LATERALITY, 2009, 14 (5), 441–456

Psychology Press
Taylor & Francis Group

The role of intellectual openness in the relationship between hand preference and positive schizotypy

Frances M. Bryson, Gina M. Grimshaw, and Marc S. Wilson
Victoria University of Wellington, New Zealand

Recently it has been suggested that the relationship between positive schizotypy and mixed handedness is limited to questionnaire measures, and thus reflects some aspect of questionnaire-taking behaviour as opposed to some aspect of atypical brain organisation. The current study set out to explore this possibility. Undergraduate psychology students completed the Magical Ideation Scale, the Waterloo Handedness Questionnaire-Revised, a manual dot-filling task, and an inventory measuring the personality trait of intellectual openness. On the questionnaire measure, magical ideation was related to mixed handedness on unskilled but not skilled hand preference; however, this relationship was partially mediated by intellectual openness. Magical ideation was not related to the behavioural measure of handedness. These findings suggest that responses on handedness questionnaires partially reflect personality variables, and such effects should be considered in future research on the nature of the relationship between handedness and schizotypy.

Keywords: Handedness; Schizotypy; Magical ideation; Right hemisphere; Openness; Personality.

The term "schizotypy" is commonly used to describe a continuum of personality traits related to psychosis. Individuals at the extreme tail meet the diagnostic criteria for Schizotypal Personality Disorder (SPD, DSM-IV; American Psychiatric Association, 1995) and might be predisposed to schizophrenia (Johnstone Ebmeire, Miller, Owens, & Lawrie, 2005; Keshavan, Diwadkar, Monstrose, Rajavethinam, & Sweeney, 2005). Like schizophrenia, schizotypy can be divided into positive and negative symptoms. Positive schizotypy is associated with magical ideation, ideas of reference, unusual perceptual experiences, and odd speech and behaviour; and negative

Address correspondence to: Gina M. Grimshaw, School of Psychology, Victoria University of Wellington, PO Box 600, Wellington, New Zealand. E-mail: gina.grimshaw@vuw.ac.nz

We wish to thank Gordon Claridge and an anonymous reviewer for helpful comments on an earlier version of this article. Laurel O'Brien provided assistance with data scoring and entry.

http://www.psypress.com/laterality DOI: 10.1080/13576500802349684

schizotypy with constricted affect, inappropriate emotional responses, few or no close friends, and excessive social anxiety (Raine, 1991). In non-clinical populations positive, but not negative, schizotypy has been associated with increases in right hemisphere activity (Brugger & Graves, 1997; Kalaycioglu, Nalcaci, Budanur, Genc, & Cicek, 2000; Leonhard & Brugger, 1998; Luh & Gooding, 1999; Mohr, Bracha, & Brugger, 2003; Mohr et al., 2005a; Mohr, Landis, Bracha, Fathi, & Brugger, 2005b; Taylor, Zach, & Brugger, 2002; Weinstein & Graves, 2002) and mixed handedness (Annett & Moran, 2006; Barnett & Corballis, 2002; Chapman & Chapman, 1987; Chen & Su, 2006; Claridge, Clark, Davis, & Mason, 1998; Gregory, Claridge, Clark, & Taylor, 2003; Kim, Raine, Triphon, & Green, 1992; Mass et al., 2007; Poreh, 1994; Richardson, 1994; Shaw, Claridge, & Clark, 2001; Stefanis et al., 2006). These findings have led researchers to argue that positive schizotypy is associated with atypical brain organisation, specifically with a reduced degree of lateralisation.

More recently the relationship between positive schizotypy and mixed handedness has been questioned. Handedness is typically assessed using questionnaire measures of hand preference; however, it can also be assessed using behavioural measures of asymmetry in hand skill. Only three studies have examined the aforementioned relationship using both types of assessment. Although each used a different behavioural task, they each found that positive schizotypy was associated with their questionnaire but not behavioural measure of handedness. Kelley and Coursey (1992) found that positive schizotypy was unrelated to performance asymmetry in peg moving, finger tapping, writing speed, and grip strength. Nicholls, Orr, and Lindell (2005) found that magical ideation was unrelated to asymmetry in finger tapping, and Grimshaw, Yelle, Schoger, and Bright (2008) found magical ideation to be unrelated to asymmetry on a dot-filling task. Give the consistent lack of relationship between positive schizotypy and behavioural measures of handedness, it seems possible that the relationship is limited to questionnaire measures and reflects some aspect of questionnaire-taking behaviour, as opposed to some aspect of atypical brain organisation (Grimshaw et al., 2008; Jaspers-Fayer & Peters, 2005; Nicholls et al., 2005). Although several authors have dismissed this possibility on logical grounds (Annett & Moran, 2006; Claridge et al. 1998), it has never been tested directly.

