| | | -42 | -46 | 60 | 2.22 |
| Orbitofrontal cortex | 11 | 24 | 28 | -12 | 2.29 |
| | | 24 | 32 | -12 | 2.07 |
| | | -40 | 34 | -14 | 1.87 |
| Temporal pole | 38 | -44 | 18 | -28 | 2.16 |
| Insula | 13 | 44 | -20 | 0 | 1.90 |
| Dorsolateral PFC | 9 | -20 | 52 | 40 | 1.85 |
| Anterior cingulate | 32 | 12 | 34 | -10 | 1.79 |
| | | | | | |
| *Negative association* | | | | | |
| Insula | 13 | 40 | -10 | 18 | -2.04 |
| Supramarginal gyrus | 40 | 68 | -30 | 22 | -1.81 |
| DLPFC | 9 | 58 | 12 | 38 | -1.82 |

*Note*. Bold indicates that associations were significant at $p < 0.01$ uncorrected for voxel-wise comparison.

Table S4. Brain regions correlated with psychopathy (total and facet) scores for the contrast non-autobiographical lie vs. non-autobiographical truth.

| | BA | x | y | z | T |
|---|---|---|---|---|---|
| Total Psychopathy | | | | | |
| *Positive association* | | | | | |
| **Frontopolar cortex** | **10** | **20** | **66** | **10** | **3.12** |
| | | **-22** | **62** | **2** | **2.78** |
| | | **-6** | **62** | **8** | **2.77** |
| | | 12 | 64 | 6 | 2.46 |
| | | -28 | 62 | 6 | 2.27 |
| | | 22 | 60 | 2 | 1.99 |
| **Supramarginal gyrus** | **40** | **-52** | **60** | **48** | **2.74** |
| | | -54 | -44 | 54 | 2.09 |
| Insula | 13 | -36 | -6 | 22 | 1.84 |
| *Negative association* | | | | | |
| Insula | 13 | 34 | -24 | 20 | -1.89 |
| | | | | | |
| Interpersonal (Facet 1) | | | | | |
| *Positive association* | | | | | |
| **Supramarginal gyrus** | **40** | **-52** | **-60** | **48** | **3.37** |
| | | -60 | -38 | 48 | 2.64 |
| | | -38 | -48 | 34 | 1.85 |
| | | 44 | -52 | 56 | 1.81 |
| Temporal pole | 38 | 34 | 10 | -22 | 2.35 |
| DLPFC | 8 | -40 | 14 | 56 | 2.15 |
| Insula | 13 | 44 | -46 | 20 | 2.12 |
| *Negative association* | | | | | |
| None | | | | | |
| | | | | | |
| Affective (Facet 2) | | | | | |
| *Positive association* | | | | | |
| **Supramarginal gyrus** | **40** | **-52** | **-60** | **48** | **3.15** |
| | | -52 | -38 | 58 | 1.79 |
| **Frontopolar cortex** | **10** | **-20** | **62** | **0** | **2.74** |
| | | 12 | 64 | 6 | 2.49 |
| | | 20 | 66 | 10 | 2.38 |
| | | -14 | 62 | 4 | 2.32 |
| | | -30 | 64 | 4 | 2.32 |
| *Negative association* | | | | | |
| Insula | 13 | 32 | -22 | 22 | -2.14 |
| Supramarginal gyrus | 40 | 56 | -26 | 34 | -1.80 |
| DLPFC | 9 | 58 | 6 | 40 | -2.00 |
| | | | | | |
| Lifestyle (Facet 3) | | | | | |
| *Positive association* | | | | | |
| **Frontopolar cortex** | **10** | **-4** | **62** | **8** | **2.79** |
| | | 12 | 64 | 6 | 2.48 |
| | | 20 | 66 | 10 | 2.43 |
| | | -20 | 62 | 0 | 2.35 |

