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THE STRUCTURE OF SELF-REPORT SCHIZOTYPY IN TWINS

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Many self-report scales have been proposed to measure in nonclinical populations the predisposition to schizophrenia, or "schizotypy." We here examine responses to 10 such scales from 409 twins from the population-based Virginia Register. Factor analysis indicates that schizotypy, as assessed by these scales, is not unidimensional. Rather, 3 distinct factors are found: *positive trait schizotypy*, *nonconformity*, and *social schizotypy*. These 3 factors are relatively distinct from the personality trait neuroticism and from self-report symptoms of anxiety and depression. However, *social schizotypy* is closely related to the personality dimension of extraversion. Twin model fitting indicates that genetic factors are important for all individual scales except perceptual aberration and for all 3 factors. Heritability estimates were often substantial (e.g. > 0.45). Conclusive evidence is still lacking to demonstrate which, if any, of the genetically influenced "schizotypy" factors reflect the inherited liability to schizophrenia.

Substantial evidence suggests that the vulnerability to schizophrenia [which we term, after Rado (1953), as schizotypy] can manifest itself in ways other than as the classic, deteriorating psychotic syndrome (Kendler, 1985). Five controlled family or adoption studies using DSM-III criteria have found higher rates for schizophrenia-like personality disorders (schizotypal, schizoid and/or paranoid personality disorder) in relatives of schizophrenic versus control probands (Baron et al., 1985; Franjos et al., 1985; Gershon et al., 1988; Kendler & Gruenberg, 1984; Lowing, Mirsky, & Pereira, 1983).

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One recent small sample study, however, finds similarly elevated rates of schizotypal personality traits in adolescent offspring of schizophrenic and affective disorder probands (Squires-Wheeler, Skodal, Friedman, & Erlenmeyer-Kimling, 1988). Although earlier studies had failed to find the predicted excess risk for schizophrenia in relatives of schizotypal individuals (e.g., Torgersen, 1984), two studies have now reported results consistent with this expectation (Lenzenweger & Loranger, 1989; Schulz et al., 1989).

Many self-report scales are now available that purport to measure one or more aspects of schizotypy. This paper addresses four potentially important limitations of the current literature on these scales. First, with the wide array of available instruments, our knowledge of how they interrelate remains limited, especially in general-population samples. Do all the available scales measure a single latent dimension of schizotypy, or is there—as suggested by previous research, conducted almost entirely with college students—multiple independent dimensions of schizotypy (Allen et al., 1987; Bentall, Claridge, & Slade, 1989; Chapman, Chapman, & Miller, 1982; Muntaner, Garcia-Sevilla, Fernandez, & Torrubia, 1988; Raine & Allbutt, 1989)?

Second, we know relatively little about how measures of schizotypy relate to more "normative" personality dimensions (Livesley, Jackson, & Schroeder, 1989; Torgersen & Alnaes, 1989). Several investigators have suggested that certain schizotypal scales may substantially correlate with the personality traits of neuroticism and/or extraversion (Bentall et al., 1989; Claridge & Hewitt, 1987; Muntaner et al., 1988). Is schizotypy a distinct personality trait, or are one or more of its dimensions closely related to other well-studied "normative" personality traits?

Third, it is unclear how separable schizotypy is from self-report levels of anxiety and depression. Allen et al. (1987) found that students with high levels of perceptual aberration had much higher levels of self-report depression than matched controls. Are measures of schizotypy meaningfully distinct from measures of self-report psychiatric distress?

Fourth, although substantial evidence supports a familial/genetic link between clinically assessed schizotypy and schizophrenia, less is known about the role of genetic factors in self-report schizotypy. Two previous twin studies, which each examined a single schizotypy scale, have suggested that they are influenced by genetic factors (Claridge & Hewitt, 1987; Kendler, Heath, & Martin, 1987a). These important results deserve replication and extension.

In this paper, we examine the interrelationship between 10 putative self-report measures of schizotypy in a sample of over 400 twins from the Virginia Twin Registry. In addition, we explore the interrelationship between the observed dimensions of schizotypy and the major personality dimensions of neuroticism and extraversion and self-report symptoms of anxiety and depression. Finally, using twin model fitting, we examine the role of genetic and environmental factors in these scale scores.

