Schizotypy is increased in mixed-handers, especially right-handed writers who use the left hand for primary actions.

Marian Annett * and Paula Moran [a]

School of Psychology, Medical Sciences Building, University of Leicester, Leicester,

LE1 9HN UK

* Corresponding author. *Email address:* doc@le.ac.uk (Marian Annett).

[a] Dr Paula Moran is now at School of Psychology, University of Nottingham,

Nottingham, NG7 2RD UK. *Email address*: paula.moran@nottingham.ac.uk

Abstract

Associations between schizotypy and handedness were examined in 733 undergraduates for the Sta and Unex scales of the O-Life inventory and several measures derived from the Annett hand preference questionnaire. Higher schizotypy scores were found for mixed-handers defined in various ways, including inconsistent preference for any item of the questionnaire and also the presence of either hand responses. There was a marked elevation of schizotypy scores ($p < .001$) for right-handed writers who prefer the left hand for other 'primary' actions (throwing, racket, match, hammer, toothbrush and scissors). This observation was replicated in 182 students assessed on the Rust Scale of Schizotypal Cognitions. Several findings agree that inconsistent hand preference is associated with a raised probability of schizotypal thinking.

Keywords: Schizotypy, handedness, O-Life inventory, Rust Inventory of Schizotypal Cognitions

1. Introduction

Schizotypy is a term that does not have a precise definition but refers to the continuity

of certain features of psychotic disorders with thinking and experience in the non-

psychotic population (Meehl et al., 1962; Claridge, 1997). The concept has been

operationalised through personality scales that assess the presence in general samples,

most often undergraduates, of ideas such as 'being watched' or 'having magical

powers'. The validity of these scales in tapping schizophrenic-like thinking has been

demonstrated in psychiatric patients (Johnstone et al., 2005; Moran et al., 2003).

Mixed-handers have been reported to have raised scores on scales

investigating aspects of schizotypy (Barnett and Corballis, 2002; Chapman and

Chapman, 1987; Claridge et al., 1998; Kim et al., 1992; Richardson, 1994; Shaw et

al., 2001). This paper describes two studies designed to replicate and extend some of

these investigations. There was a new finding, higher schizotypy scores in a particular

group of mixed-handers.

Mixed-handedness may be assessed in different ways, depending on questions

asked, and criteria of classification. Claridge et al. (1998) and Shaw et al. (2001)

defined mixed-handedness as preference for different hands for any of the 12 actions

of the Annett (1970) hand preference questionnaire (APHQ). They also looked at

subgroups of mixed-handers that were defined by Annett (1970, 1985) with the aim of

mapping degrees of hand preference with degrees of hand skill for a peg moving task.

It was of particular interest whether findings of Claridge et al. (1998) for subgroups of

mixed-handers could be replicated. They found that all groups of non-right-handers

tended to have higher Sta scores than consistent right-handers, except for the revised

class 4, which had especially low scores.

Figure 1 about here

Figure 1 shows the original 1970 subgroup classification and the 1985 revision. Class 1 includes consistent right-handers who have no left (L) hand preference for any action of the AHPQ, but they may express a preference for either (E) hand. Class 8 includes consistent left-handers, who have no right (R) hand preferences but may give E responses. Classes 2-7 inclusive are different subgroups with firm but inconsistent preference for at least one action. Classes 5 and 6 are of particular interest for the present paper. They are right and left-handed writers respectively, who prefer the other hand for any of the actions that were highly inter-correlated and described by Annett (1970) as 'primary actions' (writing, throwing, racket, match, hammer, toothbrush). Later findings suggested that cutting with normal right-handed scissors with the left hand should also be counted as a primary action for right-handed writers. (Left-handers often use right-handed scissors in the right hand, so this is a not a primary action for left-handers.)

The revised scheme, at the bottom of Figure 1, deleted class 5 and re-assigned its members to classes 3 and 4. This was because class 5 tended to be more dextral than class 4 for peg moving asymmetry (when it should have been more sinistral if the classes were to be ordered for peg moving skill). Class 4 was the most sinistral group of right-handers in the 7 group scheme.

