Published in final edited form as:
Neuropsychology. 2007 May ; 21(3): 313–318. doi:10.1037/0894-4105.21.3.313.

Behavioral evidence of prolonged interhemispheric transfer time among psychopathic offenders

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Abstract

Several lines of evidence suggest the possibility of abnormal interhemispheric communication in psychopathy, but there have been few direct empirical studies. To address this gap in the literature, we examined one important aspect of interhemispheric communication, the efficiency with which information is transferred across the corpus callosum. Using Poffenberger's (1912) paradigm for estimating interhemispheric transfer time (IHTT) from simple motor responses to lateralized stimuli, we found a substantially prolonged IHTT among psychopathic criminals relative to nonpsychopathic criminals. This prolonged IHTT was somewhat more pronounced when participants were using their right hand to respond. This study provides initial behavioral evidence of slowed interhemispheric transfer in psychopathy.

Keywords

psychopathy; interhemispheric transfer; callosal transfer

Introduction

In recent years there has been growing appreciation of the importance of coordinated exchange of information between the cerebral hemispheres. Numerous studies have demonstrated that information processing is dynamically coupled or decoupled across the cerebral hemispheres in response to task demands (Weissman & Banich, 2000; Weissman & Compton, 2003). Efficient integration of information across the hemispheres improves performance on complex, multidimensional tasks, presumably due to the advantage of parallel processing, while strategic decoupling can reduce interference in situations demanding selective attention (Banich, 1998; Belger & Banich, 1992; Compton, Heller, Banich, Palmieri, & Miller, 2000; Mikels & Reuter-Lorenz, 2004). This dynamic, adaptive coordination of processing across the hemispheres is believed to rely heavily upon the integrity of the corpus callosum, the major tract of fibers connecting the cerebral cortices of the left and right hemispheres.

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Although often overlooked, there have been recurrent indications of abnormal interhemispheric communication among psychopathic individuals. The earliest evidence came from abnormal functional asymmetries on lateralized processing tasks. The nature of these deficits suggested context-dependent abnormalities in the distribution of processing across the two hemispheres (see Hare, 1998 and Hiatt, Lorenz, & Newman, 2002 for discussion). More recently, Kosson (1996; 1998) has developed the left-hemisphere activation (LHA) hypothesis, which proposes that the antisocial and dysregulated behavior of psychopathic individuals is due in part to deficient information-processing under conditions that place substantial demands on the left hemisphere. Kosson and colleagues have produced considerable support for information-processing deficits under conditions of LHA (e.g., Kosson, 1996, 1998; Llanes & Kosson, 2006). Although no specific mechanism is proposed by the LHA hypothesis, psychopathic individuals' deficits under LHA conditions appear to be consistent with dynamic interhemispheric integration abnormalities. Further indication of interhemispheric processing abnormalities in psychopaths comes from Raine and colleagues' (2003) striking evidence of increased callosal volume among community volunteers with strong psychopathic features. Raine and colleagues interpreted this increased callosal volume as suggestive of facilitated interhemispheric communication, and provided some indirect evidence for this proposal.

Together, these findings strongly suggest interhemispheric processing abnormalities in psychopathy. One important component of interhemispheric processing is the efficiency with which simple information is transferred from one hemisphere to the other. Inefficient sharing of information between the two hemispheres can be expected to interfere with flexible and adaptive interhemispheric integration. The time required to transfer information from one hemisphere to the other, commonly referred to as “interhemispheric transfer time“ or IHTT, can be estimated using a simple behavioral paradigm originally developed by Poffenberger (1912). Although a number of studies suggest interhemispheric communication deficits in psychopathic individuals, there are no published studies of simple interhemispheric transfer time. This represents a substantial gap in the literature, as higher-level functions such as dynamic integration likely depend upon the efficiency of simple transfer.

The present study addresses this gap in the literature by providing a simple and direct test of the efficiency of interhemispheric communication among psychopathic offenders, using Poffenberger's (1912) paradigm for estimating interhemispheric transfer time (IHTT) from simple motor responses to lateralized stimuli. This paradigm involves measuring manual reaction time to brief, salient, unpatterned visual stimuli (e.g., flashes of light) presented to either the left or right visual field. IHTT is estimated by calculating the “crossed-uncrossed difference” (CUD), such that reaction times (RTs) for trials in which the stimulus is presented to the same hemisphere that controls the motor response (“uncrossed”) are subtracted from the RTs for trials in which the stimulus is presented contralateral to the hemisphere that controls the motor response (“crossed”).

