

## Inconsistent handers show higher psychopathy than consistent handers<sup>†</sup>

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### ABSTRACT

Three hundred and forty-two university students completed the Short Dark Triad (SD3) and the Edinburgh Handedness Inventory (EHI). Inconsistent handers showed higher psychopathy scores than consistent handers, and no handedness differences were observed for narcissism or Machiavellianism. Participants were further subdivided by quartile into low, moderately low, moderately high, and high psychopathy groups (non-clinical). Absolute EHI scores were equally distributed among low and moderate groups, but were significantly lower for the high psychopathy group. These findings suggest that inconsistent handedness is only associated with the upper quartile of psychopathy scores. Also, males showed significantly higher psychopathy scores than females, and the ratio of male to female inconsistent handers decreased as psychopathy score increased. No gender  $\times$  handedness interaction indicated that both female and male inconsistent handers have higher psychopathy scores than consistent handers. Although significant, the effects were small and 99.6% of participants were not in the range of a potential clinical diagnosis. The reader, therefore, is strongly cautioned against equating inconsistent handedness with psychopathy.

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The Psychopathy Checklist-Revised (PCL-R; Hare, 2003) assesses the degree to which an individual displays 20 characteristics, 18 of which are associated with the following four facets of the antisocial personality disorder:

- (1) Interpersonal (glibness/superficial charm, grandiose sense of self-worth, pathological lying, cunning/manipulative)
- (2) Affective (lack of remorse or guilt, emotionally shallow, callous/lack of empathy, failure to accept responsibility for own actions)
- (3) Lifestyle (need for stimulation/proneness to boredom, parasitic lifestyle, lack of realistic, long-term goals, impulsivity, irresponsibility)

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- (4) Antisocial (poor behavioural controls, early behavioural problems, juvenile delinquency, revocation of conditional release, criminal versatility)

Psychopaths are often depicted as among the worst elements of society, the people that are the most dangerous, useless, and maladaptive. Dutton (2012), however, argued that different patterns of psychopathic characteristics can mean the difference between society's worst nightmare and a successful, valuable member. For example, a person with violent tendencies, low intelligence, and high scores on antisocial and interpersonal facets may be a serial killer, but someone else with no violent tendencies, and high scores on interpersonal and affective facets could be a very successful CEO. So, being a psychopath is not the worst thing that could happen to you, provided that you are smart enough to know when to show it and when not to. Moreover, the incidence of psychopathic tendencies among the population is much higher than the incidence of serial killers, for certain, suggesting that psychopaths integrate well in normal, non-criminal society (LeBreton, Binning, & Adorno, 2006; see Gao & Raine, 2010 for different populations). Consider that Holmes and Holmes (2008) estimated approximately 100 active serial killers in the USA at the time of their writing, which is more than twice the common estimate of 30–40, but Quinet (2007) compellingly suggested the number of serial murder victims to also be much higher than common estimates. Adding the highest estimate of 100 active serial killers to the estimated 15–20% (as high as 29% according to Cooke & Michie, 1999) of the prison population who meet the criteria for psychopathy (Hare, 1996) estimates their number to be between one quarter and just under half a million people in the USA. However, Hare (1999) estimated at least two million psychopaths in just North America (about .6–1% of population). Today, 1% equals 5 million people. Coid, Yang, Ullrich, Roberts, and Hare (2009) estimated the approximate same percentage in the non-prison community in Great Britain. So, clearly, most psychopaths are not serial killers and may not even be incarcerated. This begs the question of who and where are they?

If psychopaths are integrated into normal society, many of them must have some perceived value to those around them and be functional in a variety of domains, even if they achieve the highest and lowest levels in those domains. Babiak, Neumann, and Hare's (2010) study of corporate psychopathy revealed many positive traits associated with high psychopathy individuals, including high charisma, strategic thinking, creativity/innovative ability, and communication styles. They also observed low ratings of the same individuals on management style and being a team player; the Interpersonal facet of the PCL was the strongest predictor of both the positive and negative assessments. Furthermore, there is enough variability within the population for psychopathy to likely overlap with other populations that are well integrated into normal society, and can be found in varied contexts and occupations (Cleckley, 1988/1988; Lykken, 1995). This includes at least medical professionals