| | | | | | |
|---|---|---|---|---|---|
| Supramarginal gyrus | 40 | -56 | -60 | 42 | 2.43 |
| | | -52 | -42 | 56 | 2.06 |
| *Negative association* | | | | | |
| Insula | 13 | 36 | -18 | 22 | -1.95 |
| | | | | | |
| Antisocial (Facet 4) | | | | | |
| *Positive association* | | | | | |
| **Frontopolar cortex** | **10** | **20** | **64** | **10** | **4.66** |
| | **10, 32** | **-6** | **62** | **8** | **3.44** |
| | **10, 11, 32** | **14** | **60** | **4** | **3.11** |
| | **10** | **-22** | **62** | **2** | **2.87** |
| | 10 | -22 | 62 | 10 | 2.30 |
| | 10 | -30 | 62 | 0 | 2.01 |
| **Dorsomedial PFC** | **8** | **22** | **36** | **54** | **2.73** |
| | 8, 9 | 14 | 54 | 42 | 2.43 |
| | 9 | -12 | 48 | 26 | 1.77 |
| Insula | 13 | -36 | -6 | 22 | 2.33 |
| Supramarginal gyrus | 40 | -56 | -60 | 42 | 2.16 |
| | | 52 | -60 | 44 | 2.07 |
| Orbitofrontal cortex | 11 | -4 | 46 | -16 | 2.15 |
| Anterior cingulate | 10, 32 | 2 | 46 | 10 | 2.03 |
| | 10, 32 | -16 | 44 | -4 | 2.00 |
| | 32 | -2 | 44 | 10 | 1.86 |
| Ventrolateral PFC | 10, 11, 32 | 26 | 50 | -4 | 1.92 |
| | | | | | |
| *Negative association* | | | | | |
| Inferior parietal lobule | 40 | 68 | -30 | 22 | -1.87 |
| Insula | 13 | 34 | -24 | 20 | -1.81 |

*Note*. Bold indicates that associations were significant at $p < 0.01$ uncorrected for voxel-wise comparison.

Table S5. Brain regions associated with psychopathy (total and facet) scores for the contrast criminal vs. non-criminal.

| | BA | x | y | z | T |
|---|---|---|---|---|---|
| Total Psychopathy | | | | | |
| *Positive association* | | | | | |
| **Frontopolar cortex** | **10** | **20** | **66** | **10** | **3.10** |
| | | 42 | 60 | 2 | 2.16 |
| | | 28 | 66 | 8 | 1.84 |
| Anterior cingulate | 32 | 4 | 30 | -8 | 2.16 |
| | 32 | -8 | 34 | -10 | 2.00 |
| Temporal pole | 38 | -44 | 18 | -28 | 2.02 |
| | | | | | |
| *Negative association* | | | | | |
| DLPFC | 8 | -48 | 18 | 46 | -2.04 |
| | | | | | |
| Interpersonal (Facet 1) | | | | | |
| *Positive association* | | | | | |
| **Temporal pole** | **38** | **-44** | **18** | **-29** | **2.43** |
| Anterior cingulate | 32 | -4 | 24 | -8 | 2.28 |
| Frontopolar cortex | 10 | 20 | 68 | 12 | 2.02 |
| | | | | | |
| *Negative association* | | | | | |
| None | | | | | |
| | | | | | |
| Affective (Facet 2) | | | | | |
| *Positive association* | | | | | |
| **Anterior cingulate** | **32** | **-4** | **22** | **-8** | **2.70** |
| Frontopolar cortex | 10 | 20 | 66 | 10 | 2.34 |
| | | 24 | 68 | 12 | 1.92 |
| | | | | | |
| *Negative association* | | | | | |
| Angular gyrus | 40 | -50 | -52 | 54 | -2.20 |
| DLPFC | 8 | -38 | 20 | 56 | -2.19 |
| | | | | | |
| Lifestyle (Facet 3) | | | | | |
| *Positive association* | | | | | |
| Frontopolar cortex | 10 | 20 | 66 | 10 | 2.60 |
| | | 24 | 68 | 12 | 2.08 |
| Anterior cingulate | 32 | -4 | 24 | 8 | 1.89 |
| | | | | | |
| *Negative association* | | | | | |
| None | | | | | |
| | | | | | |
| Antisocial (Facet 4) | | | | | |
| *Positive association* | | | | | |
| **Frontopolar cortex** | **10** | **42** | **60** | **2** | **3.25** |
| | | **20** | **68** | **12** | **3.21** |
| | | 28 | 66 | 8 | 2.41 |
| **Anterior cingulate** | **32** | **-4** | **24** | **-8** | **2.85** |

| | | | | | |
|---|---|---|---|---|---|
| | 32 | 4 | 30 | -8 | 2.52 |
| | 10, 32 | -10 | 36 | -10 | 2.43 |
| | | | | | |
| *Negative association* | | | | | |
| None | | | | | |

*Note*. Bold indicates that associations were significant at $p < 0.01$ uncorrected for voxel-wise comparison with a threshold of $p < 0.001$ for cluster-level inference.

