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Is handedness related to anxiety? New answers to an old question

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Is handedness related to anxiety? Two separable dimensions of handedness have been considered in previous studies: Direction of the preferred hand (left or right) and the consistency with which the preferred hand is used over the nonpreferred hand (consistent or inconsistent). Findings have included (1) left-handedness being associated with greater anxiety than right-handedness, (2) consistent-handedness being associated with greater anxiety than inconsistent-handedness and (3) neither dimension being associated with anxiety. Here, we administered measures of trait anxiety, state anxiety and worry to individuals classified as consistent-left, inconsistent-left, inconsistent-right or consistent-right. Neither direction nor consistency had a main effect on any measure. However, there was a direction by consistency interaction in trait and state anxiety measured on the State/Trait Anxiety Inventory. Among right-handers, inconsistent individuals reported less anxiety than consistent individuals. Among left-handers, consistency was unrelated to anxiety. In consequence of this pattern, inconsistent right-handers were less anxious than inconsistent left-handers. Hence, supporting prior studies, left-handedness was associated with greater anxiety than right-handedness (but only among inconsistent individuals) and consistency was associated with greater anxiety than inconsistency (but only among right-handers). These findings advance our understanding of handedness consistency as an important individual difference factor in personality and cognition.

Keywords: Anxiety; Handedness; Individual differences.

Is handedness related to anxiety? This question was first posed more than 30 years ago (Hicks & Pellegrini, 1978), and has been asked several times since, but a firm answer has not emerged. In Hicks and Pellegrini's (1978) seminal study, groups reporting some amount of left-hand usage were more

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anxious than individuals who very consistently used their right hand only. Similarly, in Dillon (1989), frequency of left-hand usage correlated positively with worry, albeit only among males (Hicks & Pellegrini did not report sex analyses). Most recently, Wright and Hardie (2011) found that left-handers, regardless of sex, reported significantly more state anxiety while completing a battery of cognitive tests, but not significantly more trait anxiety. Wright and Hardie took their finding to mean that left-handers experience greater momentary anxiety in response to particular situational factors, such as novelty, but do not experience greater anxiety in general. These three studies converge on the idea that left-handedness is associated with greater anxiety.

Other researchers, however, have reached starkly different conclusions. Wienrich, Wells and McManus (1982) found that individuals with a highly consistent tendency to use only one hand (whether left or right) were more anxious than relatively inconsistent individuals. In partial accord with this, Merckelbach, de Ruiter and Olff (1989, Study 1) found that consistent right-handers were more socially anxious than a group apparently composed primarily of inconsistent individuals. These two studies indicate that consistent-handedness, rather than left-handedness, is associated with greater anxiety. Finally, though, two studies concluded that neither left/right direction nor degree of consistency was related to anxiety (Beaton & Moseley, 1991; French & Richards, 1990). These null effects should be evaluated cautiously, however, because, as Wright and Hardie (2011) pointed out, they came from studies in which situational factors that might have elicited anxiety were either absent or not constant for all subjects. In sum, if any relationship exists between handedness and anxiety, which is not clear, it may be that left-handedness, consistent-handedness or possibly both are markers for greater anxiety.

What would be the significance of a relationship between handedness and anxiety? The answer is at least threefold. One, it could establish certain handedness profiles as risk factors for elevated anxiety and possibly the development of anxiety disorders. Two, it might suggest mechanisms for the modulation of anxiety. In most previous studies in which one group was more or less anxious than another, the authors were largely silent or noncommittal about why (cf. Wright & Hardie, 2011), possibly due to the preliminary or contradictory nature of their findings. More firmly establishing a relationship would permit more confident theorizing about factors influencing anxiety. Three, and most important for our purposes, if a relationship exists between anxiety and consistency of handedness, it would inform an emerging literature indicating that consistency (or degree of manual lateralization) is an important individual difference factor in personality and cognition. We expand on this third potential contribution next.