A further look at the 8 group scheme was required by another classification based on the AHPQ. Lishman and McMeekan (1976) classified psychotic patients as mixed-handed if they used different hands for the primary actions (classes 5 and 6 above). This definition was also used for a study of schizophrenics and their relatives (Orr et al., 1999) and schizophrenics among Greek conscripts (Giatokos, 2001). In all

three studies, psychiatric patients were about twice as likely to be mixed-handed for primary actions (14-16%) as healthy controls (8.2% in Annett, 2004). Collinson et al. (2004) found 20.5% of schizophrenics of early onset mixed-handed on this criterion.

Another interpretation of mixed-handedness is inconsistent preference for a specific action, termed 'ambiguous' handedness (Soper and Satz, 1984), and reported as frequent in schizophrenics (Green, 1997; Satz and Green, 1999). In questionnaires this type of uncertainty is implied by E responses. Shaw et al. (2001) found a strong negative association between the probability of endorsing an action as E and mean schizotypy score. That is, participants who reported E for actions that are rarely so endorsed were more likely to have high schizotypy scores.

Two investigations are reported here. The first study describes undergraduates responding to the O-LIFE scale (Claridge, 1997) and AHPQ over the years 1999-2003. The second study describes findings for undergraduate projects in the years 1995-1996, for students responding to the Rust Inventory of Schizotypal Cognitions (RISC, Rust, 1989). The first study led to a surprising finding. The second study checked whether this finding was present in the older data.

2. Study I: Handedness and schizotypy assessed by the O-LIFE inventory.

2.1 Method

2.1.1. Participants

Participants were psychology students at the University of Leicester taking practical classes in the years 1999 - 2003. There were 733 (141 male, 580 female, 12 of undeclared sex) giving full information for schizotypy and handedness. The majority (95%) were in the age range 17-23 years, but others were mature students up to 54

years of age (mean 20.1, sd 3.3 years). The practical class was a required course

element so the sample should be representative of the psychology student population.

 2.1.2.Procedures

The Oxford-Liverpool Inventory of Feelings and Experiences (O-LIFE) is a

compilation of scales developed as research instruments for investigating schizotypy.

It includes the Oxford Schizotypal Personality Scale (Sta), and a scale of unusual

experiences (Unex). The inventory was administered by PC. Students logged onto the

Departmental Website and answered the questions at a time of their choice, over a

period of a few weeks. Anonymity was assured by giving each student a participant

number that was entered at the start of the session, and also recorded with handedness

data so that the two sets of information could be matched. Hand preference

assessment depended in the first years of enquiry on observation in the laboratory, but

as student numbers grew this was not possible and the AHPQ was administered by

PC. Statistical analyses were by SPSS 10.1.

2.2 Results

2.2.1 Right-, mixed- and left-handers, compared for Sta and Unex.

Three groups, consistent right-handers, mixed-handers (classes 2-7 inclusive) and

consistent left-handers were compared for Sta and Unex by analysis of variance for

hand preference group (3) by sex (2). There was no sex difference in these or other

analyses below. Handedness groups were then compared for sexes combined

(including sex unknown). The groups differed for Sta (F = 3.224, d.f. 2/730 p = .040).

Inspection showed that mixed-handers tended to have higher scores than consistent

left- or right-handers in both sexes. Post hoc comparisons (with Bonferroni

correction) found mixed-handers to have higher scores than consistent right-handers (p = .040).

The corresponding analyses for Unex found no overall differences but the expected trend for mixed-handers to have higher scores. Comparison of right- and mixed-handers by t test found t = 1.713, d.f. = 690 p = .087. The direction was predicted and one-tailed test gives p = .044.

2.2.2. Seven and eight group classifications for handedness.

The prediction was that the pattern of findings for Sta over the 7 subgroups (Figure 1) would resemble that of Claridge et al. (1998). We found no significant overall effect for handedness by Sta over the 7 group classification but consistent right-handers tended to have lower scores than mixed right-handers. This was significant by post hoc tests (least significant difference, LSD) in contrast to class 2 (p = .013) and approached significance for class 4 (p = .052) (in the direction opposite that found by Claridge et al.). With correction for multiple comparisons these contrasts were not significant. The corresponding analyses for Unex over the 7 group handedness classification found similar trends but no significant effects.