One possibility is that the relationship between positive schizotypy and mixed handedness is influenced by the personality trait of intellectual openness. Those who are intellectually open tend to embrace ambiguity remain open-minded to new unusual ideas and think in individualistic and non-conforming ways (Goldberg, 1990; McCrae & Costa, 1985a,b). In non-clinical populations intellectual openness has been associated with positive schizotypy (Coolidge et al., 1994; Dyce & O'Connor, 1998; Miller & Tal,

2007; Ross, Lutz, & Bailley, 2002; Wiggins & Pincus, 1989). Furthermore, Grimshaw et al. (2008) suggested that intellectual openness could be associated with questionnaire measures of hand preference; that is, an intellectually open individual might like to remain open to the possibility that they could use both of their hands for certain activities, when in fact they would not actually do so. Therefore, the primary aim of this study was to examine the role of intellectual openness in the relationship between magical ideation and both questionnaire and behavioural measures of handedness.

The second aim of this study was to examine the relationship between magical ideation and both skilled and unskilled handedness factors. Although short hand-preference questionnaires frequently tap highly inter-correlated items that assess skilled handedness, longer questionnaires typically reveal a number of factors. For example, factor analysis of the 32-item Waterloo Handedness Questionnaire (WHQ; Steenhuis & Bryden, 1989) yields four factors. The first is a skilled factor that assesses activities that require manipulation of an object, often through execution of complex motor sequence (e.g., writing, using a toothbrush, flipping a coin). Participants commonly report that they "always" use the dominant hand for these activities. The second factor assesses hand preference for unskilled activities that typically involve picking up, pushing, or pulling an object without manipulation (e.g., pick up a piece of paper, pet a cat or dog); participants commonly report that they "usually" use the dominant hand for these activities. The third factor relates to bimanual activities (swinging an axe or a baseball bat); like skilled items these activities usually elicit an "always" response, however, people often report (10% of right-handers and 26% of left-handers) that they "always" use the non-dominant hand for these activities. A final factor taps hand strength (e.g., picking up a heavy object and carrying a suitcase) to which people most commonly respond "equally" or "usually", but often with the non-dominant hand.

There are two reasons to suppose that magical ideation might more likely be related to mixed handedness on unskilled than on skilled factors. The first is statistical; on a five-response category questionnaire there will be more variability in responses on unskilled items than on skilled items. Unskilled handedness might therefore better capture variations in degree of handedness. The second reason is more psychological. If (as Steenhuis & Bryden, 1989, suggest) skilled activities rely on the chaining of complex motor behaviours, then participants should be able to easily retrieve these motor programs when they are asked to "imagine" which hand they would use to perform the activity. However, hand use for unskilled activities is more likely to be driven by environmental and situational factors (for example, the location of the object, or whether one hand is otherwise occupied). These responses therefore involve a certain amount of guesswork on the part of the

participant, and a subjective determination of the boundaries between "always", "usually", and "equally". It is precisely these items that should be most susceptible to the influence of personality, with those high in intellectual openness (and perhaps schizotypy) more likely endorse "equally" or "usually" responses, regardless of their actual behaviour. Note that this subjective component will be a factor in any handedness questionnaire that includes an "either" category, not just those with five response categories.

Previous research on relations between positive schizotypy and skilled vs unskilled handedness is scarce. Poreh, Levin, Teaves, and States (1997) directly examined correlations between the WHQ skilled and unskilled factors, and the Schizotypal Personality Questionnaire (SPQ; Raine, 1991). In an initial testing session they found that left-handers (not mixed-handers) on the skilled factor had elevated SPQ scores for Suspiciousness and Odd Speech subscales, and both mixed and left-handers had elevated scores on the Odd Behaviour subscale. However, upon re-testing 3 weeks later, no relationships were observed. The unskilled handedness factor was not associated with schizotypy at either testing session. These results are equivocal at best, given that schizotypy was most often associated with left, not mixed handedness, and the relationship itself was unreliable.

The present study directly replicated and extended Grimshaw et al.'s (2008) study by examining relations between positive schizotypy, questionnaire and behavioural measures of handedness, and intellectual openness. Positive schizotypy was assessed with the Magical Ideation Questionnaire (Eckblad & Chapman, 1982), which has repeatedly been shown to produce higher scores for mixed handers (Barnett & Corballis, 2002; Chapman & Chapman, 1987; Grimshaw et al., 2008; Nicholls et al., 2005). The questionnaire measure of handedness was the Waterloo Handedness Questionnaire – Revised (WHQ-R; Elias, Bryden, & Bulman-Fleming, 1998), a 36-item revision of the original WHQ. The primary change in the revision is the removal of the bimanual items, and the inclusion of more unskilled items (therefore exclusively tapping the skilled and unskilled dimensions of handedness). The behavioural measure was a dot-filling task (Tapley & Bryden, 1985) that was also used in Grimshaw et al. (2008). This task produces two overlapping near-normal distributions; one for right-handers centred to the right of the handedness continuum, and one for left-handers centred to the left. It was expected that magical ideation would be related to the questionnaire, but not behavioural measure of handedness. Furthermore, it was hypothesised that the former relationship would be stronger with unskilled than with skilled handedness items, and be mediated by the personality trait intellectual openness. If supported, these findings would suggest that the relationship between positive schizotypy and mixed handedness in non-clinical populations reflects personality variables that

influence questionnaire-taking behaviour, and not neuropsychological variables.