Recent research has indicated that consistently and inconsistently handed individuals differ, not only in their manual behaviour, but also in cognition and personality. Memory differences have been repeatedly investigated, with inconsistent individuals' memories being more accurate (e.g., Christman, Propper & Dion, 2004; Lyle, Hanaver-Torrez, Hackländer & Edlin, 2012; Lyle, McCabe & Roediger, 2008; Propper, Christman & Phaneuf, 2005) and more subjectively vivid and detailed (Parker & Dagnall, 2010; Propper & Christman, 2004). Other studies have extended differences into domains far beyond memory. For example, inconsistently handed individuals may be more creative (Badzakova-Trajkov, Häberling & Corballis, 2011; Shobe, Ross & Fleck, 2009), more persuadable (Christman, Henning, Geers, Propper & Niebauer, 2008), more likely to engage in some types of risky behaviour (Christman, Jasper, Sontam & Cooil, 2007) and less likely to ruminate (Niebauer, 2004). Such diverse differences suggest that the study of handedness consistency may help us understand variability in many aspects of personality and cognition.

Here, we seek to answer two questions raised by prior consistency research. One, does direction of handedness interact with consistency-related differences in personality and cognition or exert an independent main effect? The recent studies of consistency have, for the most part, not examined the possibility of direction-related effects. The reasons for this are both theoretical and practical. Theoretically, one account of consistency-related differences (Christman et al., 2004; Propper et al., 2005) is that a high degree of consistency, regardless of direction, is associated with poor functional coordination of the left and right cerebral hemispheres (or *interhemispheric interaction*). By this account, certain aspects of personality and cognition show consistency-related differences because they are sensitive to interhemispheric interaction, and direction is largely inconsequential. Practically, the study of direction-related effects is difficult because left-handedness is uncommon. This proves especially problematic for consistency studies, which require sampling left-handers in sufficient numbers to permit further subdivision into inconsistent and consistent groups. For these reasons, most recent consistency studies have simply compared consistent right-handers, who are common (Peters & Murphy, 1992), to heterogeneous groups consisting mostly of inconsistent right-handers, but also including a small number of inconsistent left-handers (and occasionally even a few consistent left-handers; e.g., Christman, Bentle & Niebauer, 2007; Lyle et al., 2008). This method permits assessment of consistency-related differences, because mean consistency is always greater in the consistent right group than the comparison group, but it does not permit assessment of direction-related effects. Researchers who have used this method have sometimes argued, on the basis of post hoc analyses, that direction does not interact with consistency (e.g., Christman, Bentle & Niebauer, 2007; Christman,

Sontam & Jasper, 2009; Kempe, Brooks & Christman, 2009; Niebauer, 2004), and that is indeed what Wienrich et al. (1982) found in their anxiety study. However, in all those analyses, and in Wienrich et al., the number of left-handers was small. For example, Wienrich et al.'s study included only six inconsistent left-handers. As for whether there may be a main effect of direction and a main effect of consistency on the same measure of personality and cognition, none of the recent post hoc analyses have addressed this possibility.

Only once before have direction and consistency been investigated simultaneously with a large sample of left-handers, thereby permitting examination of a main or interactive effect of direction. Consonant with the theory and preliminary evidence described earlier, direction and consistency did not interact in that study, which was concerned with memory. Lyle et al. (2012) found that inconsistency was associated with superior memory accuracy, and equally so for left- and right-handers (i.e., a main effect of consistency). There was no main effect of direction; left- and right-handers were equally accurate.

Although direction had no effect on memory accuracy in Lyle et al. (2012), there are reasons to believe that direction of handedness may be important in the context of anxiety. First, recall that left-hand usage has previously been associated with elevated anxiety in some studies (Dillon, 1989; Hicks & Pellegrini, 1978; Wright & Hardie, 2011). Second, there is evidence that left-handers are more behaviourally inhibited (Wright, Hardie & Wilson, 2009) and more fearful (Rogers, 2009) than right-handers. Behavioural inhibition is positively correlated with anxiety (Barlow, 2002; Degnan & Fox, 2007), and fear and anxiety are obviously closely related constructs, so this strengthens the expectation engendered by some prior studies that left-handers should be more anxious than right-handers.