Poffenberger reasoned that when information must be communicated across the hemispheres in order to initiate a motor response, an extra step of cross-callosal transmission is required, which should lead to increased reaction times relative to trials on which the stimulus is presented to the same hemisphere that controls the motor response. For example, right-handed responses should be faster to a right visual field stimulus than a left visual field stimulus; in the former case, both the visual input and motor output are processed within the same hemisphere (left), whereas in the latter case interhemispheric transfer is necessary to initiate the motor response.

Consistent with this assumption, the Poffenberger paradigm consistently produces longer RTs on crossed versus uncrossed trials. Among healthy controls, most estimates of the IHTT based on unimanual responses to simple visual stimuli range between 2.0 and 6.0 msec (Bashore, 1981; Marzi et al., 1991). In support of the interpretation that the CUD reflects callosal transfer time, the CUD has been shown to be markedly increased among individuals with congenital or acquired absence of the corpus callosum (e.g., Forster & Corballis, 1998; Zaidel & Iacoboni, 2003; Berlucchi, Aglioti, Marzi, & Tassinari, 1995; Clarke & Zaidel, 1989; Milner et al., 1985; Lassonde, Sauerwein, & Lepore, 2003). This lengthening of the CUD is believed to reflect the transfer of information across longer, noncallosal pathways. In addition, reaction time measures of IHTT have been found to closely approximate ERP latency differences for the ipsilateral versus contralateral hemisphere in response to monaural clicks (Wolpaw & Penry, 1977) and unilateral tactile stimulation (Salamy, 1978). Although more recent studies indicate that behavioral estimates of IHTT are less reliable than physiological (i.e., event related potential) measures and do not provide pure estimates of physiological callosal transfer time (see Saron, Foxe, Schroeder, & Vaughan, 2003; Saron & Davidson, 1989), the Poffenberger paradigm remains an efficient and useful method for investigating the overall integrity of interhemispheric transfer across the corpus callosum.

Despite strong suggestions of interhemispheric processing abnormalities, the existing literature does not allow clear predictions as to whether the IHTT of psychopathic offenders will be slower or faster than that of nonpsychopathic controls. Increased callosal volume, such as that reported by Raine et al. (2003), is often assumed to correspond to more efficient interhemispheric transfer, but the empirical evidence is equivocal (Hellige, Taylor, Lesmes, & Peterson, 1998; Jancke & Steinmetz, 1994; see also Banich, 1995). Raine et al. (2003) found some behavioral evidence of increased interhemispheric integration among volunteers with psychopathic features, but the implications for simple transfer time (and classic PCL-R psychopathy) are unclear. In addition, psychopathic individuals' pattern of unusual cerebral asymmetries, as well as Kosson's evidence of poor information processing under LHA conditions, are more suggestive of slowed IHTT (see Hiatt, Lorenz, & Newman, 2002; Hiatt & Newman, 2006 for further discussion). The existing data can thus be interpreted as suggesting either speeded or slowed IHTT. Accordingly, we did not make directional predictions for psychopathic individuals' interhemispheric transfer time.

In addition to investigating overall IHTT, the design of the Poffenberger paradigm allows investigation of Kosson's LHA hypothesis because response hand is alternated across blocks of trials. Right-hand response blocks can be assumed to produce greater LHA relative to left-hand response blocks (Kinsbourne, 1970; McElroy & Seta, 2004). Thus we also examined IHTT with respect to Kosson's LHA hypothesis, which would suggest that any abnormalities in psychopathic individuals' IHTT will be specific to right-handed response blocks.

Methods

Participants

Participants were 93 Caucasian male inmates with Psychopathy Checklist-Revised (PCL-R) scores in either the psychopathic (30 or higher, n = 54) or nonpsychopathic (20 or lower, n = 39) range. Participants were drawn from either a medium-security (n = 51) or maximum-security (n=42) prison in south-central Wisconsin. File screens were used to exclude individuals who were over 45 years of age, were prescribed psychotropic medication, or scored below the fourth-grade reading level on prison-administered achievement tests. Participants were also excluded if they were left-handed according to their score (greater than 21) on the Hand Usage Questionnaire (Chapman & Chapman, 1987) or had borderline or lower intelligence (WAIS-R estimate less than 70) as assessed by the Shipley Institute of

Living Scale (Zachary, 1986). All participants gave informed consent and received modest financial compensation for their participation.