Table 1 about here

Comparison of Sta means for the 8 group classification found a highly significant effect (F = 4.240, d.f. = 7/725, p < .001). Table 1 shows the group means, ranges and significant contrasts. Post hoc comparisons found class 5 (right-handed writers who perform one or more primary action with the left hand) had a significantly higher mean than all other groups (with Bonferroni correction). Class 2 had a higher mean than classes 1 and 3 (by LSD but not with correction).

Repetition of the 8 group analyses for Unex gave similar findings overall (F = 2.461, d.f. = 7/725, p = .017). Post hoc tests found that class 5 had a significantly higher mean than all other groups by LSD, and with correction higher than classes 1, 2 and 7.

2.2.3. 'Either' hand responses and schizotypy.

Shaw et al. (2001) showed in several analyses that the tendency to give E responses was associated with higher Unex scores. The correlation between number of E responses given by individual participants and Unex mean was small but highly significant in the large Shaw et al. sample (r = +0.12, p <.001, d.f. = 3415). In the present sample the correlation was of similar size and also significant (r = +0.089, p = .015, d.f. = 733). When Shaw et al. ranked items of the AHPQ for probability of E responses (from 1.6% for hammer to 16.1% for sweeping, omitting writing) the correlation with rank mean unex scores was rho = -0.85, p < .01, N = 11. For the present sample, similar rankings for E responses (from 1.5% for hammer to 16.9% for jar) and Unex means found rho = -0.583, p = .060, N = 11. The corresponding analysis for Sta found rho = -.829, p = .002, N = 11.

The above analyses included all participants, many of whom were among the mixed-handers in previous analyses. Does the E effect hold among consistent right-handers who made no L responses (and were not included in the mixed-handers above)? Considering each handedness item separately, the means for Unex could be compared between those giving and those not giving E responses (except for writing with only one E respondent). The participants endorsing E tended to have higher Unex scores in 10/11 comparisons (binomial test p =.05, 2-tail).

2.3 Discussion

The first aim was to replicate previous findings that elevated schizotypy scores are characteristic of groups of mixed-handers. When mixed-handedness was defined as any mixture of preference among 12 actions the predicted difference was found for Sta. For Unex there was a strong trend in the predicted direction, and by one-tailed test the effect was significant for both schizotypy scales.

Another criterion of mixed-handedness was uncertain preference for either hand (E response). Several analyses supported the conclusion that the tendency to give E is associated with elevated schizotypy scores. The rank order of actions for probability of E response tended to be negatively related to the rank order of means for Unex ($p = .03$ by one-tailed test). The corresponding correlation for Sta was highly significant, in the same direction and of the same order as found for Unex by Shaw et al. (2001). It is worth noting, as did Shaw et al., that the actions least likely to be given E responses are the primary actions (hammer, throw, racket etc.). That is, actions less likely to be E were associated with higher schizotypy scores when E was given. The tendency for higher schizotypy scores to be associated with E responses remained when analyses were restricted to consistent right-handers (who made R or E but no L responses).

The second aim of this enquiry was to test the replicability of the pattern of findings described by Claridge et al. (1998) over the 7 subgroup classification. There was no overall statistical significance for the 7 group analysis, nor was there the trend to low scores in class 4. By contrast, a highly significant difference between hand preference subgroups was found for the 8 subgroup analysis. Almost all of the effect depended on class 5, which had a higher mean than all other groups. This was true for the Sta scale, and also for the Unex scale.

These several analyses show that higher schizotypy scores are associated with a tendency to report mixed-handedness, both in the sense of mixtures of R and L responses, and also in the sense of E responses. Means were highest for right-handed writers who were inconsistent for other primary actions. In the present sample there was no hint of a corresponding elevation for left-handed writers who preferred the right hand for other primary actions (class 6).