(Dutton, 2012), college students (Gao & Raine, 2010), business professionals, attorneys, and professors (Mullins-Sweatt, Glover, Derefinko, Miller, & Widiger, 2010). These successful psychopaths differ from unsuccessful psychopaths mostly in that the former may have high conscientiousness (i.e. competence, achievement-striving, discipline, and deliberation) (Mullins-Sweatt et al., 2010) and high Facet 1 scores (Gao & Raine, 2010). Yet, even though we accept that there are many psychopaths integrated into normal society, in a variety of contexts and occupations, this does not suggest that they are evenly distributed for all, some, or any population parameters.

Currently, we investigated whether individuals with different degrees of handedness would also show different amounts of psychopathy. A number of studies have described behavioural and neurological patterns associated with psychopathy, some of which have also been associated with inconsistent handedness (preferential use of the right hand for some tasks, the left for others, or no hand preference), but not consistent handedness (preferential use of one hand, either the left or right, for most tasks). For example, Raine et al. (2003) observed a larger white matter volume of corpus callosum and greater functional inter-hemispheric connectivity in psychopaths, and this has also been reported for inconsistent handers (Habib et al., 1991; Hopper, Patel, Cann, Wilcox, & Schaeffer, 1994; Luders et al., 2010; Witelson & Goldsmith, 1991). Psychopaths also appear to have less amygdala volume than non-psychopaths (Yang, Raine, Narr, Colletti, & Toga, 2009), and Cherbuin, Sachdev, and Anstey (2011) observed greater age-related atrophy in the amygdala of inconsistent handers where age may exacerbate differences already existing in youth.

Behavioural similarities also exist. For example, inconsistent handers show enhanced episodic memory (Christman & Propper, 2001; Lyle, Logan, & Roediger, 2008; Lyle, McCabe, & Roediger, 2008; Propper, Christman, & Phaneuf, 2005) and this has also been observed in psychopaths, at least for their own crimes (Cooper, Hervé, & Yuille, 2007). Aligning with this is that pre-diagnosis adolescents with psychopathic tendencies recall fewer critical lures in the Deese–Roediger–McDermott false memory paradigm (Thijssen, Otgaar, Howe, & de Ruiters, 2013) and this has also been observed for inconsistent handers (versus consistent) (Christman, Propper, & Dion, 2004). Inconsistent handers show higher creativity (Shobe, Ross, & Fleck, 2009), and this may also be true for psychopaths, as measured directly (Salekin, Neumann, Lestic, & Zalot, 2004) and by indirect ratings by others (Babiak et al., 2010).

Incidentally, there have been several reports of non-right handers (left and inconsistent handedness) also reaching the upper echelons as artists (Preti & Vellanti, 2007), mathematicians (Annett & Kilshaw, 1982), and musicians (Aggleton, Kentridge, & Good, 1994). While their charisma may earn psychopaths high ranking positions in some fields (e.g. corporate), it is unlikely that psychopaths would reach the upper echelons of humanities owing to their deficiency in processing emotion (e.g. see Blair et al., 2006). On the

lower end of achievement, inconsistent handed children may show broad cognitive deficits (social/emotional, gross/fine motor, and receptive English skills) (Johnston, Nicholls, Shah, & Shields, 2009) relative to their more consistent handed peers. These broad cognitive deficits have also been observed in a pre-diagnostic category of kindergartners, and may be of predictive diagnostic value because they are notably consistent with maladaptive and violent tendencies in adolescent and adult offenders (Moffitt, 1993; Vaughn, DeLisi, Beaver, & Wright, 2008).