The second question an investigation of the handedness–anxiety relationship can help answer is: Are consistency-based differences sensibly inter-related such that we can accurately predict novel differences from known ones? Niebauer (2004) found that inconsistent-handers ruminate less than consistent-handers. Given the well-established positive relationship between rumination, anxiety and worry (e.g., Chapman, Kertz & Woodruff-Borden, 2009; McEvoy, Mahoney & Moulds, 2010; Yook, Kim, Suh & Lee, 2010), we would therefore expect inconsistent-handers to report less anxiety than consistent-handers. This effect has been reported in some studies (Merckelbach et al., 1989; Weinrich et al., 1982), but denied in others (Beaton & Moseley, 1991; French & Richards, 1990). Resolving this discrepancy is important because degree of consistency is likely to come to be considered a meaningful individual difference factor only if the characteristics associated with a particular consistency group are sensibly interrelated.

To summarize, it is unclear from prior research whether handedness is related to anxiety. To resolve the ambiguity and to contribute to the literature on handedness consistency as an individual difference factor in personality and cognition, we administered four commonly used anxiety questionnaires to college-aged subjects who were divided into four handedness groups: Consistent-left, inconsistent-left, inconsistent-right and consistent-right. The questionnaires were the Penn State Worry Questionnaire (PSWQ; Meyer, Miller, Metzger & Borkovec, 1990), State/Trait Anxiety Inventory (STAI; Spielberger, Gorsuch, Lushene, Vagg & Jacobs, 1983) and Beck Anxiety Inventory (BAI; Beck & Steer, 1990). Finally, to control for individual differences in positive and negative mood not specific to anxiety, we also administered the Positive and Negative Affect Schedule (PANAS; Watson, Clark & Tellegen, 1988).

We selected questionnaires on the basis of their common use in contemporary anxiety research, rather than their use in prior studies. Some previously used questionnaires, including the Manifest Anxiety Scale (in Hicks & Pellegrini, 1978; Wienrich et al., 1982), Fear Questionnaire (in Merckelbach et al., 1989) and Student Worry Survey (in Dillon, 1989), are not widely used today. The one questionnaire used previously that is in wide current use—the State/Trait Anxiety Inventory (in Beaton & Moseley, 1991; French & Richards, 1990)—was also used here.

Given Wright and Hardie's (2011) argument that direction-based differences in anxiety may emerge only when there are potentially anxiety-provoking situational factors, it bears noting that most subjects in the present study ($n = 128/163$, 78.5%) completed the anxiety questionnaires during a break in an unrelated experimental procedure involving cognitive testing. More information about this aspect of the study is provided later.

METHOD

Subjects

Subjects were students aged 18–28 years who received credit in psychology courses or \$10 for participating. Subjects were classified (see later) as consistent-left ($n = 31$, 14 females), inconsistent-left ($n = 41$, 21 females), inconsistent-right ($n = 36$, 28 females) or consistent-right ($n = 55$, 43 females).

Materials

The hand preference inventory was a modified version of Oldfield's (1971) Edinburgh Handedness Inventory that we have used in numerous other studies (e.g., Lyle & Martin, 2010; Lyle et al., 2008, 2012). The inventory

queries direction and consistency of hand use for 10 activities (writing, drawing, using a spoon, opening jars, using a toothbrush, throwing, combing hair, using scissors, using a knife without a fork and striking a match). For each activity, the response options (and corresponding point values for the purpose of scoring) are “always right” (+10), “usually right” (+5), “no preference” (0), “usually left” (−5) and “always left” (−10). Scores range from −100 (exclusive left-hand usage) to +100 (exclusive right-hand usage) in 5-point increments.

The PSWQ is a 16-item self-report measure of one’s perceived tendency and ability to control worry over personally salient events. Higher scores indicate greater worry. Internal consistency in the current sample was .94. The STAI is a 40-item questionnaire that assesses state and trait anxiety as separate subscales. Higher scores indicate greater anxiety. Internal consistency in the current sample was .93 for both subscales. The BAI is a 21-item self-report inventory of somatic and cognitive symptoms of anxiety. Higher scores indicate greater symptomatology. Internal consistency in the current sample was .92. The version of the PANAS we used is a 20-item self-report measure that was designed to assess the distinct dimensions of positive and negative affect on a 5-point Likert-type scale. Respondents indicate the extent to which they generally experience (on average) a variety of affective states.