METHOD

Participants

A total of 171 undergraduate students at the Victoria University of Wellington, New Zealand received course credit for participating in the study. The average age of participants was 19 years (range: 16–44); 113 were female, and 58 were male; 143 were right-handed, and 28 were left handed (as indicated by writing hand). The study was approved by the University Human Ethics Committee.

Measures

The Magical Ideation Scale (MIS) was used to assess the positive symptoms associated with schizotypy (Eckblad & Chapman, 1983). This 30-item self-report questionnaire consists of various statements of belief. For example, "Some people can make me aware of them just by thinking about me". Participants responded either "yes" or "no". Possible scores range from 0 (very low magical ideation) to 30 (very high magical ideation).

The Waterloo Handedness Questionnaire-Revised (WHQ-R) was used to assess hand preference (Elias et al., 1998). This 36-item measure consists of various skilled (e.g. "With which hand would you use a paintbrush") and unskilled (e.g. "Which hand would you use to open a drawer") unimanual activities. Participants indicated how often they used each hand on a 5-point scale (left always, left usually, equally, right usually, right always) scored with values of $-2, -1, 0, +1$, and $+2$ respectively. Total scores were transformed into a laterality index for "direction of hand preference", with values ranging from -100 (exclusively left-handed) to $+100$ (exclusively right-handed). Taking the absolute value of the laterality index produced a measure of "degree of hand preference", with values ranging from 0 (not handed) to 100 (strongly handed). As previous investigations of the dimensionality of the original WHQ indicated a distinction between skilled and unskilled domains of dexterity (Steenhuis & Bryden, 1989), the data were subjected to a principal component analysis. Previous analyses have indicated that handedness domains are typically highly correlated, so an oblique rotation was used (Giles, 2004). The Scree plot indicated an obvious "elbow" around two components, with a large first general component (22 items associated with 54% of the variance in responses) marked by skilled

uses such as writing, drawing a picture, and throwing a dart. The second (smaller) component (14 items accounting for 8% variance) was most strongly marked by unskilled uses such as flicking a light switch, holding a mug, and opening a drawer. Together, the skilled and unskilled components reflected almost two-thirds of the variance in responses (62%) and adding a third component added only 3% of variance to the solution. Table 1 shows loadings for items on the two components extracted. Each factor was transformed (as described above) into a laterality index for direction and degree of handedness. Both factors were internally reliable (skilled, $\alpha = .98$; unskilled, $\alpha = .89$).

A manual dot-filling task was used to assess hand skill (Tapley & Bryden, 1985). Participants were given a sheet of paper printed with a series of circles (3 mm in diameter) arranged in an alternating descending and ascending pattern that snaked across the page. Participants were required to place a dot in the middle of each circle with a fine-point felt marker. They were told that

TABLE 1
Principal components analysis of the WHQ-R ($N = 195$)

Factor 1 (Skilled)		*Factor 2 (Unskilled)*	
Use for writing	1.02*	Flick a light switch	.76
Draw a picture	.99	Hold a mug of coffee	.69
Throw a dart	.99	Open a drawer	.66
Use a needle to sew	.97	Open a door	.62
Use a paintbrush	.96	Pick up a book	.62
Hammer a nail	.94	Carry a suitcase	.61
Use a saw	.93	Use remote control	.55
Use a knife to cut bread	.93	Hold an open umbrella	.54
Use a spoon to eat	.90	Point to something	.51
Use an eraser	.87	Hold a walking stick	.48
Use an iron	.82	Insert a plug into outlet	.47
Use scissors	.80	Pick up a piece of paper	.46
Use tweezers	.78	Turn a page in a book	.45
Throw a ball	.76	Erase a blackboard	.41
Strike a match	.76		
Pour coffee	.70		
Operate a calculator	.70		
Use a spoon to stir	.68		
Use a toothbrush	.66		
Flip a coin	.62		
Turn radio knob	.57		
Use mouse	.37		

*Handedness factors are highly correlated; therefore, an oblique rotation was used. In oblique rotations factor loadings can be >1 as they are analogous to regression coefficients, not correlations (Joreskog & Sorbom, 1984).

TABLE 2
Descriptive statistics for personality and handedness measures

	N	*M*	*SD*
Personality measures			
Magical Ideation	170	6.60	3.87
Intellectual Openness	161	4.22	0.72
Questionnaire handedness			
Total Direction	171	45.02	41.69
Skilled Direction	171	57.69	53.48
Unskilled Direction	171	25.15	28.89
Total Degree	171	58.80	17.29
Skilled Degree	171	76.42	18.25
Unskilled Degree	171	32.21	20.67
Behavioural handedness			
Direction	171	0.15	0.15
Degree	171	0.20	0.07

accuracy and speed were important and that dots would only be counted if they fell entirely within the circle. They completed four trials of 20 seconds each. Participants used their preferred hand on the first and fourth trial, and their non-preferred hand on the second and third trial. Total scores were transformed into a laterality index (RH – LH/RH + LH). This produced a measure of "direction of hand skill", with values ranging from –1 (left dominant) to +1 (right dominant). Taking the absolute value of the laterality index produced a measure of "degree of hand skill", with values ranging from 0 (hands equivalent) to +1 (one hand completely dominant).