There are also some coincidences between inconsistent handedness and the classic psychopathy characteristics of risk seeking, impulsivity, trouble with the law, and low anxiety. Increased risk/sensation seeking and impulsivity have both been associated with psychopathy (Jones & Paulhus, 2014) and inconsistent handedness (Christman, 2014; Schmidt, Schmidt, Carvalho, & Carvalho, 2013). Both psychopaths and inconsistent handers are also more likely to have had trouble with the law (Bogaert, 2001; Bogaerts, Polak, Spreen, & Zwets, 2012; Mayer & Kosson, 2000). Psychopaths are also notorious for lack of emotion or low anxiety (i.e. keeping their cool) (Zágon & Jackson, 1994; also see Schmitt & Newman, 1999, who refute this). Similarly, Lyle, Chapman, and Hatton (2013) showed evidence for lower anxiety among inconsistent right handers than consistent right handers, and consistent handers may be more sensitive to disgust than inconsistent handers (Christman, 2014). Beratis, Rabavilas, Papadimitriou, and Papageorgiou (2011) also suggest that high neuroticism is associated with inconsistent handers, another trait that has also been associated with psychopathy (Jakobwitz & Egan, 2006; Paulhus & Williams, 2002). Indirectly, authoritarianism has been shown to negatively correlate with or be unrelated to psychopathy (Hodson, Hogg, & MacInnis, 2009; Ray, 1985) and consistent handers show greater expressions of authoritarian characteristics than inconsistent handers (Christman, 2014; Lyle & Grillo, 2014). This suggests that consistent handedness should not be associated with psychopathy. In contrast, the number of behavioural and neurological similarities suggests that inconsistent handedness and psychopathy may be associated.

While there are some striking similarities between psychopaths and inconsistent handers, there are also some important differences. Examination of the PCL-R (Bresin, Boyd, Ode, & Robinson, 2013) reveals that psychopaths can be high on egocentrism, but inconsistent handers are lower on egocentrism than consistent handers (Rose, Jasper, & Corser, 2012). Also, there is no evidence that inconsistent handers exhibit clinical levels of many or even most of the behavioural characteristics on the PCL-R. Furthermore, medial temporal (MT) dysfunction has been repeatedly observed in violent individuals (adolescents, offenders, antisocial, and psychopaths), but no handedness differences have been observed for MT (Bartha et al., 2003). This suggests that if inconsistent handers are higher in psychopathy then they may be more likely to be successful or non-violent psychopaths or that violent psychopathy is

unrelated to handedness. Frontal lobe dysfunction, specifically prefrontal cortex, has also been associated with antisocial personality (includes psychopathy) (Yang & Raine, 2009), but has not been associated with inconsistent handedness. Furthermore, cortical thinning has been observed in psychopathic versus non psychopathic inmates (Ly et al., 2012) but Li et al. (2015) observed greater cortical thickness in the same vicinity for non-right handers (left and inconsistent). Despite some fairly obvious and major differences between pathological psychopaths and inconsistent handers enough similarities have been reported for us to hypothesize that inconsistent handers will show higher psychopathic tendencies than consistent handers.

## Method

**Participants.** 342 Stockton University Introduction to Psychology students (Age  $M = 19.3$ ,  $SD = 2.3$ ; 241 Females, Mean Age = 19.2; 97 Males, Mean Age = 19.6; 4 gender unknown) participated for extra or required credit in their course. This population was specifically chosen for its inherent diversity in major and background, as this course is required by a variety of social science, natural science, and health science majors. These participants are also similar in their limited knowledge of psychological concepts because Introduction to Psychology is a required prerequisite for all other psychology courses. All other populations were excluded from participation. These data were collected across three semesters and four, large section introductory psychology courses.

## Materials

Instructions were typed on a separate piece of paper as follows:

Thank you for agreeing to participate in this study. We are currently collecting information on personality characteristics. You are being asked to complete the two accompanying questionnaires. There are no right or wrong answers on either questionnaire. There is no risk to your participation and we thank you for your time. Your decision of whether or not to participate in this study will have no bearing on your current or future standing with the researchers, the Psychology program, or the Richard Stockton College of New Jersey [Stockton University for data collected during Spring, 2015 semester]. All information obtained through this study will remain confidential in a locked area and will be destroyed within 5 years.