Procedure

We first administered the handedness inventory. Following our method in Lyle et al. (2012), we classified subjects scoring less than zero as left-handed and greater than zero as right-handed. Within each directional group, we classified subjects as inconsistent if the absolute value of their score was less than 80 and consistent if it was 80 or greater.

Next we administered paper-and-pencil versions of the questionnaires in the following invariant order: PSWQ, STAI-State, STAI-Trait, BAI and PANAS. Subjects filled out the questionnaires sequentially with no break between them. Most subjects ($n = 70$ left-handers and 58 right-handers) filled out the questionnaires during a break in an unrelated cognitive task.¹ The remaining two left-handed and 33 right-handed subjects were not asked to do the unrelated task. We conducted all analyses reported later both including and excluding the subjects who did not do the unrelated task. Inclusion of those subjects did not change the significance level of any effects. The reported results include data from all subjects.

¹ Data on the unrelated task from some of the subjects were reported in Lyle and Martin (2010).

RESULTS

The absolute value of hand preference inventory scores did not differ between inconsistent left- and right-handers ($M_s = 57.0$ and 62.9 , respectively), $t(75) = 1.54$, or between consistent left- and right-handers ($M_s = 92.3$ and 92.9 , respectively), $t(84) = 0.71$. Hence, left- and right-handers were equally inconsistent and consistent.

Scores from each of the anxiety questionnaires were submitted to a 2 (direction: Left or right) \times 2 (consistency: Inconsistent or consistent) \times 2 (sex: Female or male) between-subjects ANCOVA with the covariates of positive PANAS score and negative PANAS score.²

Handedness was related to both trait and state anxiety as measured by the STAI. Specifically, there was a significant direction by consistency interaction in both scales: Trait, $F(1, 153) = 7.15$, $p = .008$, $\eta_p^2 = .045$; state, $F(1, 153) = 6.91$, $p = .009$, $\eta_p^2 = .043$. The interaction took the same form for both scales. Although the three-way interaction with sex was not significant for either scale, largest $F(1, 153) = 1.85$, $p = .176$, the two-way interaction is shown separately for females and males in Figures 1a and 1b, respectively. Means reported in the body of the text are collapsed across sex. As shown in Figures 1a and 1b, inconsistent right-handers reported less anxiety (trait $M = 38.8$, state $M = 33.8$) than consistent right-handers (trait $M = 44.5$, state $M = 39.7$). The difference was significant for both scales: Trait, $F(1, 85) = 8.52$, $p = .004$, $\eta_p^2 = .091$; state, $F(1, 85) = 9.36$, $p = .003$, $\eta_p^2 = .10$. However, this effect was completely absent, and in fact numerically reversed, for left-handers, among whom inconsistent individuals reported nonsignificantly more anxiety (trait $M = 42.2$, state $M = 39.1$) than consistent individuals (trait $M = 41.3$, state $M = 37.7$), $F_s < 1$. Inconsistent right-handers, in addition to being significantly less anxious than consistent right-handers, were also significantly less anxious than inconsistent left-handers on both the trait scale, $F(1, 71) = 4.23$, $p = .043$, $\eta_p^2 = .056$, and the state scale, $F(1, 71) = 8.67$, $p = .004$, $\eta_p^2 = .11$.

Neither direction nor consistency nor their interaction was significantly related to worry as measured by the PSWQ, largest $F(1, 153) = 2.45$, $p = .12$, $\eta_p^2 = .016$, or to trait anxiety as measured by the BAI, largest $F < 1$. However, the numeric pattern was the same for these measures as for the two STAI scales: Lower scores for inconsistent right-handers than consistent right-handers but higher scores for inconsistent left-handers than consistent left-handers. Given these patterns, and because each measure was significantly

²To verify the appropriateness of using positive and negative PANAS scores as covariates in analyses of the effects of direction and consistency on anxiety, we submitted the two score types to separate 2 (direction: Left or right) \times 2 (consistency: Inconsistent or consistent) \times 2 (sex: Female or male) between-subjects ANOVAs. Neither positive nor negative scores were significantly affected by direction, consistency or their simple interaction (all $p_s \geq .093$).