A 50-item inventory from The International Personality Item Pool (IPIP, Goldberg, 1999) was used to assess the five personality traits of Neuroticism, Extraversion, Intellectual Openness, Agreeableness, and Conscientiousness. This inventory is available on the internet (www.ipip.ori.org). Each personality trait was measured using 10 items. Participants were told to rate how accurately each statement best described them on a 7-point Likert scale (1 = Very Inaccurate, 7 = Very Accurate). The intellectual openness score was computed by taking the average response across each of the 10 items used to assess it. Possible scores ranged from 0 (low) to 7 (very high).

Procedure

Participants completed the MIS and the IPIP inventory as part of an exercise in their introductory psychology laboratory. In a separate 30-minute session, carried out on a different day, participants completed the WHQ-R and the

manual dot-filling task. Participants were unaware of the relationship between the assessments. The handedness measures were counterbalanced; that is, approximately half of participants completed the manual dot-filling task first and approximately half of participants completed the WHQ-R first.

RESULTS

Performances on all measures are presented in Table 2. Nine participants did not complete the personality inventory, and so they are included in the analyses involving relations between handedness and magical ideation, but not analyses including intellectual openness. Given there were no sex differences on any measures, values are presented for men and women combined. To test whether magical ideation was related to direction or degree of handedness, Pearson's product–moment correlations were computed (see Table 3).

On the questionnaire measure, magical ideation was not associated with total degree, $r(169) = -.117$, $p = .129$, or skilled degree, $r(169) = -.048$, $p = .535$; however, it was negatively correlated with unskilled degree, $r(169) = -.157$, $p = .040$. Consistent with previous research (Grimshaw et al., 2008; Nicholls et al., 2005), magical ideation was not associated with the degree of handedness on the behavioural measure, $r(169) = -.010$, $p = .901$.

Another way to examine relations between magical ideation and handedness is to look at the number of "equal" responses endorsed on the questionnaire measure of hand preference (see Annett & Moran, 2006; Claridge et al., 1998; Shaw et al., 2001). This analysis allows one to

TABLE 3
Correlations between questionnaire and behavioural measures of handedness, magical ideation, and intellectual openness

	Magical ideation	*Intellectual openness*
Questionnaire handedness		
Total Direction	.001	−.180**
Skilled Direction	−.002	−.162**
Unskilled Direction	−.004	−.197**
Total Degree	−.117	−.140*
Skilled Degree	−.048	−.113
Unskilled Degree	−.157**	−.150*
Behavioural handedness		
Direction	.078	−.104
Degree	−.010	−.115

Not all participants completed all assessments; therefore, *N*s vary between 160 and 171.
** $p < .05$,* $p < .10$.

determine whether magical ideation is related to mixed handedness (preferences for the left hand for some activities, and the right hand for others) or ambiguous handedness (no preference for either hand). Similar to correlations yielded with mixed handedness, there was a trend indicating that magical ideation was related to the number of ambiguous responses on unskilled items, $r(169) = .146$, $p = .058$, but not skilled items, $r(169) = .074$, $p = .337$.

In order to explore the relationship between intellectual openness and handedness, Pearson's product–moment correlations were computed (see Table 3). On the questionnaire measure, intellectual openness was negatively correlated with total, skilled, and unskilled direction of hand preference, indicating that left-handers are more intellectually open than right-handers. Of greater relevance to our hypotheses, intellectual openness was marginally related to unskilled, $r(160) = -.150$, $p = .058$, but not skilled degree of hand preference, $r(160) = -.113$, $p = .154$. However, intellectual openness was positively correlated with the number of ambiguous responses on skilled $r(160) = .170$, $p = .031$, and unskilled items $r(160) = .153$, $p = .052$. The correlations between intellectual openness and the direction and degree of handedness on the behavioural measure were non-significant.

We specifically hypothesised that there would be shared variance between the handedness measure and intellectual openness, and that this variance would be associated with magical ideation. Consistent with its potential role as a mediating variable (Baron & Kenney, 1986), intellectual openness was significantly correlated with magical ideation, $r(160) = .213$, $p = .007$, and marginally correlated with unskilled degree on the questionnaire measure, $r(160) = -.150$, $p = .058$. A hierarchical regression predicting magical ideation was therefore computed (see Table 4). Notably, unskilled degree was a significant predictor of magical ideation when entered alone, but was not a significant predictor when entered simultaneously with intellectual

TABLE 4
Summary of hierarchical regression analysis for predicting magical ideation ($N = 160$)

	Magical ideation			
	B(SE)	*Beta (β)*	*t*	*Part correlations*
Step 1				
Unskilled Degree	−.030(.015)	−0.156	−1.988**	−0.156
Step 2				
Unskilled Degree	−.025(.015)	−0.129	−1.654	−0.128
Intellectual Openness	1.056(.422)	0.195	2.503**	0.194

$R^2 = .024$ for Step 1: $\Delta R^2 = .038$ for Step 2. **$p < .05$.

openness. In other words, when the variance in the handedness measure associated with intellectual openness was removed, the relationship between handedness and magical ideation was no longer observed. This suggests that the relationship between unskilled degree of handedness and magical ideation was partially mediated by intellectual openness (Baron & Kenny, 1986; Howell, 2007).