A first check for replication was made by examining the sexes separately. For females the 8 group analysis was significant overall for Sta ($p = .002$) and tended to significance for Unex ($p = .099$). For males subgroups were too small to allow a clear test of relationships. However, inspection of the means showed that class 5 males had a higher mean than all other subgroups for both Sta and Unex.

3. Study 2. Handedness and Schizotypy assessed by the Rust (1989) Inventory.

3.1 Participants

Participants were first year psychology students volunteering to take part in experimental projects run by third year students, under staff supervision. There were 182 with full information for hand preference and schizotypy (38 male, 144 female). The median and mode for age was 18 years, but the range was 18 - 47 years (mean 20, SD 4.8 years).

3.2 Procedures

Participants were tested in groups of up to about N =15, typically by a pair of third year students, in the presence of MA or one of her postgraduate assistants. Hand preference for the AHPQ was assessed by demonstration. Several tests were given, mainly of literacy skills as described elsewhere (Annett, 1999, 2002, p 212-213).

The Rust Inventory of Schizotypal Cognitions (1989), described in our protocol as the 'Rust Inventory of Student Cognitions', was administered as a written questionnaire. The instructions were read out aloud by the presenting examiner. Participants were assured that all information would be treated in the strictest confidence.

3.3 Results

Among the 182 participants there were only 5 (2.7%) in class 5. However, the finding looked for was very specific, that the schizotypy mean should be elevated in this group. The mean for class 5 (46.8, s.d. 10.3) was the highest of all groups. Table 2 gives the means, ranges and significant contrasts. By post hoc tests (LSD) the class 5 mean was higher than class 6 ($p = .043$) and tended to be higher than classes 1 ($p = .053$) and 2 ($p = .086$).

<div align="center">Table 2 about here</div>

3.4 Discussion

This analysis checked whether the finding for class 5 in Study 1 would be replicated. The scores for schizotypy were elevated in class 5 above all other groups. High levels of statistical significance were not expected because of the small Ns, but it is worth noting that the strongest contrast was with class 6, left-handed writers who perform other primary actions in the right hand. Class 6 had a particularly low schizotypy mean suggesting that it is not the mixture of primary actions that is critical. The higher level of schizotypy appears to apply to the mixture of primary actions in right-handed writers only.

4. General Discussion

There were two main findings, one a general finding that was predicted and the second a specific finding that was not predicted. The general finding was that schizotypy scores tend to be elevated in mixed-handers, when mixed-handedness is defined in several different ways. These included combinations of R and L preferences for the AHPQ and also E responses. Statistical contrasts were not always significant by conventional standards but the trends of results were consistently in the direction predicted.

Could these associations be due to a tendency to give unusual responses to questionnaires? Perhaps some participants are inclined to give 'different' responses to questionnaires, for handedness and for schizotypy. This explanation is unlikely here because about half of the participants of study 1 and all those of study 2 did not answer a written handedness questionnaire but demonstrated the actions of the AHPQ to an observer.

Are the findings specific to mixed-handers, or would it be more accurate to attribute them to non-right-handers (mixed- and left-handers combined)? In the three group classification (2.2.1) mixed-handers included right- and left-handed writers, while consistent left-handers were few (5.6% of study 1 and 1.1% of study 2). Consistent left-handers did not differ significantly from other groups but tended to have lower means than mixed-handers. Shaw et al. (2001) in a much larger sample found consistent left-handers tended to have lower, not higher, scores than consistent right-handers. Some of the present analyses were run for left- versus right-handed writers and no significant differences were found. Effects appear to be a function of mixed-handedness rather than non-right-handedness.

The specific and unexpected finding was that one subgroup of mixed-handers was particularly likely to have elevated schizotypy scores, right-handed writers who perform other primary actions with the left hand. Given the unexpected nature of this finding, the question was whether it is reliable. The trend was present in both sexes. Another check on reliability was offered by Study 2. The mean for class 5 was clearly higher than for all other classes. In isolation, this observation would not merit attention, but it gives striking support for the unpredicted finding of Study 1. Rust (1989, Table 1) interprets the class 5 mean (43.1) as just within the category of 'high' schizotypy scores, while all other means were in the 'average' or 'above average' categories (range 37.0 - 40.8).