Short Dark Triad (SD3; Jones & Paulhus, 2014). This measure was administered by paper, and titled *SHORT Personality or Personality Characteristics*, but was otherwise identical to the SD3. It consisted of 27 typed items corresponding to three subscales (nine questions per): narcissism, Machiavellianism, and psychopathy. The SD3 psychopathy scale included three

items that reflect the antisocial facet (disregard for law or consequences), two items reflecting the lifestyle facet (need for stimulation and impulsivity/irresponsibility), three reflecting affective facet (mainly callousness and emotional shallowness), and one item that reflects the interpersonal facet (manipulative). Participants indicated the extent to which they agree/disagree with each item using a scale from 1 (strongly disagree) to 5 (strongly agree). We did not use the PCL-R because it is interview based and should be administered by clinically trained individuals (and so is expensive and time-consuming), nor did we use other self-report scales due to their length. For example, the Self-Report Psychopathy Scale-III (SRPP-III) (Paulhus, Neumann, & Hare, 2009) consists of 67 items and the Psychopathic Personality Inventory (PPI) (Lilienfeld & Andrews, 1996) is 100 items. The SD3 was specifically developed to be self-administered and short. Jones and Paulhus (2014) present strong evidence for the reliability and validity of the SD3, including item analysis for factor loading, cross validation of factors, and concurrent validity with SRP-III and PPI (among others). Moreover, although we had no a priori hypotheses regarding narcissism or Machiavellianism, the inclusion of those subscales had the potential to reduce the demand characteristics that may be present by just using the psychopathy scale.

The Edinburgh Handedness Inventory (EHI) (Oldfield, 1971). This is a paper and pencil measure consisting of a list of 10 tasks (e.g. writing, throwing, and drawing) from Oldfield's (1971) original EHI, with typed instructions for participants to report their hand preference for each task using the ratings: always left, usually left, no preference, usually right, always right. The response choices were a slight modification of Oldfield's (1971) EHI. The original EHI requested participants to place + for left or right hand preference, ++ if the hand preference was strong, or a + for each hand if there were no preferences. Also, we did not include the two questions in the original about eyed-ness and footed-ness. Fazio, Coenen, and Denney (2012) demonstrated that most participants understood the Likert-type scale on the EHI, but fewer than half of participants understood the original + system. EHI scores can be between 100 (perfectly right-handed) and -100 (perfectly left-handed). This EHI detail is reported in response to Edlin et al.'s (2015) discussion of the variety of ways the EHI has been used and reported. They recommended greater detail in reporting and uniformity in using the EHI to increase validity and replicability in handedness research, and we agreed.

Procedure. Following Informed consent and instructions, participants completed the SD3 and then the EHI.

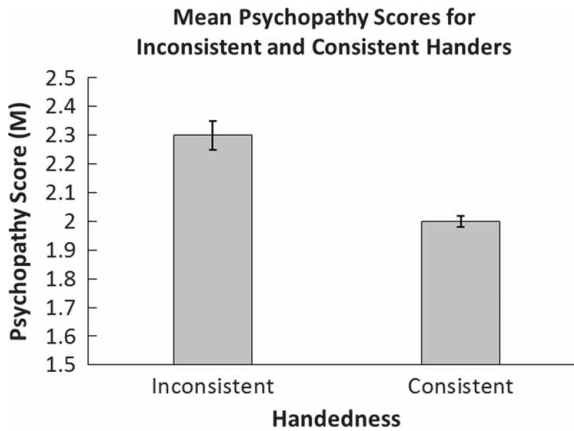
## Results

Participant handedness was categorized as consistent or inconsistent based on absolute value EHI scores, where consistent handers scored  $\geq 80$  ( $n =$

176, right-sided  $n = 164$ , left-sided  $n = 13$ ), and inconsistent handers scored  $\leq 75$  ( $n = 166$ , right-sided  $n = 140$ , left-sided  $n = 25$ ). The EHI score of 80 (which was also our observed EHI median score) is the population median and is also the most commonly used and the recommended method of dividing consistent from inconsistent handers by Prichard, Propper, and Christman (2013). This method results in two groups of approximately equal size, one comprised predominately of consistent right handers and a second comprised of inconsistent left and right handers (Christman, Prichard, & Corser, 2015). Both of our handedness group were right-side dominant. Moreover, Christman et al. (2015) observed that responses to the items on the EHI results in different kinds of response patterns for consistent versus inconsistent handers. This finding indicates that using a score of 80 on the EHI does produce a reliable and psychometrically valid parsing by degree of handedness, even though it may fail to catch more subtle differences within at least the inconsistent handed group. While the EHI has been criticized for its equal weighting of items contributing to the overall score, and Christman et al.'s (2015) findings do suggest that all items are not equal across and within the two handedness groups, we did not currently investigate more precise parsing within either handedness group.