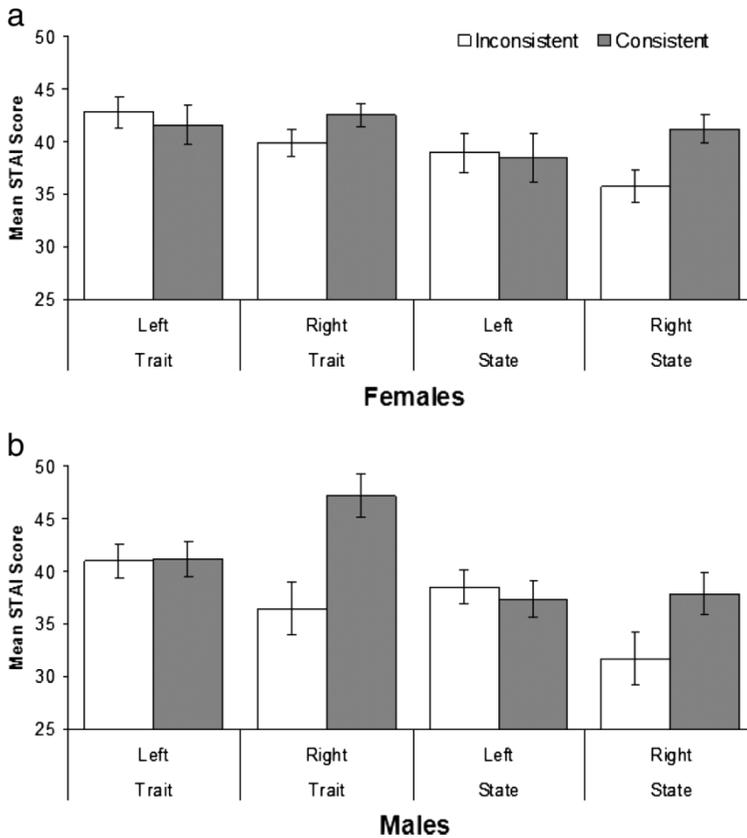


Figure 1. Mean STAI trait and state anxiety as a function of handedness direction and consistency, plotted separately for females (a) and males (b). The number of females in each condition was 21 inconsistent-left, 14 consistent-left, 28 inconsistent-right and 43 consistent-right. The number of males in each condition was 20 inconsistent-left, 17 consistent-left, 8 inconsistent-right and 12 consistent-right. Errors bars indicate ± 1 SEM.

correlated with the other three (see Table 1), we created a composite measure of anxiety by normalizing the scores on each measure and then taking the average of the four z -scores. We analysed the composite measure in the same manner as the individual measures. The direction by consistency interaction was significant, $F(1, 153) = 6.18$, $p = .014$, $\eta_p^2 = .039$. Inconsistent right-handers ($M = -0.28$) were significantly less anxious than consistent right-handers ($M = 0.09$), $F(1, 85) = 8.42$, $p = .005$, $\eta_p^2 = .09$, and significantly less anxious than inconsistent left-handers ($M = 0.03$), $F(1, 71) = 6.77$, $p = .011$, $\eta_p^2 = .087$. Inconsistent left-handers were nonsignificantly more anxious than consistent left-handers ($M = -0.04$), $F < 1$.

TABLE 1
Bivariate correlations for scores on the anxiety measures

<i>Measure</i>	1	2	3	4
1. STAI-State	1.0	–	–	–
2. STA-Trait	.80*	1.0	–	–
3. PSWQ	.55*	.63*	1.0	–
4. BAI	.57*	.61*	.54*	1.0

* $p < .001$.

The only significant main or interactive effect of sex on any of the individual anxiety measures was the main effect on PSWQ scores, $F(1, 153) = 22.45$, $p < .001$, $\eta_p^2 = .128$. Scores were higher for females ($M = 53.1$) than males ($M = 44.4$). There was a significant main effect of sex on the composite measure of anxiety, $F(1, 153) = 5.71$, $p = .018$, $\eta_p^2 = .036$, with higher scores for females ($M = 0.06$) than males (-0.15). Sex did not interact significantly with any other factors on the composite measure, largest $F(1, 153) = 1.09$, $p = .299$.