Table S6. Brain regions associated with psychopathy (total and facet) scores for the contrast criminal truth vs. non-criminal truth.

| | BA | x | y | z | T |
|---|---|---|---|---|---|
| Total Psychopathy | | | | | |
| *Positive association* | | | | | |
| Frontopolar cortex | 10 | 22 | 66 | 10 | 2.62 |
| | | 42 | 60 | 2 | 2.51 |
| | | 24 | 62 | 2 | 1.90 |
| Temporal pole | 38 | -44 | 20 | -24 | 2.46 |
| | | | | | |
| | | | | | |
| *Negative association* | | | | | |
| **DLPFC** | **8** | **-28** | **48** | **40** | **-3.10** |
| | | **-32** | **22** | **58** | **-2.80** |
| | 9 | -54 | 26 | 34 | -2.49 |
| | 10 | -46 | 44 | 24 | -2.37 |
| | 9 | 62 | 6 | 26 | -2.16 |
| | 8 | -48 | 18 | 46 | -2.04 |
| | 10 | -36 | 56 | 22 | -1.98 |
| Supramarginal gyrus | 40 | 44 | -36 | 60 | -2.01 |
| Insula | 13 | 38 | 16 | 14 | -2.00 |
| | 13 | -32 | 22 | 14 | -1.98 |
| Anterior cingulate | 32 | -18 | 32 | 22 | -1.80 |
| | | | | | |
| Interpersonal (Facet 1) | | | | | |
| *Positive association* | | | | | |
| Temporal pole | 38 | -42 | 20 | -24 | 3.12 |
| | | 52 | 12 | -18 | 2.06 |
| Frontopolar cortex | 10 | 20 | 66 | 10 | 2.46 |
| | | 24 | 62 | 2 | 2.31 |
| | | 6 | 64 | 4 | 1.89 |
| *Negative association* | | | | | |
| None | | | | | |
| | | | | | |
| Affective (Facet 2) | | | | | |
| *Positive association* | | | | | |
| Frontopolar cortex | 10 | 22 | 66 | 10 | 2.52 |
| | | 12 | 64 | 6 | 1.84 |
| Temporal pole | 38 | -44 | 20 | -24 | 2.00 |

| | | | | | |
|---|---|---|---|---|---|
| *Negative association* | | | | | |
| **DLPFC** | **8, 9** | **-28** | **48** | **40** | **-3.94** |
| | **9** | **-46** | **44** | **24** | **-2.81** |
| | 8, 9, 10, 32 | -16 | 34 | 32 | -2.55 |
| | 9 | 42 | 38 | 42 | -2.37 |
| | 10 | -44 | 42 | 16 | -2.32 |
| | 9, 10 | 38 | 48 | 34 | -2.31 |
| | 9 | -20 | 52 | 40 | -2.29 |
| | 9 | -36 | 4 | 28 | -2.19 |
| | 9 | -54 | 20 | 38 | -1.95 |
| | 8 | -30 | 12 | 42 | -1.87 |
| | 8 | -20 | 28 | 58 | -1.87 |
| | 9 | 10 | 46 | 32 | -1.79 |
| **Lateral PFC** | **9** | **62** | **6** | **26** | **-2.92** |
| **Insula** | **13** | **38** | **16** | **14** | **-2.68** |
| | | -32 | 22 | 14 | -2.58 |
| Anterior cingulate | 32 | -10 | 8 | 50 | -2.48 |
| | | -12 | 22 | 26 | -2.30 |
| | | 10 | 22 | 26 | -2.12 |
| | | 10 | 16 | 30 | -2.09 |
| | 8, 9, 32 | 12 | 22 | 40 | -2.01 |
| Postcentral gyrus | 40 | 44 | -38 | 50 | -2.47 |
| Frontopolar cortex | 10 | 34 | 62 | 20 | -2.29 |
| | | -28 | 52 | 8 | -1.94 |
| OFC | 11 | 44 | 34 | -14 | -2.00 |
| Angular gyrus | 40 | -52 | -52 | 52 | -2.00 |
| | | | | | |
| Lifestyle (Facet 3) | | | | | |
| *Positive Associations* | | | | | |
| Frontopolar cortex | 10 | 22 | 66 | 10 | 2.13 |
| Angular gyrus | 40 | 48 | -46 | 60 | 2.00 |
| | | | | | |
| *Negative Associations* | | | | | |
| **DLPFC** | **8, 9** | **-28** | **48** | **40** | **-3.82** |
| | **9, 10** | **-46** | **44** | **24** | **-3.03** |
| | 10 | -40 | 54 | 20 | -2.33 |
| | 9, 10 | 38 | 52 | 28 | -2.25 |
| | 9 | 62 | 6 | 26 | -2.18 |
| | 9 | -54 | 2 | 34 | -1.98 |
| | 9 | -54 | 20 | 38 | -1.96 |
| | 9 | -30 | 50 | 36 | -1.94 |
| | 8 | 22 | 26 | 58 | -1.90 |
| | 9 | 12 | 48 | 30 | -1.79 |
| Insula | 13 | -32 | 22 | 14 | -2.59 |
| | | 38 | 16 | 12 | -2.49 |
| Medial PFC | 8, 9, 32 | -6 | 44 | 30 | -2.42 |
| | 9, 32 | 8 | 38 | 30 | -2.16 |
| | 8 | -4 | 20 | 54 | -2.12 |