To determine if inconsistent handers differed from consistent handers on the SD3 subscales, mean scores for narcissism, Machiavellianism, and psychopathy were submitted to a one-way multivariate analysis of variance. The multivariate test revealed a significant difference between handedness groups,  $F(3, 338) = 4.14$ ,  $p = .007$ , Wilk's  $\Lambda = .96$ ,  $\eta_p^2 = .035$ . Inconsistent handers ( $M = 2.25$ ,  $SE = .05$ ) scored significantly higher in psychopathy than consistent handers ( $M = 2$ ,  $SE = .02$ ),  $F(1, 340) = 11.87$ ,  $p = .001$ , with a small effect size,  $\eta_p^2 = .034$ . No handedness differences were observed for narcissism,  $F = 1$ , or Machiavellianism,  $F(1, 340) = 1.4$ ,  $p = .24$ . These findings indicate inconsistent handers are higher in psychopathy than consistent handers (Figure 1).

Follow-up correlation analyses revealed an inverse correlation for absolute EHI scores and psychopathy,  $r(340) = -.14$ ,  $p = .004$ . While handedness did not correlate significantly with either narcissism or Machiavellianism, psychopathy correlated with both narcissism,  $r(340) = .12$ ,  $p = .01$  and Machiavellianism,  $r(340) = .12$ ,  $p = .02$ . The significant correlation between psychopathy and handedness suggests that as EHI scores increase, psychopathy decreases. However, we questioned whether inconsistent and consistent handedness would be disproportionately dispersed at different levels of psychopathy. To determine this, we categorized individuals into four psychopathy groups. Because there are no published categories for the SD3, we used quartiles as cut points for groups (Q1 range = 1.0–1.65; Q2 = 1.66–1.99; Q3 = 2.00–2.54; Q4 = 2.55+), and submitted handedness and psychopathy to a chi-square test,  $\chi^2(3, n = 342) = 8.08$ ,  $p = .04$ . The distribution (Table 1) indicates that



**Figure 1.** Inconsistent handers had significantly higher mean psychopathy scores ( $M = 2.25$ ,  $SE = .05$ ) than consistent handers ( $M = 2$ ,  $SE = .02$ ).

there were more consistent than inconsistent handers in the Q1, Q2, and Q3, but more inconsistent than consistent handers in the Q4.

To test for significant differences in handedness between psychopathy groups, a one-way analysis of variance (ANOVA), using the four psychopathy groups as a factor and handedness scores (absolute value) as a dependent measure revealed a barely significant effect,  $F(3, 338) = 2.56$ ,  $p = .055$ ,  $\eta_p^2 = .02$ . Simple contrasts confirmed that there were no significant handedness differences between Q1 (low psychopathy,  $Me = 80$ ,  $M = 75.5$ ,  $SE = 2.8$ ), Q2 (moderately low psychopathy,  $Me = 80$ ,  $M = 74$ ,  $SE = 2.8$ ), and Q3 (moderately high psychopathy,  $Me = 80$ ,  $M = 76$ ,  $SE = 2.4$ ),  $p$ 's  $\geq .5$ ; but significant differences were observed between Q4 (high psychopathy,  $Me = 70$ ,  $M = 67$ ,  $SE = 2.5$ ) and Q3,  $p = .01$  and between Q4 and Q1,  $p = .03$ . Planned comparisons confirmed that the highest psychopathy group (Q4) was significantly lower in handedness than all other groups combined,  $t(338) = 2.24$ ,  $p = .03$ ; but Q1 did not differ in handedness from the combined Q2 and Q3 quartiles,  $t(338) < 1$ ; nor was there a difference in handedness between the two lowest