DISCUSSION

The present study partially replicated the previously reported finding of a relationship between magical ideation and mixed handedness as assessed with a questionnaire, but not with a behavioural measure. Magical ideation was not related to overall degree of handedness (as it was in Grimshaw et al., 2008); however, it was related to degree of handedness for unskilled activities, with higher scores on magical ideation associated with reduced degrees of handedness. We proposed that questionnaire effects might be more apparent in unskilled than in skilled handedness, and these findings are consistent with that hypothesis. Our interpretation is further strengthened by the findings with intellectual openness: Consistent with its role as a potential mediator, intellectual openness was correlated with both magical ideation and unskilled degree of hand preference. Furthermore, when the effect of intellectual openness was controlled, the relationship between magical ideation and unskilled degree of hand preference was no longer significant (see Baron & Kenny, 1986). Therefore, the relationship between positive schizotypy and questionnaire measures of hand preference might partially reflect common variance that influences responses on handedness questionnaires, and not an underlying neuropsychological relationship. A note of caution is warranted, however, as all effects were very small. Although degree of handedness changed from a significant to a non-significant predictor of magical ideation, the magnitude of the change was very small. It is therefore safest to conclude that intellectual openness partially mediates rather than fully accounts for the relationship between unskilled handedness and magical ideation.

Might personality variables contribute to relations between schizotypy and handedness in other studies? Most other researchers have used shorter handedness questionnaires that do not tap unskilled activities, including the Edinburgh Handedness Inventory (EHI; Oldfield, 1971) and the Annett Hand Preference Questionnaire (AHPQ; Annett, 1970). However, both questionnaires include bimanual activities: the EHI has an item on holding a broom, and five of the six items in the non-primary factor of the AHPQ are bimanual (dealing cards, threading a needle, using a broom, using a shovel, and unscrewing a jar). Given that use of the non-dominant hand for

bimanual activities is not unusual (Healey, Liederman, & Geschwind, 1986; Steenhuis & Bryden, 1989) it is likely that many of the mixed-handers who are identified with these questionnaires have opposite handedness for skilled vs bimanual activities. Although intellectual openness was found to be unrelated to skilled handedness in the present study, it is unknown whether it might be related to responses for bimanual activities as we chose to use a questionnaire that assessed only unimanual activities. An exploration of personality correlates of reported hand use for bimanual activities will be necessary to make any reasonable conclusions. However, we do note that very little is known about the neuropsychological underpinnings of bimanual hand preference. Some theorists have suggested that those with mixed preferences on unimanual and bimanual activities might differ not in hand preference per se, but rather in their preference for the role of the dominant hand (Steenhuis & Bryden, 1989). Most bimanual activities require the two hands to play complementary roles, with one engaged in a support or strength role, and the other involved in manipulating or guiding an object. Thus a right-hander who unscrews a jar lid with the left hand may simply prefer to have the dominant hand play the steady supporting role of holding the jar.

The finding of an association between magical ideation and unskilled but not skilled handedness is at odds with the only other study to explicitly examine the relationship between schizotypy and both dimensions of handedness (Poreh et al., 1997). However, results from that study were unreliable. Some indication of the importance of skilled items comes from studies that have used the AHPQ. Annett and Moran (2006) report that individuals in her Class 5 (right-handed writers who do other primary actions with the left hand) are highest in schizotypy (unusual experiences), although such individuals are exceedingly rare (2% of her sample). Although this finding suggests that schizotypy is associated with mixed handedness for skilled activities, it directly contradicts the findings of Claridge et al. (1998), who found that individuals in Annett's revised Class 4 (which included Class 5, plus individuals who deal cards with the left hand) have the lowest scores on the same schizotypy measure, a pattern that was replicated (although not significantly) in Shaw et al. (2001).

A different picture emerges when one examines rates of "either" responses as an indication of ambiguous handedness. Shaw et al. (2001) report that the highest levels of schizotypy are observed in those rare individuals who respond "either" for the most skilled items (e.g., using a hammer). In our study magical ideation was related to number of "equally" responses to unskilled items, but not to skilled items. Again, further research that distinguishes between skilled, unskilled, and bimanual hand preferences will be necessary to clarify the nature of any relationship with schizotypy.