| | | | | | |
|---|---|---|---|---|---|
| | | -8 | 34 | 44 | -2.03 |
| Orbitofrontal cortex | 10, 11 | -6 | 44 | 30 | -2.41 |
| | 11 | 42 | 34 | -14 | -1.99 |
| | | -24 | 46 | -8 | -1.98 |
| Supramarginal gyrus | 40 | 44 | -36 | 60 | -2.30 |
| Frontopolar cortex | 10 | 20 | 50 | 0 | -2.19 |
| | 10 | 32 | 62 | 20 | -2.10 |
| | | -32 | 48 | 12 | -1.96 |
| | | -48 | 50 | 4 | -1.94 |
| | | 6 | 48 | 16 | -1.78 |
| Anterior cingulate | 32 | -12 | 22 | 26 | -2.10 |
| | | -16 | 16 | 36 | -2.07 |
| | | 14 | 16 | 34 | -1.90 |
| | | | | | |
| Antisocial (Facet 4) | | | | | |
| *Positive associations* | | | | | |
| **Frontopolar cortex** | **10** | **40** | **60** | **0** | **2.88** |
| | | | | | |
| *Negative associations* | | | | | |
| DLPFC | 9 | -28 | 48 | 40 | -2.64 |
| | | -30 | 44 | 42 | -2.00 |
| | | 38 | 48 | 34 | -1.91 |
| | 8 | -38 | 20 | 56 | -1.85 |
| | 9 | 62 | 6 | 26 | -1.80 |

*Note*. Bold indicates that associations were significant at $p < 0.01$ uncorrected for voxel-wise comparison.

Table S7. Brain regions associated with psychopathy (total and facet) scores for the contrast non-criminal lie vs. non-criminal truth.

| | BA | x | y | z | T |
|---|---|---|---|---|---|
| Total Psychopathy | | | | | |
| *Positive associations* | | | | | |
| **Frontopolar cortex** | **10** | **20** | **66** | **0** | **3.87** |
| | | **30** | **32** | **0** | **3.80** |
| | | **-20** | **62** | **0** | **3.32** |
| | | **12** | **64** | **6** | **3.23** |
| | | **-30** | **64** | **4** | **3.23** |
| | | **-14** | **62** | **4** | **2.89** |
| **Angular gyrus** | **40** | **-42** | **-46** | **36** | **2.77** |
| | | 64 | -48 | 32 | 1.94 |
| | | 60 | -48 | 42 | 1.98 |
| Supramarginal gyrus | | -50 | -32 | 24 | 2.01 |
| Postcentral gyrus | 40 | 52 | -38 | 58 | 2.54 |
| Insula | 13 | -46 | -36 | 20 | 2.35 |
| *Negative associations* | | | | | |
| **DLPFC** | **9, 10** | **-32** | **56** | **22** | **-2.92** |
| | **8, 9** | **-50** | **28** | **38** | **-2.76** |
| | **8** | **-42** | **16** | **54** | **-2.71** |
| | 10 | -44 | 44 | 16 | -2.36 |
| | 8 | -52 | 6 | 46 | -2.11 |
| | 9 | 62 | 8 | 24 | -2.04 |
| **Dorsomedial PFC** | **8, 32** | **-6** | **14** | **54** | **-2.91** |
| Orbitofrontal cortex | 11 | 44 | 34 | -14 | -2.50 |
| | | -42 | 34 | -12 | -2.42 |
| Anterior cingulate | 32 | -8 | 8 | 52 | -2.46 |
| Postcentral gyrus | 40 | 38 | -30 | 46 | -2.08 |
| Angular gyrus | 40 | 38 | -60 | 44 | -1.97 |
| Frontopolar cortex | 10 | -34 | 52 | 12 | -1.79 |
| | | | | | |
| Interpersonal (Facet 1) | | | | | |
| *Positive associations* | | | | | |
| **Angular gyrus** | **13, 40** | **-58** | **-56** | **38** | **5.06** |
| **Frontopolar cortex** | **10** | **-24** | **62** | **2** | **4.28** |
| | | **-30** | **64** | **4** | **3.25** |
| | | **-12** | **64** | **6** | **2.88** |
| | | **12** | **64** | **6** | **2.79** |
| | | **30** | **62** | **0** | **2.67** |
| **Insula** | **13** | **-34** | **-36** | **20** | **3.06** |
| | | 28 | -32 | 18 | 2.44 |
| **Supramarginal gyurs** | **13, 40** | **46** | **-42** | **18** | **3.04** |
| | 40 | -26 | -48 | 56 | 2.09 |
| Temporal pole | 38 | 42 | 10 | -18 | 2.60 |
| | | -50 | 8 | -24 | 2.00 |
| Postcentral gyrus | 40 | 64 | -24 | 22 | 1.97 |
| | 40 | -34 | -40 | 56 | 1.77 |