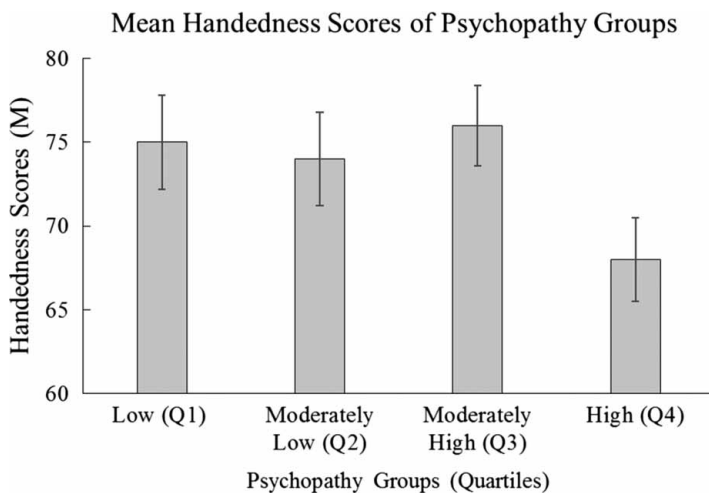
**Table 1.** Frequencies (and proportions of group  $N$ ) of consistent and inconsistent handers in low (1st quartile), moderately low (2nd quartile), moderately high (3rd quartile), and high (4th quartile) psychopathy groups.

Psychopathy group quartiles	Handedness		Total frequency (proportions of total $N$ )
	Consistent	Inconsistent	
1st	46 (.61)	30 (.39)	76 (.22)
2nd	41 (.55)	33 (.45)	74 (.22)
3rd	52 (.525)	47 (.475)	99 (.29)
4th	37 (.40)	56 (.60)	93 (.27)
Total	176 (.51)	166 (.49)	342



groups (Q1 + Q2) and the combined two highest groups (Q3 + Q4),  $t(338) < 1$ . Taken together, these analyses indicate that only the highest quartile of psychopathy includes more inconsistent than consistent handers, where inconsistent handedness is more likely to be observed at the highest level of psychopathy than consistent handedness. Lower and moderate levels of psychopathy do not appear to be associated with handedness (Figure 2).

**Gender.** Secondary analyses were conducted on gender because there have been several reports where males show significantly higher psychopathy than females in normal (Levenson, Kiehl, & Fitzpatrick, 1995; Wilson, Frick, & Clements, 1999) and clinical (Cale & Lilienfeld, 2002) populations. Also, while males are equally likely to be consistent or inconsistent handed, females are more likely to show consistent handedness, and males are more likely than females to show inconsistent handedness (Prichard et al., 2013). We wondered whether the observed effect of handedness consistency could potentially be due to more males than females in the high psychopathy group, and whether there was a gender  $\times$  handedness interaction. To test whether the number of males and females differed within each psychopathy group, Psychopathy Group (Q1, Q2, Q3, and Q4) and Gender (M, F) were submitted to a chi-square test for independence,  $\chi^2(3, n = 338) = 11.09, p = .01$ . There was a higher frequency of females in each group, due to the many more females in the study, and so we report the percentages because they are more informative. For Q1, 18% were male (82% female); for Q2, 25% were male (75% female); for Q3 29% were male (71% female); and for Q4, 44% were male (56% female). These percentages suggest a much higher ratio of females to males in Q1, Q2, and Q3, but this ratio is much smaller



**Figure 2.** Mean handedness scores for each psychopathy group. Only the High (4Q) Psychopathy group showed significant handedness differences from the other groups.

for Q4, where the number of males increased from previous quadrants and the number of females decreased from previous quadrants. Additional chi squares were calculated to test for a relationship between the number of males and females in each psychopathy group by handedness consistency. Among inconsistent handers, gender was related to psychopathy,  $\chi^2(3, n = 338) = 10.1, p = .02$ , but this was not significant for consistent handers,  $\chi^2(3, n = 338) = 10.1, p = .02$ . This pattern for inconsistent handers was similar to the overall gender  $\times$  psychopathy chi-square, confirming that inconsistent handed males comprise an increasing percentage of each psychopathy group (13% in Q1, 32% in Q2, 39% in Q3, and 51% in Q4). Thus, for inconsistent handers only, the highest psychopathy quartile is split between males and females, but females comprise the much larger percentage of Q1, Q2, and Q3. As such, to determine whether psychopathy scores depended on gender and handedness, psychopathy scores were submitted to a 2 (Handedness: Consistent, Inconsistent)  $\times$  2 (Gender: Female, Male) univariate ANOVA. There were small main effects of handedness,  $F(1, 334) = 5.3, p = .02, \eta_p^2 = .02$  (M reported, above); and of gender,  $F(1, 334) = 10.6, p = .001, \eta_p^2 = .04$ , where males ( $M = 2.37, SE = .66$ ) had significantly higher psychopathy scores than females ( $M = 2.1, SE = .56$ ). No handedness  $\times$  gender interaction,  $F(1, 334) = 2.7, p = .10$  was observed, suggesting that females and males are similar in psychopathy across the two levels of handedness, where males have higher psychopathy scores for each handedness condition, but that both female and male inconsistent handers have higher psychopathy scores than consistent handers.