DISCUSSION

Is handedness related to anxiety? The present study provides new answers to this old question. Alternatively, it may be more precise to say that the present study qualifies old answers that were previously given. Previously, some researchers proposed that highly lateralized handedness behaviour (referred to herein as consistent-handedness) is associated with greater anxiety (Wienrich et al., 1982; see also Merckelbach et al., 1989), whereas others proposed that left-hand usage is associated with greater anxiety (Dillon, 1989; Hicks & Pellegrini, 1978; Wright & Hardie, 2011). According to the present study, there may be an element of truth to both prior proposals, but the whole truth may be more complex. We found that handedness was related to trait and state anxiety, at least as measured by the STAI, in the following manner: Consistent-handedness was associated with greater anxiety, but only among right-handers. Among left-handers, degree of consistency was not significantly related to anxiety and, if anything, inconsistent left-handers were slightly more anxious than their consistent counterparts. In consequence of the fact that inconsistency was associated with lower anxiety for right-handers but not left-handers, left-leaning tendency was associated with greater anxiety than right-leaning tendency among inconsistent individuals.

In the past, the possibility has been considered (Beaton & Moseley, 1991; French & Richards, 1990; Wienrich et al., 1982) that individuals who have

inconsistent response profiles on handedness inventories may obtain lower anxiety scores than individuals with consistent profiles, not because they are actually less anxious, but because they have a tendency to avoid selecting extreme response options on handedness and anxiety questionnaires (and perhaps all other types of questionnaire). If that were the case, we would have found a main effect of consistency, whereby inconsistent left- and right-handers alike obtained lower anxiety scores than their consistent counterparts, instead of finding that the effect was specific to right-handers. Hence, we feel our finding is incompatible with an explanation in terms of individual differences in response set. Prior investigations by Beaton and Moseley and French and Richards also have not revealed evidence that individuals classified as less consistently handed respond differently on anxiety questionnaires than individuals classified as more consistent.

Our finding that inconsistent left-handers were more anxious than inconsistent right-handers was not specific to state anxiety, which makes it unlike Wright and Hardie's (2011) recent finding. The reason for this difference is unknown. Any across-study comparison is difficult because Wright and Hardie did not analyse their data as a function of consistency, as we did. Even post hoc comparisons would be complicated because Wright and Hardie used a different handedness inventory than we did.

The direction by consistency interaction was not individually significant when anxiety was measured by the PSWQ or the BAI. The lack of significance for the measure of worry (the PSWQ) is somewhat surprising given that a sample of mostly right-handed inconsistent individuals was previously found to ruminate less than a sample of consistent right-handers (Niebauer, 2004), and worry and rumination are very similar constructs (Hong, 2007; McLaughlin, Borkovec & Sibrava, 2007). However, the same numeric pattern as in the STAI data was also present in the PSWQ data, as well as in the BAI data. Unsurprisingly, the four measures were correlated and, when averaged together, the same direction by consistency interaction emerged. Hence, it is difficult to know how to interpret the null results from the PSWQ and BAI. Anxiety is not a monolithic construct and there is unshared variance between questionnaires (Brown, Chorpita & Barlow, 1998; Chapman et al., 2009; Wells & Carter, 1999). Perhaps different aspects of anxiety are differentially influenced by handedness. For example, the BAI assesses more somatic (e.g., numbness or tingling, feeling hot) than cognitive (e.g., fear of the worst happening, fear of dying) symptoms of anxiety and it was this measure that yielded the least evidence of a handedness – anxiety relationship. Whatever the mechanism that reduces anxiety among inconsistent right-handers, perhaps it does not affect the experience of somatic symptoms of anxiety. Alternatively, we simply may have been observing, across the four interrelated measures, natural variability in the magnitude of *p*-values (Cumming, 2008).

The present findings are further evidence that self-reported degree of consistency in handedness behaviour is an important individual difference factor in personality for right-handers, who comprise most of the population. Moreover, the findings help answer two questions posed in the introduction. One, does direction of handedness interact with consistency-related differences or exert an independent main effect? The present study indicates yes to the possibility of interaction, while providing no evidence of a main effect of direction. The interaction was such that inconsistent-handers reported less anxiety than consistent-handers, but only among right-handers. We feel confident that we did not simply miss a similar effect that actually exists among left-handers because inconsistent left-handers in our sample reported numerically more anxiety than consistent right-handers, so there was no hint of the effect that occurred among right-handers. The present finding is the first evidence that consistency-related personality differences that occur in one directional group do not necessarily occur in the other directional group.