| | | | | | |
|---|---|---|---|---|---|
| *Negative associations* | | | | | |
| None | | | | | |
| | | | | | |
| Affective (Facet 2) | | | | | |
| *Positive associations* | | | | | |
| **Frontopolar cortex** | **10** | **12** | **64** | **6** | **3.79** |
| | | **-24** | **62** | **2** | **3.45** |
| | | **8** | **64** | **6** | **3.33** |
| | | **30** | **62** | **0** | **3.30** |
| | | **-30** | **64** | **4** | **3.12** |
| | | **-14** | **62** | **4** | **2.98** |
| **Supramarginal gyurs** | **13, 40** | **-60** | **-44** | **20** | **3.15** |
| | **40** | **-60** | **-44** | **20** | **3.15** |
| | | 64 | -52 | 30 | 2.11 |
| | | -50 | -32 | 24 | 2.05 |
| **Postcentral gyrus** | **40** | **52** | **-38** | **58** | **3.01** |
| | | -34 | -42 | 56 | 1.92 |
| Insula | 13 | -40 | 34 | 20 | 1.98 |
| *Negative associations* | | | | | |
| **Frontopolar cortex** | **9, 10** | **32** | **56** | **22** | **-3.78** |
| | 10 | 26 | 62 | 18 | -2.23 |
| **DLPFC** | **8, 9** | **-50** | **28** | **38** | **-2.99** |
| | 8 | -42 | 16 | 54 | -2.51 |
| | 8, 9 | -26 | 48 | 40 | -2.30 |
| | 9 | -30 | 50 | 36 | -2.09 |
| | 9 | 40 | 14 | 34 | -1.99 |
| | 8 | -22 | 26 | 44 | -1.89 |
| **Ventrolateral PFC** | **10** | **54** | **42** | **0** | **-2.85** |
| | | -44 | 48 | 8 | -2.01 |
| **Anterior cingulate** | **8, 9, 32** | **-8** | **8** | **52** | **-2.79** |
| | 9, 32 | -20 | 40 | 20 | -2.07 |
| | 32 | 10 | 16 | 30 | -1.83 |
| Orbitofrontal cortex | 11 | 44 | 38 | -14 | -2.52 |
| | | -42 | 34 | -12 | -2.50 |
| Medial PFC | 9 | 12 | 48 | 26 | -1.84 |
| Lateral PFC | 9 | 32 | 8 | 24 | -1.78 |
| | | | | | |
| Lifestyle (Facet 3) | | | | | |
| *Positive associations* | | | | | |
| **Frontopolar cortex** | **10** | **30** | **62** | **0** | **3.92** |
| | | **-20** | **62** | **0** | **3.17** |
| | | **20** | **66** | **10** | **2.94** |
| | | 12 | 64 | 6 | 2.55 |
| | | -14 | 62 | 4 | 2.28 |
| | | -30 | 64 | 4 | 2.28 |
| Insula | 13 | -46 | -36 | 20 | 2.29 |
| Supramarginal gyrus | 40 | -42 | -46 | 36 | 2.26 |
| | | -66 | -32 | 30 | 2.10 |
| | | -54 | -52 | 30 | 2.08 |