Psychopathy assessment

Psychopathy Checklist-Revised (PCL-R; Hare, 2003) ratings were made by trained research staff following a 60- to 90-minute structured interview and a review of the participant's prison file. The PCL-R is a 20-item checklist of behaviors and characteristics associated with psychopathy. Each item is scored 0, 1, or 2, for a maximum total score of 40. The reliability and validity of the PCL-R is well documented (e.g., Hare, 1991, 1996; Hare & McPherson, 1984; Hart & Hare, 1997; Kosson, Smith & Newman, 1990). Following the recommendations of Hare (1991), and in accord with standard practice, individuals scoring 30 or above were classified as psychopathic, individuals scoring 20 or below were classified as nonpsychopathic controls, and individuals scoring between 20 and 30 ("middles") were excluded from categorical data analyses.

Additional measures

Our laboratory has routinely divided participants on the basis of trait anxiety and tested hypotheses regarding primary psychopaths using only low-anxious psychopaths and controls. This distinction has proven to be particularly important for laboratory measures of attention and impulsivity, where interactions between psychopathy and trait anxiety are common (e.g., Arnett, Howland, Smith, & Newman, 1993; Devonshire, Howard, & Sellars, 1988; Widom, 1976). The importance of anxiety interactions for measures of cerebral asymmetry and interhemispheric integration has not yet been determined. We therefore took the conservative step of including anxiety as a factor but not directing hypotheses specifically to low-anxious groups. This strategy facilitates comparison with existing studies that do not assess anxiety, while also allowing examination of anxiety/neuroticism as a potential moderator of interhemispheric transfer efficiency. Anxiety was assessed using the WAS, a self-report measure of trait anxiety. Median splits on the WAS were used to classify participants into high- and low-anxious groups for data analyses (see Newman, MacCoon, Vaughn, & Sadeh, 2005; Schmitt & Newman, 1999, for evidence regarding the validity of the WAS for distinguishing psychopathic subgroups).

Task and Procedure

Participants returned approximately one to four weeks following the interview to complete the interhemispheric transfer task, which was administered as one of four to six counterbalanced tasks during a 1-hr testing session. Participants were tested individually by a male experimenter who was blind to participants' group membership. The task was developed following standard methodology for the Poffenberger paradigm (see Bashore, 1981). Each trial began with a fixation cross in the center of the screen that remained present throughout the trial. At a variable interval of 1000, 1500, 2000, or 2500 ms following appearance of the fixation cross, the imperative stimulus ('#') occurred for a duration of 150 ms in either the right visual field (RVF) or left visual field (LVF). This was followed by a 1500 ms inter-trial interval. Participants completed 4 blocks of 40 trials each, with response hand alternating between blocks in the following order: right hand, left hand, right hand, left hand. For right-hand blocks, participants responded by pressing the 'J' key on a standard keyboard with their right index finger. For left-hand blocks, they pressed the 'F' key with their left index finger. Targets were presented approximately 3.1 degrees to the left or right of the central fixation cross. Stimuli were presented in white font on a black background.

Trials with reaction times (RTs) less than 150 ms or greater than 1500 ms were excluded from analyses. The crossed-uncrossed difference (CUD) was computed for each participant by calculating the difference between mean RT on crossed (RVF stimulus on left-hand blocks, LVF stimulus on right-hand blocks) and uncrossed (LVF stimulus on left-hand blocks, RVF stimulus on right-hand blocks) trials. Participants performing greater than 2.5 standard deviations below the mean for accuracy (1 psychopathic participant), or greater than 2.5 SDs above or below the mean for reaction time (2 control participants), were excluded from analysis. To achieve homogeneity of variance, participants were also excluded from analysis if their CUD was greater or less than 2.0 SDs from their group mean (1 control, 2 psychopathic participants). This resulted in analyzing data from 87 participants (36 controls, 51 psychopathic participants).