Clinical descriptives. The SD3 was not validated with a clinical population, and has not been tested with a clinical population, to date. As such, we can only speculate the number of "real" psychopaths in our sample by using Hare's estimate of the highest .6–1% of scores. The top 1% of scores on the SD3 correspond to a mean psychopathy score between 4 and 5 (D. Jones, personal communication, 20 July 2015). Presently, there were two participants in this range, one female (score = 4, EHI score = -20, indicating inconsistent handedness) and one male (score = 4.8, EHI score = 25 indicating inconsistent handedness) (relative frequency = .6%). So, although we qualified the 4th quartile group as "high psychopathy", 99.6% of participants in that group were unlikely to be clinically diagnosable psychopaths. The frequencies and proportions of the 4th quartile psychopathy scores appear in [Table 2](#). Levenson et al. (1995) also observed "few if any full blown psychopaths" in their study of 487 undergraduates at University of California-Davis.

## Discussion

First, although our findings demonstrate that inconsistent handers show significantly higher psychopathy scores than consistent handers and that only

**Table 2.** Frequencies (and proportions of total group  $N = 93$ ) for the high psychopathy group.

4th Quartile Scores	Frequency (proportion)
2.50–2.99	60 (.65)
3.00–3.49	27 (.29)
3.50–3.99	4 (.04)
4.0+	2 (.02)

the top psychopathy group showed significantly more inconsistent than consistent handedness, neither these findings nor previous research warrants the conclusion that inconsistent handers are psychopaths (successful or unsuccessful) or serial killers. We also strongly caution against the suggestion that inconsistent handers have a propensity towards psychopathy. Rather, because handedness was used here as a quasi-experimental variable, it is more reasonable to conclude that the similarity between inconsistent handers and psychopathy may be due to other causative variables. Even though psychopathy and handedness inconsistency share some neural similarities (e.g. greater corpus callosum volume), they fail to share others that seem to be key, and perhaps defining, for psychopathy. For example, structural abnormalities associated with psychopathy, such as reduced grey matter in fronto-temporal limbic regions (frontopolar, orbitofrontal and anterior temporal cortices, superior temporal sulcus region, and insula) (de Oliveira-Souza et al., 2008), structural abnormalities of the amygdala (Boccardi et al., 2011; Yang et al., 2009), and dysfunctional connectivity between the amygdala and the ventromedial prefrontal cortex (Blair, 2008; Herpers, Scheepers, Bons, Buitelaar, & Rommelse, 2014) have not been associated with varying degrees of handedness.

However, the larger corpus callosum may be an important structural similarity underlying the many cognitive and behavioural similarities discussed in the introduction. Increased size of the corpus callosum may be related to greater inter-hemispheric interaction and reduced behavioural lateralization (Aboitiz, Scheibel, Fisher, & Zaidel, 1992; see Bloom & Hynd for review, 2005; Prichard et al., 2013; Propper et al., 2010). Psychopathy and inconsistent handedness both appear to have reduced functional (behavioural) lateralization. For example, Chiarello, Welcome, Halderman, and Leonard (2009) observed interesting functional differences between consistent and inconsistent handers, where inconsistent handers show less stable lateralization than consistent handers, and the extent of lateralization predicted reading performance in consistent handers only. This pattern of greater lateralization for consistent handers has also been observed for processing positive emotions (Bourne, 2008), and lateralization for words and speech sounds decreasing as non-right handedness increases (Jörgens, Kleiser, Indefrey, & Seitz, 2007; Knecht et al., 2000; Propper et al., 2010; Szafarski et al., 2002).