Although positive schizotypy was related to the questionnaire measure of hand preference for unskilled activities, it was not related to the behavioural measure of asymmetry in hand skill. This is perhaps not surprising, given that the task of placing a dot in a circle with a pen is very similar to writing, and is thus a very skilled activity. However, the present findings add to the growing body of research that has consistently reported that positive schizotypy is associated with questionnaire measures of hand preference, but not behavioural measures of asymmetry in hand skill, including finger-tapping, pegboard, writing-speed, dot-filling, and grip-strength tasks (Grimshaw et al., 2008; Kelley & Coursey, 1992; Nicholls et al., 2005). Across studies, correlations are in the range of $-.02$ to $+.01$, (with a combined N of over 1500 participants) so these non-significant findings are not likely to reflect a lack of statistical power.

It is difficult to know whether behavioural measures are really superior to questionnaire measures, as each have their strengths and weaknesses. Questionnaires can be easily administered to large samples, making them ideal for picking up the small effects that are typically observed. They can also assess a wide range of activities; however, they are subject to effects of response style, which might be particularly relevant when one is looking for a relationship with personality variables (like schizotypal thinking) that might specifically affect patterns of responding. Behavioural measures are not subject to those biases, but they are influenced by practice and motivational factors. They also do not correlate well with each other (Steenhuis & Bryden, 1999), and so it is difficult to know which might be the best measure of some underlying neurological asymmetry. Furthermore, questionnaire measures provide an assessment of hand preference, whereas behavioural measures reflect asymmetries in hand skill. Although preference and skill are highly correlated, they have been observed to dissociate (McManus, Murray, Doyle, & Baron-Cohen 1992), and debate continues on the nature of the relationship between the two. Thus, it is possible that positive schizotypy is correlated with hand preference, but not hand skill. However, in the absence of a comprehensive neuropsychological understanding of handedness, it is unclear why schizotypy would be related to one but not the other.

Our findings do not invalidate associations reported between positive schizotypy and increases in right hemisphere activity. Such studies have examined hemispheric specialisation using direct neuropsychological measures including lateralised lexical decision (Leonard & Brugger, 1998; Mohr et al., 2005a), dichotic listening (Weinstein & Graves, 2002), and line bisection tasks (Brugger & Graves, 1997; Kalaycioglu et al., 2002; Taylor et al., 2002). Yet the nature of the relationship between hand preference and hemispheric activity remains elusive. Non-right-handers are less lateralised than right-handers for language processing (Bryden, 1982), and appear to

have facilitated interhemispheric integration (Christman, 2001) and a larger corpus callosum (Witelson, 1985, 1989). However, to our knowledge there is no evidence that mixed handedness is specifically associated with increased right hemisphere activity; therefore, right hemisphere correlates of schizotypy do not necessitate a relationship with handedness.

Given that the participants in this study were drawn from a normal student population, the current findings also do not challenge the relationship between clinical schizotypy and handedness (e.g., Chapman & Chapman, 1987). It may well be that magical ideation in the non-clinical population reflects something qualitatively different from that observed in clinical schizotypy (Meehl, 1990). If so, the relationship between handedness and schizotypal thinking may reflect different factors in the two groups. The relationship between intellectual openness and positive schizotypy is not consistently observed in clinical populations (Ross et al., 2002; Trull, 1992; Yeung, Lyons, Waternaux, & Faraone, 1993), suggesting that intellectual openness might mediate the handedness–schizotypy relationship in non-clinical individuals, but not in those with clinical schizotypy.

Although the link between positive schizotypy and mixed handedness appears robust, comparisons across studies are difficult because different studies have used different populations and sampling techniques, different measures of schizotypy, different handedness assessments, and different definitions of mixed-handedness. The reliance on self-report across all measures further complicates the picture. Given the interpretive difficulties inherent in the use of questionnaires, perhaps an optimal strategy would involve the use of behavioural measures to assess handedness (across a number of skilled, unskilled, and bimanual activities), right hemisphere activity, and positive schizotypy in both non-clinical and clinical populations.

Manuscript received 27 March 2008
Revised manuscript received 26 June 2008
First published online 27 September 2008

REFERENCES

American Psychiatric Association. (1995). *Diagnostic and statistical manual of mental disorders* (4th ed.). Washington DC: American Psychiatric Association.

Annett, M. (1970). A classification of hand preference by association analysis. *British Journal of Psychology*, *61*, 303–321.

Annett, M., & Moran, P. (2006). Schizotypy is increased in mixed-handers, especially right-handed writers who use the left hand for primary actions. *Schizophrenia Research*, *81*, 239–246.

Baron, R., & Kenny, D. A. (1986). The moderator–mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. *Journal of Personality & Social Psychology*, *51*, 1173–1182.

Barnett, K. J., & Corballis, M. C. (2002). Ambidexterity and magical ideation. *Laterality*, *7*, 75–84.

Brugger, P., & Graves, R. E. (1997). Right hemispatial inattention and magical ideation. *European Archives of Psychiatry and Clinical Neuroscience*, *247*, 55–57.

Bryden, M. P. (1982). *Laterality: Functional asymmetry in the intact brain*. San Diego, CA: Academic Press.

Chapman, J. P., & Chapman, L. J. (1987). Handedness of hypothetically psychosis-prone subjects. *Journal of Abnormal Psychology*, *96*, 89–93.