Results

Preliminary Analyses

Overall accuracy was 99.3%, (range = 96-100%, or 153-160 of 160 trials). Psychopathic and control participants did not differ with respect to overall mean reaction time ($\underline{F}$ (1, 85) = .13, $\underline{p} > .70$; $\underline{M}$ (SD) = 320.91 (42.54) msec and 317.49 (46.06) msec for psychopathic and control participants, respectively). Multivariate analysis of mean reaction time for each of the four trial types with psychopathy as the grouping variable failed to reveal any significant differences between psychopathic and control participants (all $\underline{F}$s < 1.0, all $\underline{p}$s >.40). Mean RTs by trial type are presented in Table 1. There were no group differences in estimated WAIS-R IQ ($\underline{F}$ (1, 85) = .02, $\underline{p} > .80$; $\underline{M}$ (SD) = 101.37 (11.58) and 101.73 (10.28) for psychopathic and control participants, respectively), or age ($\underline{F}$ (1, 85) < .01, $\underline{p} > .90$; $\underline{M}$ (SD) = 30.19 (7.38) and 30.31 (6.50) for psychopathic and control participants, respectively). As expected, a significant, positive CUD was obtained across subjects, indicating slower responses on crossed versus uncrossed trials ($\underline{t}$ (1, 86) = 6.41, $\underline{p} < .001$; $\underline{M}$ (SD) = 6.73 (9.79)). To examine possible effects of prison site, an initial analysis of variance (ANOVA) was conducted on CUD with prison site, anxiety, and psychopathy as the grouping variables. This analysis revealed no main effects or interactions involving site (all $\underline{F}$s < 1.0, all $\underline{p}$s >. 35). Data were therefore collapsed across site for all subsequent analyses.

Primary Analyses

Overall CUD—Group differences in CUD were examined by means of a 2 (psychopathy or control) by 2 (high or low anxiety) ANOVA with CUD as the dependent variable. This analysis revealed a significant main effect for psychopathy ($\underline{F}$ (1, 83) = 4.27, $\underline{p} < .05$, partial $\underline{\eta}^2 = .05$) with psychopathic participants showing a larger overall CUD than controls ($\underline{M}$ (SD) = 8.71 (10.62) msec for psychopathic participants, 3.92 (7.77) msec for controls). There were no significant effects involving anxiety (all $\underline{F}$s < 1.8, $\underline{p}$s > .19).

Response hand analyses—To examine group differences in CUD as a function of response hand, the CUD was calculated separately for left- and right-hand trial blocks and a repeated measures analysis was conducted on CUD with psychopathy as the grouping variable and response hand as the repeated measure. This analysis revealed a significant hand x anxiety x psychopathy interaction ($\underline{F}$ (1, 83) = 5.13, $\underline{p} < .05$, partial $\underline{\eta}^2 = .06$), reflecting a significant anxiety x psychopathy interaction for left-hand trial blocks ($\underline{F}$ (1, 83) = 7.22, $\underline{p} < .01$, partial $\underline{\eta}^2 = .08$) but not right-hand trial blocks ($\underline{F} < 1.0$, $\underline{p} > .35$). For right-hand trial blocks, there was a significant main effect of psychopathy ($\underline{F}$ (1, 83) = 4.92, $\underline{p}$ < . 05, partial $\underline{\eta}^2 = .06$), irrespective of anxiety, with psychopathic participants showing a larger CUD than controls ($\underline{M}$ (SD) = 10.90 (16.42) for psychopathic participants, 2.50 (13.73) for controls). For left-hand trial blocks, the anxiety x psychopathy interaction indicated that psychopathic participants' prolonged CUD was specific to low-anxious groups ($\underline{M}$ (SD) = 9.41 (15.05) for psychopathic participants, -0.22 (12.82) for controls); among high-anxious groups, psychopathic participants' CUD was not significantly different from controls'. [1] Response hand did not significantly interact with either psychopathy or anxiety alone. [2]

Supplementary analyses—We also conducted dimensional analyses using the entire sample. Bivariate correlations were calculated between total PCL-R score, F1 score, F2 score, and CUD, CUD for right-hand responses (CUD-RH), and CUD for left-hand responses (CUD-LH). These correlations are presented in Table 2. There was a significant correlation between total PCL-R score and overall CUD ($r = .22$, $p < .05$). Trend-level correlations were observed between each factor score and overall CUD ($r = .19$, $p = .06$ and $r = .18$, $p = .09$ for F1 and F2, respectively). Additionally, there was a trend-level correlation between CUD-LH and Factor 1.