METHODS

Ascertainment of Twins and Zygosity Determination. Twins were ascertained from the Virginia Twin Registry, which is based on a complete screening of birth

certificates within the Commonwealth of Virginia. Between August 1988 and April 1989, questionnaires were mailed to 500 male and 300 female Caucasian twins between the ages of 18 and 50, sampling monozygotic (MZ) and dizygotic (DZ) twins equally within each sex and including both same-sex and opposite-sex DZ pairs. We oversampled males to compensate for their anticipated lower cooperation rate. Nonresponders received a follow-up mailing 6 weeks later, together with a telephone reminder if phone numbers could be obtained. After adjusting for post office returns without forwarding addresses and deceased individuals, the overall participation rate was 50%. This sample of 377 individuals was augmented by an additional 45 subjects that had been independently recruited from the Virginia Twin Registry for a laboratory-based study of schizotypy (Kendler et al., 1991). As both samples were ascertained from the Virginia Twin Registry and completed the identical questionnaire, we felt justified in combining them. All the major analyses were repeated excluding these 45 twins without major alteration in findings. Zygosity was determined from self-report questions that, when tested against blood typing, are around 95% accurate (Eaves et al., 1989).

The Measures of Schizotypy. We assessed, in this project, 10 separate self-report scales that are putative indices of schizotypy. These scales were chosen because for their diversity and/or wide usage in the field. We use, in this article, "code names" for these scales. With the assistance of Loren Chapman, we developed shortened versions of 5 of his scales: Magical Ideation (20 items—termed "Chapman magical ideation"), Perceptual Aberration (24 items—termed "Chapman perceptual aberration"), Impulsive Nonconformity (20 items—termed "Chapman nonconformity"), Physical Anhedonia (18 items—termed "Chapman physical anhedonia") and Social Anhedonia (26 items—termed "Chapman social anhedonia") (Chapman et al., 1976, 1980, 1982, 1984; Chapman & Chapman, 1985, 1987). We also used the 3 subscales previously derived from the Schizotypy, or STA, scale of Claridge and Broks (1984; also Hewitt & Claridge, 1989): Magical Thinking (8 items—termed "Claridge magical ideation"), Unusual Perceptual Experience (8 items—termed "Claridge perceptual aberration"), and Paranoid Ideation (8 items—termed "Claridge paranoid ideation"). The two final "schizotypy" scales included were the entire 12-item Launay–Slade Hallucination Scale (1981) and 18 items from a revised version of Eysenck's Psychoticism scale (Eysenck, Eysenck, & Barrett, 1985), including the 12 items from the EPQ-R short form augmented by additional core psychoticism items appearing in both the Eysencks' earlier EPQ and PEN questionnaires and by the "suspiciousness" items analyzed by Kendler et al. (1987a).

Other Measures. Personality was measured by Eysenck's shortened Neuroticism and Extraversion scales (Eysenck et al., 1985) because these are well-developed and widely tested scales that have been extensively studied in twins (Eaves et al., 1989). Symptoms of anxiety and depression over the last 30 days were measured using empirically derived subscales from the SCL-90 (Derogatos, Lipman, & Covi, 1973). Depression was measured by 10 of the original 13 items from the Depression scale. Anxiety was measured by 18 items from the Anxiety, Phobic Anxiety and Somatic Anxiety scales.

Statistical Analysis. Orthogonal and oblique factor analyses were carried out using the VARIMAX and PROMAX routines in SAS (SAS Institute, 1985), respectively. The number of meaningful factors was determined by an examination of the scree plot. Pearson product moment correlations were used to examine the relationship between various putative indices of schizotypy. For these analyses, twins were treated as individuals.