Chen, W. J., & Su, C. H. (2006). Handedness and schizotypy in non-clinical populations: Influence of handedness measures and age on the relationship. *Laterality.*, *11*, 331–349.

Christman, S. (2001). Individual differences in Stroop and local–global processing: A possible role of interhemispheric integration. *Brain & Cognition*, *45*, 97–118.

Claridge, G., Clark, K., Davis, C., & Mason, O. (1998). Schizophrenia risk and handedness: A mixed picture. *Laterality*, *3*, 209–220.

Coolidge, F. L., Becker, L. A., DiRito, D. C., Durham, R. L., Linlaw, W. W., Philbrick, P. B., et al. (1994). On the relationship of the five-factor personality model to personality disorders: Four reservations. *Psychological Reports*, *75*, 11–21.

Dyce, J. A., & O'Connor, B. P. (1998). Personality disorders and the five-factor model: A test of facet-level predictions. *Journal of Personality Disorders*, *12*, 31–45.

Eckblad, M., & Chapman, L. J. (1983). Magical ideation as an indicator of schizotypy. *Journal of Consulting and Clinical Psychology*, *51*, 215–225.

Elias, L. J., Bryden, M. P., & Bulman-Fleming, M. B. (1998). Footedness is a better predictor than is handedness of emotional lateralization. *Neuropsychologia*, *36*, 37–43.

Giles, D. C. (2004). *Advanced research methods in psychology*. London: Routledge.

Goldberg, L. R. (1990). An alternative "description of personality": The Big-Five factor structure. *Journal of Personality & Social Psychology*, *59*, 1216–1229.

Goldberg, L. R. (1999). A broad-bandwidth, public-domain, personality inventory measuring the lower-level facets of several five-factor models. In I. Mervielde, F. Deary, F. De Fruyt, & F. Ostendorf (Eds.), *Personality psychology in Europe* (Vol. 7, pp. 7–28). Tilburg, The Netherlands: Tilburg University Press.

Gregory, A. M., Claridge, G., Clark, K., & Taylor, P. D. (2003). Handedness and schizotypy in a Japanese sample: An association masked by cultural effects on hand usage. *Schizophrenia Research*, *65*, 139–145.

Grimshaw, G. M., Yelle, S. K., Schoger, J., & Bright, K. S. (2008). Magical ideation is related to questionnaire but not behavioural measures of handedness. *Laterality*, *13*, 22–33.

Healey, J. M., Liederman, J., & Geshwind, N. (1986). Handedness is not a unidimensional trait. *Cortex*, *22*, 33–53.

Howell, D. C. (2007). *Statistical methods for psychology* (6th ed.). Belmont, CA: Thomson Wadsworth.

Jaspers-Fayer, F., & Peters, M. (2005). Hand preference, magical thinking and left-right confusion. *Laterality*, *10*, 183–191.

Johnstone, E. C., Ebmeier, K. P., Miller, P., Owens, D. G. C., & Lawrie, S. M. (2005). Predicting schizophrenia: Findings from the Edinburgh High-Risk Study. *British Journal of Psychiatry*, *186*, 18–25.

Joreskog, K. C., & Sorbom, D. (1984). *LISREL VI*. Chicago: National Educational Resources.

Kalaycioglu, C., Nalcaci, E., Budanur, O. E., Genc, Y., & Cicek, M. (2000). The effect of familial sinistrality on the relation between schizophrenia-like thinking and pseudoneglect. *Brain & Cognition*, *44*, 564–576.

Kelley, M. P., & Coursey, R. D. (1992). Lateral preference and neuropsychological correlates of schizotypy. *Psychiatry Research*, *41*, 115–135.

Keshavan, M. S., Diwadkar, V. A., Montrose, D. M., Rajarethinam, R., & Sweeney, J. A. (2005). Premorbid indicators and risk for schizophrenia: A selective review and update. *Schizophrenia Research*, *79*, 45–57.

Kim, D., Raine, A., Triphon, N., & Green, M. F. (1992). Mixed handedness and features of schizotypal personality in a nonclinical sample. *Journal of Nervous and Mental Disease*, *180*, 133–135.

Leonhard, D., & Brugger, P. (1998). Creative, paranormal, and delusional thought: A consequence of right hemisphere semantic activation? Neuropsychiatry. *Neuropsychology & Behavioural Neurology*, *11*, 177–183.

Luh, K. E., & Gooding, D. C. (1999). Perceptual biases in psychosis-prone individuals. *Journal of Abnormal Psychology*, *108*, 283–289.

Mass, R., Girndt, K., Matouschek, A. K., Peter, P. M., Plitzko, N., Andresen, B., et al. (2007). Introducing the Eppendorf Schizophrenia Inventory (ESI) as a psychometric method for schizotypy research. *Personality & Individual Differences*, *42*, 525–534.

McCrae, R. R., & Costa, P. T. (1985a). Updating Norman's taxonomy: Intelligence and personality dimensions in natural language and in questionnaires. *Journal of Personality and Social Psychology*, *49*, 710–721.