Psychopaths have also demonstrated reduced lateralization for word processing (Hare & MacPherson, 1984; Raine, O'Brien, Smiley, Scerbo, & Chan, 1990) and emotional processing (Day & Wong, 1996). Thus, inconsistent handers and psychopaths may exhibit similar behaviours because both are functionally less lateralized than consistent handers, not because they have the same structural abnormalities. This commonality has also been suggested by Mayer and Kosson (2000).

Interestingly, the pattern of association we observed between handedness and psychopathy has also been observed for other psychotic disorders (or behaviours). For example, Barnett and Corballis (2002) observed an inverse relationship between consistency of handedness and magical ideation, and Poreh (1994) replicated Chapman and Chapman's (1987) finding that inconsistent handers are more prone to psychosis. Chapman, Grimshaw, and Nicholls (2011) and Tsuang, Chen, Kuo, and Hsiao (2013) also observed positive schizotypy (e.g. magical ideation) to be related to inconsistent handedness more so than left or right handedness. This relationship between schizotypy and non-right handedness was further confirmed in a meta-analysis that included over 10,000 participants (Somers, Sommer, Boks, & Kahn, 2009). A meta-analysis of 50 studies by Hirnstein and Hugdahl (2014) similarly observed schizophrenia to be associated with degree and not direction of handedness. Van der Hoorn, Oldehinkel, Ormel, Bruggeman, Uiterwaal, and Burger (2010) specifically demonstrated non-right handedness to be associated with psychotic more so than non-psychotic symptomology. Furthermore, similar to inconsistent handedness and psychopathy, schizotypy has been observed to coincide with reduced or atypical lateralization in language (Sommer, Ramsey, Kahn, Aleman, & Bouma, 2001; Spaniel et al., 2007) and a variety of other domains (for review, see Grimshaw & Kranz, 2015). Dissimilar to psychopathy and inconsistent handedness is that there may be fewer callosal connections in schizotypy (Arnone, McIntosh, Tan, & Ebmeier, 2008; Keshavan et al., 2002), but Downhill et al. (2000) observed larger callosal genu but smaller posterior callosum in schizotypy as compared to normal controls. Nonetheless, the connection between handedness and psychotic disorders or behaviours may be reduced behavioural lateralization and associated colossal abnormalities.

There are several additional reasons why equating inconsistent handedness with psychopathy would be erroneous at this point. One reason is that although the group difference was significant, the effect was small. This suggests that inconsistent handers may show only slightly elevated psychopathy scores as compared to consistent handers. A second reason is that only two of our participants actually showed potentially clinical scores, whereas 99.6% did not show such high levels. This means that our sample cannot generalize to a clinical population. Of course, we wonder if the effect would be larger in a clinical population, or be larger or disappear

entirely if the population from which this sample was drawn was from a different school where there is a pervasive cultural expectation for graduates to become leaders of industry or other professional fields. Moreover, even though the estimated 2 million (or 5 million, today) psychopaths in N. America is a lot of people, high psychopathy is actually somewhat rare. So, while our data suggest that there is a greater chance for inconsistent handers to have higher psychopathy than consistent handers, suspecting a neighbour or colleague to be a psychopath based on inconsistent handedness would be an enormous leap, a real longshot.

Finally, and perhaps most obviously, it would be erroneous to conclude that inconsistent handers are psychopathic because there is no evidence that inconsistent handers reliably demonstrate the extreme pathological tendencies encompassed by the PCL-R or the Diagnostic and Statistical Manual of Mental Disorders (APA, 2013) requirement for clinical diagnosis of psychopathy. The SD3 was validated with community and student samples (Jones & Paulhus, 2014), and so it is useful for research identifying narcissism, Machiavellianism, and psychopathy in the same population, as we have done, here. It is interesting, however, that the SD3 is sensitive to different amounts of psychopathy in the normal population and that our somewhat arbitrary division into quartiles correspond to real differences in handedness, and therefore, neural organization. In our opinion, more research should be conducted in normal and clinical populations on the SD3 to perhaps refine classifications by degree of psychopathy.

## Disclosure statement

No potential conflict of interest was reported by the authors.

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