Model fitting was applied to the variance and covariance matrices for MZ and DZ twins separately using the computer program LISREL (Joreskog & Sorbom, 1989). Prior to analysis, variables with positively skewed distributions were transformed, by either a log $(x + 1)$ or square root transformation to reduce skewness. The goal of these analyses was to obtain estimates for the proportion of variance in these scales

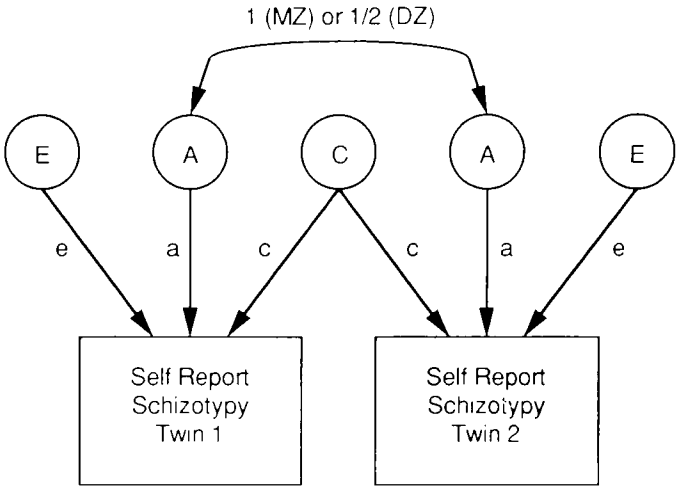

FIGURE 1. The twin model for causes of self-report schizotypy used in this report. Etiologic factors are divided into additive genetic effects (A), family or common environment (C), and individual specific environment (E). The correlation in additive genetic effects in MZ twins equals 1 and in DZ twins equals .5. Common environment is, by definition, correlated perfectly in both MZ and DZ twins. Individual specific environment is, by definition, uncorrelated in twin pairs. Capital letters indicate the latent variables (e.g., A, C, or E) and lowercase letters indicate the path coefficients (e.g., a, c, or e). The proportion of variance in the liability to self-report schizotypy accounted for by the latent variables is the square of the path coefficient (e.g., a^2, c^2 or e^2).

that was due to additive genetic factors (A), family environment (C; that portion of environmental factors shared by twins such as rearing environment, social class, school, etc.), and individual specific environment (E; that portion of the environment unique to each member of a twin pair, including any unreliability of measurement). The full model is illustrated in Figure 1. Additive genetic effects contribute twice as much to the correlation in MZ twins as in DZ twins (because MZ twins share all their genes identical by descent, whereas DZ twins, like nontwin siblings, share on average only half their genes). By contrast, family environment contributes equally to the correlation in MZ and DZ twins. For all twin pairs, we fit three models: (i) ACE, (ii) AE, and (iii) CE. In addition, we tested for the presence of nonadditive or dominance genetic factors but found no evidence for their presence for any of the scales tested in this sample.

The second model assumes that all familial aggregation results from genetic effects, and the third model assumes that all observed familial aggregation is the result of shared environmental influences. Only the first model assumes that familial resemblance is the result of *both* genetic and shared environmental features. The fit of each of these models is assessed by a goodness of fit χ^2 test. The best-fitting model is then chosen using Akaike's information criterion (1987), which reflects both the goodness of fit and parsimony of the model.

The final step of twin analysis was to estimate, based on the best-fitting model, the proportion of variance in our various measures of schizotypy that are due to individual specific environment (e^2) and, depending upon the results of model fitting, additive gene action (a^2) or common environment (c^2). The proportion of variance in liability due to additive genetic effects is often termed "heritability" and is equivalent to narrow heritability as used in quantitative genetics.

RESULTS

Sample. Questionnaires were available from 422 twins, but in 13, more than 40% of the items were blank so they were excluded from further analyses. The mean age (+ *SD*) of the final sample of 409 twins was 37.7 ± 13.0 years and contained 54.9% males. Responses from both members of a pair were available for 70 pairs classified as MZ (37 female-female and 33 male-male) and 63 classified as DZ (11 female-female, 25 male-male, 27 opposite-sex).

Demographic Correlates and the Effect of Zygosity and Cooperation. An examination of the relationship between our 10 putative self-report indices of schizotypy and age, sex, and social class, as indexed by years of education, is seen in Table 1. Six of the 10 scales had a significant or near-significant inverse relationship with age. Six of the 10 scales had a significant relationship with sex, which in 5 instances was due to higher levels in males. Eight of the 10 scales had a significant inverse relationship with years of education.