What might be said of the theoretical significance of the finding for class 5? This is the only group of right-handers, in the original classification, that prefers the left hand for other primary actions. Primary actions were so-called because they tend to be highly associated (Annett, 1970). However, there is no hint in the present data that *left-handers* discordant for primary actions (class 6) also have high schizotypy scores. There are rather indications to the contrary. This suggests that discordance for primary actions is not a general risk for both right- and left-handed writers, but only for the former.

Class 5, like other subgroups, was defined with the aim of mapping degrees of hand preference with degrees of hand skill as objectively measured. It presented a challenge from the start because this group, that seemed likely (a priori) to be the most sinistral of right-handers, tended to be more dextral for hand skill than the original class 4 (right-handers who deal playing cards with the left hand). Annett (2004) confirmed in combined samples of nearly 2400 participants that class 4 is

closest to zero for peg moving asymmetry (1.9% when the difference between hands is a proportion of the total time taken by both hands), while class 5 was more dextral (3.5%). (Class 1 was most dextral at 5.0%). The re-assignment of class 5 in the 7 group classification smoothed the regression of preference groups on relative hand skill. However, the present findings strongly suggest that class 5 should be re-instated. A practical difficulty for research is the small Ns expected in some subgroups, but normative data from large healthy samples is available (Annett, 2004).

How might these findings fit into the wider context of research on mixed- and non-right-handedness? Raised incidences of atypical handedness have been associated with twinning, low birth weight, learning disabilities, dyslexia, criminality and psychopathy, as well as schizophrenia, but also with groups having special talents such as artists, mathematicians, surgeons, and tennis, baseball and cricket professionals (Annett, 2002 for review). The length and variety of these lists show that differences for handedness cannot be the cause of any of these conditions but are rather likely to be a by-product of other mechanisms influencing development. One possible mechanism suggests that individuals who are mildly rather than strongly biased to right-handedness may enjoy a heterozygote advantage, and that this has been sufficient to maintain a genetic balanced polymorphism for variation in cerebral dominance and handedness in the population. The present findings for unusual types of thinking seem to apply to a range of manifestations of mixed and either hand preference, but especially for the primary actions. This type of thinking among undergraduates may be associated with special talents rather than risks for disorder.

A substantial body of research has found raised incidences of non-right-handedness among schizophrenics, as confirmed by several meta-analyses (Dragovic

and Hammond, 2005; Satz and Green, 1999; Sommer et al., 2001) using different classifications of handedness. Increased frequency of mixed-handers has also been found among the relatives of schizophrenics (Orr et al., 1999). These associations are consistent with both genetic and neurodevelopmental accounts of schizophrenia as due to failures of cerebral dominance (Annett, 1997; Crow et al, 1996; Crow 1997) and also as a risk at what Crow et al. (1998) call 'the point of hemispheric indecision'. The present findings suggest that the classification of mixed-handedness should be refined further to examine a specific subgroup, right-handed writers who perform other primary actions with the left hand. The findings underscore the importance of subdivisions of the handedness continuum and the possible heterogeneity of the mixed-handed classification.

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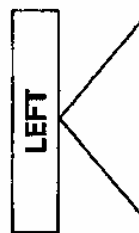   A new explanatory model. Neuropsychologia, 22, 511-515.

Captions

Figure 1. A decision tree for subgroup hand preference, showing the original 8 group

and the revised 7 group classifications. Primary actions are writing, throwing,

racket, match, hammer and toothbrush; non-primary actions are scissors,

needle, broom, spade, dealing cards, unscrewing jar. Classes are numbered

from right to left, and classes to the left in the Figure take precedence over

those to the right (Annett, 2002, Figure 2.8). Note that it is class 5 in the

original classification that has elevated schizotypy scores.

Table 1. Oxford Schizotypal Personality Scale (Sta) in hand preference subgroups:

Means, ranges and significant contrasts.