Discussion

The principal goal of this study was to determine whether psychopathy is associated with an abnormal interhemispheric transfer time. The results of the overall CUD analysis provide clear evidence of a prolonged CUD among psychopathic offenders, suggesting delayed transfer of information between the cerebral hemispheres. While nonpsychopathic offenders demonstrated an average CUD of 3.92 msec, which falls within the expected range for healthy populations, psychopaths' average CUD was more than twice as long. Psychopathic participants' prolonged CUD was also evident in correlational analyses showing a significant positive correlation between PCL-R total score and the CUD. This evidence of prolonged interhemispheric transfer time among psychopathic individuals has important implications, as it suggests a fundamental deficit that occurs without complex processing demands (e.g., competing response contingencies, divided attention) and could have a broad and pervasive influence on cognitive and affective processing among individuals with psychopathy.

It was also predicted on the basis of Kosson's (1996; 1998) left-hemisphere activation (LHA) hypothesis that psychopathic individuals would show especially slow transfer on right-handed trial blocks. This finding was partially supported by the 3-way hand x anxiety x psychopathy interaction, which revealed a main effect of psychopathy for right-handed but not left-handed trial blocks. On left-handed trial blocks, an unexpected interaction of psychopathy and anxiety was found, such that the CUD was prolonged only for low-anxious psychopathic participants relative to low-anxious controls. High-anxious psychopathic and control participants did not differ. The significance and implications of the anxiety interaction will need to be clarified by future studies. It is possible that this effect is related to baseline hemispheric activation, as anxiety has been associated with changes in resting hemisphere activity (Davidson,1993; Heilman, Bowers, & Valenstein,1993; Heller, Nitschke, Etienne, & Miller, 1997). However, this interpretation is speculative. More importantly for the present study, anxiety did not interact with the prolonged overall CUD, nor with the prolonged CUD on right-handed trial blocks. In addition, when the CUD from left-handed trials was collapsed across anxiety, psychopathic participants still tended to show a longer CUD than controls. Overall, this pattern of results suggests robust overall slowing of interhemispheric transfer for both high- and low-anxious psychopathic participants, with somewhat more pronounced slowing under right-hand response conditions.

[1]At the suggestion of an anonymous reviewer, we also conducted separate follow-up analyses of the 3-way Hand x Anxiety x Psychopathy interaction for low-anxious and high-anxious groups. For low-anxious groups, there was a significant main effect of psychopathy ($F(1, 45) = 6.46$, $p < .05$, partial $\eta^2 = .13$) and the hand x psychopathy interaction was not significant. For high-anxious groups, the main effect of psychopathy was not significant but there was a significant hand x psychopathy interaction ($F(1, 38)$, $p < .05$, partial $\eta^2 = .12$), with psychopathic participants showing a slower CUD on right-hand trials and control participants showing a slower CUD on left-hand trials.

[2]For controls only, there was a significant response hand x anxiety interaction ($F(1, 34) = 5.54$, $p < .05$, partial $\eta^2 = .14$) such that low-anxious controls showed a larger CUD on right-hand trials, while high-anxious controls showed a larger CUD on left-hand trials. To our knowledge, there are no existing studies of the relationship between anxiety and simple IHTT, although there are a number of reports showing that anxiety modulates interhemispheric integration (e.g., Compton et al., 2000). Full examination of controls' anxiety effect is beyond the scope of the present paper, but it would be useful to investigate these effects in future studies.

The somewhat more pronounced slowing of interhemispheric transfer on right-hand response blocks could be interpreted in either of two ways. First, the right-hand response condition can be interpreted as a LHA condition, given that right-hand motor responses are controlled by the left hemisphere. From this perspective, the stronger effects for right-hand response blocks can be viewed as consistent with Kosson's hypothesis of impaired information processing under LHA conditions. However, this interpretation also suggests a refinement of the LHA hypothesis, as psychopathic individuals' deficits under LHA conditions were specific to the measure of interhemispheric transfer, rather than overall performance (i.e., performance on both crossed and uncrossed trials). Alternatively, the longer CUD for right-hand response blocks can be interpreted with respect to the direction of transfer across the hemispheres. When participants are responding with their right hand, uncrossed trials occur when the stimulus is initially presented to the RVF/left-hemisphere (i.e., the hemisphere that also controls the right-hand motor response). Crossed trials occur when the stimulus is initially presented to the LVF/right-hemisphere. The CUD for right-handed trials thus provides an estimate of the time needed to transfer stimulus information from the right hemisphere (site of initial stimulus presentation) to the left hemisphere (site of response control). Therefore, the stronger effects for right-hand response blocks could indicate relatively slower transfer of information from the right hemisphere to the left hemisphere (right-hand CUD), rather than impaired transfer under LHA conditions. Because direction of CUD transfer and response hand are confounded in the Poffenberger design, it is not possible to differentiate between these two interpretations.