However, it appears that not all consistency-related differences depend on direction and that degree of consistency can be an important individual factor for left-handers, as well as right-handers, at least in some domains. In Lyle et al. (2012), direction did not interact with consistency-related differences in memory accuracy: Inconsistent-handers, regardless of direction, were more accurate than consistent-handers. Hence, the relevance of direction may depend on the specific behaviour under consideration. More research will be needed to determine the specific domains in which direction and consistency do and do not interact. For now, the take-home message is that investigators should be cautious about assuming the presence or absence of a potential interaction when studying handedness differences in personality and cognition.

The second question about consistency-related differences that the present study can help answer is: Are these differences sensibly interrelated? As described in the introduction, differences have been reported in highly diverse domains. If handedness consistency is to be considered a meaningful individual difference factor, we believe that consistency-related differences must hang together in a sensible way. Here, we were concerned with the previously documented difference that inconsistent-handers ruminate less than consistent-handers (Niebauer, 2004), which strongly predicts that inconsistent-handers should be less anxious than consistent-handers. Encouragingly, we indeed found the expected difference in anxiety, at least among right-handers, who comprised most of the subjects in the previous study of rumination. Furthermore, the difference in anxiety also accords well with two other known consistency-related differences. First, in Christman, Bente and Niebauer (2007), consistent-handers reported more body image dissatisfaction, and body image dissatisfaction is positively correlated with anxiety (Kostanski & Gullone, 1998). Second, in Christman, Jasper, et al. (2007), inconsistent-handers reported being more likely than consistent-

handers to engage in risky social behaviours, despite perceiving the behaviours as equally risky. Given equivalent perceived risk, inconsistent-handers may be more likely to engage in certain social behaviours because they experience less anxiety over the risk. This idea meshes well with Merckelbach et al.'s (1989) finding that inconsistent-handers are less socially anxious than consistent right-handers. In sum, there is an emerging sense of cohesion in the recent literature on consistency-based differences. This cohesion should help to direct future research towards other domains that might be expected to show consistency-based differences. Ultimately, it might be possible to describe in broader terms the divergent personality profiles associated with inconsistent-handedness and consistent-handedness. For example, perhaps inconsistent-handers could be characterized as able to live more fully "in the moment" than their consistent counterparts insofar as they are calmer, dwell less on the past and are more willing to engage in behaviours despite recognized risks.

Having provided these answers, we are left with the two-part question of why inconsistency is linked to lower anxiety among right-handers, but not to lower anxiety among left-handers. We offer two possible explanations for the consistency-based difference among right-handers. First, as already noted, inconsistent-handers have been found to ruminate less than consistent-handers (Niebauer, 2004). To this may be added a finding by Jasper, Barry and Christman (2008), who gave subjects scenarios with negative outcomes and instructed the subjects to think of ways the outcomes could have been even worse (i.e., downward counterfactuals in the form of "at least X didn't happen"). Inconsistent-handers generated more such counterfactuals than did consistent-handers. Taking these two findings together, inconsistent individuals might avoid or reduce anxiety by dwelling less on negative experiences and/or by construing negative experiences as nonetheless superior to conceivable alternatives.

Second, Christman and colleagues (Christman et al., 2004; Propper et al., 2005) have developed the theory that inconsistent handedness is a behavioural marker for greater interhemispheric interaction, and they have attributed many consistency-related differences to this underlying difference in neural function. (The same investigators have alternatively proposed that inconsistent-handers have greater access to neural processes subserved more by the right hemisphere than the left.) The validity of this account as an explanation for some or all consistency-related differences in personality and cognition remains uncertain (for discussions, see Lyle & Martin, 2010; Lyle & Orsborn, 2011). Nevertheless, it bears asking whether the account could explain the finding that anxiety was lower among inconsistent than consistent right-handers. Inconsistent-handers' lesser rumination (Niebauer, 2004) and greater production of downward counterfactuals (Jasper et al., 2008) have already been explained in terms of this account. What of the lesser anxiety? A relationship between anxiety and interhemispheric inter-