Table 2. Rust Inventory of Schizotypal Cognitions (RISC) in hand preference

subgroups: Means, ranges and significant contrasts.

CRITERION

1 WRITING HAND

2 CONSISTENCY

3 PREF. CLASS

4 REVISION

RIGHT — R-PURE, R-MIXED

LEFT — L-MIXED, L-PURE

1 R-PURE: R+E (no L) → 1

2 R-weak L: L for Broom spade or needle only → 2

3 R-mild L: L for Jar → 3; R-mod L: L for Jar &/or 1 Primary

4 R-mod L: L for cards → 4; R-strong L: L for cards &/or 2 Primary &/or 1 Primary

5 R-strong L: PRIMARY L → DELETED

6 L-strong R: PRIMARY R → 6

7 L-weak R: PRIMARY L any other R → 7

8 L-PURE: L+E (no R) → 8

Table 1. Oxford Schizotypal Personality Scale (Sta) in hand preference subgroups:
Means, ranges and significant contrasts.

Hand Pref. Class		N	Mean	SD	Range	Significance
1	R-pure	430	15.4	7.2	0-37	
2	R-weak L	86	17.5	8.4	1-38	1*, 3*
3	R-mild L	86	15.3	7.0	5-35	
4	R-mod.L	34	16.9	7.0	3-30	
5	R-strong L	19	23.5	7.4	9-36	1**, 2**, 3**, 4**, 6**, 7**, 8**
6	L-strong R	24	15.5	7.2	4-29	
7	L-weak R	13	14.3	4.6	9-27	
8	L-pure	41	15.3	6.8	3-32	

* $p < .05$, ** $p < .01$ for LSD positive contrasts.

Table 2. Rust Inventory of Schizotypal Cognitions (RISC) in hand preference
subgroups: Means, ranges and significant contrasts

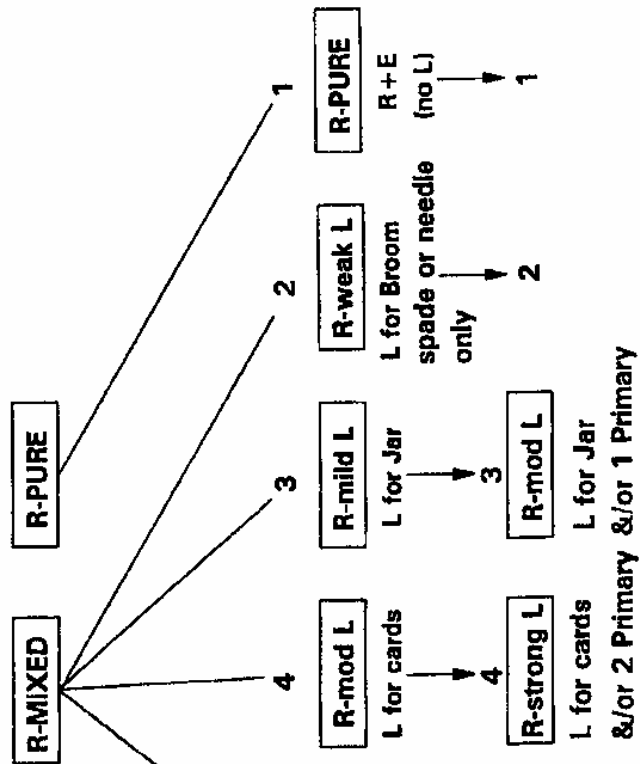| Hand pref. class		N	Mean	SD	Range	Significance
1	R-pure	116	39.1	8.2	16-60	
2	R-weak L	18	39.3	7.4	28-56	
3	R-mild L	14	40.5	13.5	14-69	
4	R-mod. L	14	41.6	8.5	27-61	
5	R-strong L	5	46.8	10.3	34-62	1*, 2*, 6**
6	L-strong R	9	37.0	6.8	24-49	
7	L-weak R	4	40.2	7.1	32-48	
8	L-Pure	2	38.5	9.2	32-45	

* p< .10, ** p < .05 for LSD positive contrasts.