Given that at least some degree of communication and coordination between the hemispheres is presumed to occur under most natural conditions, even a slight delay in information transfer across the hemispheres could lead to wide-ranging disruptions in information processing. These disruptions may be magnified by the different processing biases of the left and right hemispheres, with delayed IHTT causing functions mediated predominantly by the left hemisphere (e.g., approach behavior, language processing) to be relatively unmodulated by functions mediated predominantly by the right hemisphere (e.g., behavioral inhibition, emotion processing) and vice versa. Interestingly, many of the cognitive and affective abnormalities associated with psychopathy are consistent with poor utilization of right-hemisphere processing under left-hemisphere activating conditions (see Hiatt & Newman, 2006; Hiatt, 2005 for further discussion).

Although the present study provides clear evidence of a prolonged CUD among psychopathic offenders, it also has a number of limitations. First, the behavioral CUD estimate used in the current study is not a direct measure of interhemispheric transfer time. Although behavioral CUD estimates using the Poffenberger paradigm are widely accepted as an index of callosal integrity, physiological (i.e., event-related potential) measures provide IHTT estimates that are more reliable and more consistent with the biophysics of interhemispheric transmission (see Saron et al., 2003; Saron & Davidson, 1989). Thus, it will be important to confirm our behavioral findings using physiological techniques.

Another limitation of the present study is the lack of eye-gaze verification. We encouraged central fixation by instructing participants to maintain their gaze on the fixation point and by presenting stimuli for a duration that is too brief to allow saccadic eye movements. Further, stimuli were presented unpredictably and with equal frequency to each visual field, and were therefore unlikely to bias attention to one or the other hemifield. Nevertheless, it is possible that participants' gaze was not directed to the central fixation stimulus on every trial, and these variations in gaze could have influenced performance. It is also not possible to rule out group differences in fixation compliance, which may have affected the overall pattern of findings.

Finally, response hand order was fixed across all participants, and therefore response hand effects could be confounded by order. As such, the response hand analyses should be interpreted somewhat cautiously until verified by future replications.

Despite these limitations, the present study provides clear and important evidence of a prolonged CUD among psychopathic offenders. Delayed interhemispheric transfer could play a fundamental role in psychopaths' known affective and cognitive processing abnormalities and should be examined further in future studies. An important first step will be to replicate the current findings using evoked potentials. In addition, imaging technologies have the potential to provide crucial insight into the mechanisms underlying the apparent transfer deficits in psychopathy. The integrity of psychopathic individuals' callosal fiber pathways could be examined using diffusion tensor imaging. Based on the current findings and those of Raine et al. (2003), one might expect increased callosal volume but degradation of fibers in people with psychopathy. Studies of this nature will help to clarify the relationship between structural and functional callosal abnormalities among psychopathic offenders. In addition, functional imaging techniques could be employed to examine dynamic patterns of brain activation in bilateral performance paradigms, potentially providing further insight into the behavioral and processing ramifications of interhemispheric transfer deficits among individuals with psychopathy.

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Table 1

Mean reaction times (in ms) by response hand and visual field.

		Control	Psychopathic
		M (SD)	**M (SD)**
Response Hand	Visual Field		
Left			
	Left	312.32 (47.02)	314.05 (42.98)
	Right	317.11 (50.00)	321.38 (41.74)
	CUD	4.79 (14.43)	7.33 (15.03)
Right			
	Left	321.78 (45.84)	329.15 (47.89)
	Right	318.73 (47.48)	319.05 (43.43)
	CUD	3.05 (17.33)	10.10 (16.42)

Table 2

Bivariate correlations between CUD and PCL-R Total Factor scores

	PCL-R Total N = 103	**PCL-R Factor 1 n=103**	**PCL-R Factor 2 n=96**
CUD	0.22*	0.19†	0.18†
CUD-RH	0.14	0.06	0.14
CUD-LH	0.14	0.18†	0.09

[1] As recommended by Hare (1991; 2003), PCL-R factor scores were not calculated if > 2 items for the factor were unable to be scored (e.g., due to lack of information), resulting in missing Factor 2 scores for 7 participants.

* $p < .05$

† $p < .10$