action has been proposed. Compton and Mintzer (2001) argued that stressors can consume processing resources within each hemisphere, thereby impairing each hemisphere's ability to individually perform a given task. This increases the functional advantage conferred by interhemispheric interaction, because dividing processing across the hemispheres mitigates stress-induced impairment. Extending this argument, more efficient interhemispheric coordination could produce greater mitigation of stress-induced impairment. To the extent that behavioural impairment might produce anxiety, reducing impairment via superior interhemispheric interaction might reduce anxiety for inconsistent right-handers.

How can these explanations for the consistency-based difference among right-handers accommodate the absence of a difference among left-handers? We do not yet know whether inconsistent left-handers ruminate less than consistent left-handers or are better able to generate downward counterfactuals. Future research could test for these differences among left-handers. If it is these differences that drive consistency-related anxiety differences and these differences are absent among left-handers, it would explain why anxiety differences are also absent among left-handers. As for the possibility that greater interhemispheric interaction leads to lower anxiety, there is evidence that consistency-related effects on interhemispheric interaction may not be the same among left-handers as among right-handers. First, Chase and Seidler (2008) found that, although there was evidence of greater interhemispheric transfer of skill learning among inconsistent-handers regardless of direction, the particular type of skill differed by direction. Inconsistent left-handers showed superior transfer of sensorimotor adaptation, whereas inconsistent right-handers showed superior transfer of sequence learning. Second, analyses by Cherbuin and Brinkman (2006) suggested that the efficiency of interhemispheric interaction is linearly and positively related to frequency of left-hand usage. Therefore, interhemispheric interaction increases between consistent and inconsistent right-handers, because the latter use their left hand more than the former, but decreases between consistent and inconsistent left-handers, because the latter use their left hand less than the former. While this pattern is tentative, because only seven consistent and 13 inconsistent left-handers were tested, it provides at least preliminary cause, along with Chase and Seidler's finding, to doubt that consistency-related differences in interhemispheric interaction are identical among left- and right-handers. If they are not identical, and if there is a causal relationship between interhemispheric interaction and anxiety, then consistency-related differences in anxiety would not be identical among left- and right-handers. The nature of consistency-related differences in interhemispheric interaction could be sufficiently dissimilar in left- and right-handers to allow for the existence of consistency-related anxiety differences in right-handers but not left-handers.

Other factors may also help to explain why inconsistent left-handers do not exhibit the same reduced anxiety seen in inconsistent right-handers. Wright et al. (2009) have found that left-handers are more behaviourally inhibited than right-handers (and they may also be more fearful; see Rogers, 2009). Behavioural inhibition is associated with elevated anxiety (Barlow, 2002; Degnan & Fox, 2007). Therefore, an intriguing possibility is that greater behavioural inhibition in inconsistent left-handers somehow offsets, or prevents them from capitalizing on, whatever anxiety-reducing mechanism is operating in their right-handed counterparts.

Wright and Hardie (2011) argued that left-handers' greater behavioural inhibition causes them to experience greater anxiety only when situational factors produce a conflict between approach and avoidance. They argued that a test setting could produce such conflict. We measured the anxiety of almost all of the subjects in the current study in the midst of a procedure testing cognitive performance. An intriguing possibility that could be taken to follow from Wright and Hardie's argument is that, if left- and right-handers were tested in the absence of any situational factors that could produce conflict, then inconsistent left-handers might report levels of anxiety more similar to those of inconsistent right-handers. This possibility awaits future investigation.

A final consideration is that left-handedness may be a marker for a unique psychological vulnerability in which contingencies within the environment (e.g., one conducive to right-handers) are potentially anxiety provoking in certain situations. The process of anxiety begins with the evocation of anxiety-provoking propositions (Barlow, 2002) followed by an increase in negative affectivity, attentional biases (e.g., self-evaluative in nature), increases in arousal and attempts to cope. The propositions that evoke anxiety in left- and right-handers could differ based on subjective differences in environmental experiences. If the underlying propositions that evoke anxiety differ between left- and right-handers, it would not be surprising if different factors mediated anxiety in the two populations.

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