| | | | | | |
|---|---|---|---|---|---|
| Angular gyrus | 40 | 52 | -38 | 58 | 2.14 |
| Postcentral gyrus | 40 | 56 | -32 | 54 | 1.80 |
| *Negative associations* | | | | | |
| **DLPFC** | **8, 9, 10, 32** | **-34** | **20** | **58** | **-4.07** |
| | **8, 9** | **-50** | **18** | **42** | **-3.78** |
| | 9 | -54 | 20 | 38 | -2.38 |
| | 9 | -30 | 50 | 36 | -1.82 |
| | 9 | 36 | 8 | 40 | -1.81 |
| | 9 | 62 | 8 | 24 | -1.95 |
| **Frontopolar cortex** | **9, 10, 32** | **22** | **62** | **20** | **-3.09** |
| | 9, 10, 32 | 4 | 56 | 18 | -2.41 |
| | 10 | -2 | 54 | 12 | -1.98 |
| | 10 | 20 | 50 | 0 | -1.92 |
| | 10 | 24 | 50 | -2 | -1.86 |
| | 10 | 16 | 50 | -4 | -1.78 |
| | 10 | -20 | 48 | 0 | -1.78 |
| **Orbitofrontal cortex** | **11** | **-42** | **34** | **-12** | **-2.71** |
| | | 42 | 40 | -14 | -2.49 |
| | 10, 11 | -24 | 50 | -4 | -1.92 |
| Ventrolateral PFC | 10 | 54 | 40 | 0 | -2.57 |
| | | -44 | 46 | 4 | -2.04 |
| Dorsomedial PFC | 8 | 20 | 38 | 48 | -2.52 |
| | | -20 | 28 | 54 | -2.13 |
| | | 2 | 20 | 52 | -2.11 |
| | | 14 | 28 | 46 | -1.84 |
| Anterior cingulate | 10, 32 | -12 | 34 | -8 | -2.00 |
| | 32 | 18 | 8 | 50 | -1.80 |
| Angular gyrus | 40 | 38 | -60 | 44 | -1.94 |
| | | | | | |
| Antisocial (Facet 4) | | | | | |
| *Positive associations* | | | | | |
| **Frontopolar cortex** | **10** | **30** | **62** | **0** | **3.11** |
| | | **-14** | **62** | **4** | **2.81** |
| | | 20 | 66 | 10 | 2.41 |
| | | -4 | 62 | 2 | 2.40 |
| *Negative associations* | | | | | |
| **Insula** | **13, 40** | **64** | **-26** | **20** | **-3.54** |
| | 13 | -42 | -14 | -8 | -2.08 |
| **Anterior cingulate** | **8, 32** | **-6** | **14** | **54** | **-3.33** |
| | 32 | 6 | 4 | 42 | -2.41 |
| | 8 | 2 | 16 | 54 | -2.03 |
| | 32 | -6 | 22 | 38 | -1.96 |
| **Orbitofrontal cortex** | **11** | **-44** | **34** | **-12** | **-3.07** |
| | | **42** | **48** | **-14** | **-2.74** |
| | | -24 | 28 | -12 | -1.93 |
| **Frontopolar cortex** | **10** | **-32** | **58** | **24** | **-2.74** |
| | 9, 10 | -4 | 60 | 30 | -2.50 |
| | 10 | -40 | 54 | 20 | -1.80 |

| | | | | | |
|---|---|---|---|---|---|
| **DLPFC** | **9** | **62** | **6** | **24** | **-3.21** |
| | **8** | **-34** | **20** | **58** | **-2.69** |
| | 8 | -52 | 6 | 46 | -2.57 |
| | 8, 9 | -28 | 44 | 42 | -2.41 |
| | 8, 9 | -50 | 28 | 38 | -2.37 |
| | 8 | -26 | 24 | 58 | -2.09 |
| | 10 | -46 | 44 | 22 | -2.02 |
| | 9 | -62 | 4 | 24 | -2.01 |
| | 9 | -20 | 52 | 40 | -1.98 |
| | 8 | -54 | 14 | 42 | -1.86 |
| | 8 | 40 | 14 | 56 | -1.84 |
| Angular gyrus | 40 | 38 | -60 | 44 | -2.51 |

*Note*. Underline indicates that associations were significant at $p < 0.05$ after FWE correction. Bold indicates that associations were significant at $p < 0.01$ uncorrected for voxel-wise comparison.