McCrae, R. R., & Costa, P. T. (1985b). Openness to experience. In R. Horgan & W. H. Jones (Eds.), *Perspectives in personality* (Vol. 1, pp. 145–172). Greenwich, CT: JAI Press.

McManus, I. C., Murray, B., Doyle, K., & Baron-Cohen, S. (1992). Handedness in childhood autism shows a dissociation of skill and preference. *Cortex*, *28*, 373–381.

Meehl, P. E. (1990). Toward an integrated theory of schizotaxia, schizotypy, and schizophrenia. *Journal of Personality Disorders*, *4*, 1–99.

Miller, G. F., & Tal, I. R. (2007). Schizotypy versus openness and intelligence as predictors of creativity. *Schizophrenia Research*, *93*, 317–324.

Mohr, C., Bracha, H. S., & Brugger, P. (2003). Magical ideation modulates spatial behavior. *Journal of Neuropsychiatry & Clinical Neuroscience*, *15*, 168–174.

Mohr, C., Krummenacher, P., Landis, T., Sandor, P. S., Fathi, M., & Brugger, P. (2005a). Psychometric schizotypy modulates levodopa effects on lateralized lexical decision performance. *Journal of Psychiatric Research*, *39*, 241–250.

Mohr, C., Landis, T., Bracha, H. S., Fathi, M., & Brugger, P. (2005b). Levodopa reverses gait asymmetries related to anhedonia and magical ideation. *European Archives of Psychiatry & Clinical Neuroscience*, *255*, 33–39.

Nicholls, M. E. R., Orr, C. A., & Lindell, A. K. (2005). Magical ideation and its relation to lateral preference. *Laterality*, *10*, 503–515.

Oldfield, R. C. (1971). The assessment and analysis of handedness: The Edinburgh Inventory. *Neuropsychologia*, *9*, 97–113.

Poreh, A. M. (1994). Reexamination of mixed handedness in psychosis-prone college students. *Personality & Individual Differences*, *17*, 445–448.

Poreh, A. M., Levin, J., Teves, H., & States, J. (1997). Mixed handedness and schizotypal personality in a non-clinical sample: The role of task demands. *Personality & Individual Differences*, *23*, 501–507.

Raine, A. J. (1991). The SPQ: A scale for the assessment of schizotypal personality based on DSM-III-R criteria. *Schizophrenia Bulletin*, *17*, 555–564.

Richardson, A. J. (1994). Dyslexia, handedness and syndromes of psychosis-proneness [Special issue: Developmental psychophysiology]. *International Journal of Psychophysiology*, *18*, 251–263.

Ross, S. R., Lutz, C. J., & Bailley, S. E. (2002). Positive and negative symptoms of schizotypy and the Five-Factor Model: A domain and facet level analysis. *Journal of Personality Assessment*, *79*, 53–72.

Shaw, J., Claridge, G., & Clark, K. (2001). Schizotypy and the shift from dextrality: A study of handedness in a large non-clinical sample. *Schizophrenia Research*, *50*, 181–189.

Steenhuis, R. E., & Bryden, M. P. (1989). Different dimensions of hand preference that relate to skilled and unskilled activities. *Cortex*, *25*, 289–304.

Steenhuis, R. E., & Brysden, M. P. (1999). The relation between hand preference and hand performance: What you get depends on what you measure. *Laterality*, *4*, 3–26.

Stefanis, N. C., Vitoratou, S., Smyrnis, N., Constantinidis, T., Evdokimidis, I., Hatzimanolis, I., et al. (2006). Mixed handedness is associated with the Disorganization dimension of schizotypy in a young male population. *Schizophrenia Research*, *87*, 289–296.

Tapley, S. M., & Bryden, M. P. (1985). A group test for the assessment of performance between the hands. *Neuropsychologia*, *23*, 215–221.

Taylor, K. I., Zach, P., & Brugger, P. (2002). Why is magical ideation related to leftward deviation on an implicit line bisection task? *Cortex*, *38*, 247–252.

Trull, T. J. (1992). DSM-III–R personality disorders and the five-factor model of personality: An empirical comparison. *Journal of Abnormal Psychology*, *101*, 553–560.

Weinstein, S., & Graves, R. E. (2002). Are creativity and schizotypy products of a right hemisphere bias? *Brain & Cognition*, *49*, 138–151.

Wiggins, J. S., & Pincus, A. L. (1989). Conceptions of personality disorders and dimensions of personality. *Psychological Assessment: A Journal of Consulting & Clinical Psychology*, *1*, 305–316.

Witelson, S. (1985). The brain connection: The corpus callosum is larger in left handers. *Science*, *229*, 665–668.

Witelson, S. (1989). Hand and sex differences in the isthmus and genu of the human corpus callosum. *Brain*, *112*, 799–835.

Yeung, A. S., Lyons, M. J., Waternaux, C. M., & Faraone, S. V. (1993). The relationship between DSMII personality disorders and the five-factor model of personality. *Comprehensive Psychiatry*, *34*, 227–234.