Prior to twin model fitting, it is useful to determine whether MZ and DZ twins differ significantly on our schizotypy scales. Controlling for the effect of age and sex, zygosity had a significant effect on two scales (Chapman nonconformity and psychoticism), in both cases because DZ twins had significantly higher scores than MZ twins ($p = 0.049$ and 0.027, respectively). However, the marginal level of significance of these differences and the absence of any significant effect of zygosity on the 8 other scales, suggested that zygosity did not have a consistent or major impact on schizotypy scores.

Twin samples provide a method for testing for a "cooperation" bias. If the

Table 1. Relationship With Demographic Factors and Internal Reliability of Putative Self-Report Indices of Schizotypy

	Regression coefficients			
Schizotypy scale	Age × 10^2	Sex[a]	Years of Education	Cronbach's alpha
Launay–Slade Hallucination	−.52[b]	+.039	+.130	.737
Chapman Perceptual Aberration	−.86[d]	+.073	−.188[f]	.843
Chapman Magical Ideation	−.60[b]	+.140[b]	−.135[d]	.818
Chapman Social Anhedonia	+.20	+.200[d]	−.097[e]	.761
Chapman Physical Anhedonia	+.01	+.261[f]	−.111[a]	.709
Chapman Nonconfomrity	−.90[d]	+.185[c]	−.161[e]	.792
Claridge Magical Ideation	−.82[f]	−.106[b]	−.003	.705
Claridge Perceptual Aberration	−.52[c]	−.049	−.048	.675
Claridge Paranoid Ideation	−.38	+.001	−.109[d]	.697
Eysenck Psychoticism	+.103	+.173[d]	−.142[f]	.516

[a] For sex, + means higher in males.
[b] $p < .10$.
[c] $p < .05$.
[d] $p < .01$.
[e] $p < .001$.
[f] $p < .0001$.

level of schizotypy is correlated in twin pairs, and if cooperativeness is negatively related to schizotypy, then twins whose co-twin did not return a questionnaire should have higher schizotypy levels than twins whose co-twin returned the survey. In a regression analysis controlling for age, sex, and zygosity, no significant difference was found in any of the 10 scales between twins whose co-twin did versus did not return a questionnaire.

Scale Intercorrelations. The observed within-individual correlations between our 10 schizotypy scales, Neuroticism and Extraversion and symptoms of anxiety and depression are seen in Table 2. In addition, Cronbach's coefficient alpha for each scale is seen in Table 1 (Cronbach, 1951). Particularly high correlations ($\geq +0.55$) were seen between (i) the Launey–Slade Hallucination Scale and Chapman's magical ideation and perceptual aberration scales, (ii) Chapman's and Claridge's magical ideation scales, and (iii) Claridge's paranoid ideation scale and Neuroticism. Correlations greater than + 0.50 were seen between (i) the Launey–Slade Hallucination Scale and Claridge's magical ideation and perceptual aberration scales, (ii) Chapman's magical ideation and Claridge's perceptual aberration scales, (iii) Chapman's nonconformity scale and Psychoticism, (iv) Claridge's magical ideation and perceptual aberration scales, and (v) Anxiety and Chapman's and Claridge's perceptual aberration scales.

Factor Analysis I—The 10 Schizotypy Scales. Our first factor analysis of the 10 putative schizotypy scales yielded 3 meaningful factors, which explained 67.4% of the variance. The results of the VARIMAX rotation are seen in Table 3. The first, the "positive trait schizotypy" factor, has highest loadings on the "core" measures of (i) perceptual aberration, as indexed by the Launey–Slade Hallucination and Chapman's and Claridge's perceptual aberration scales, and (ii) magical ideation, as indexed by Chapman's and Claridge's magical ideation scales. The second, the "nonconformity" factor, has highest loadings on Psychoticism and Chapman's nonconformity and physical anhedonia scales. The third, the "social schizotypy" factor, has high loadings on the Claridge paranoid ideation and Chapman social anhedonia scales. Of the 10 scales, only 2, Chapman's nonconformity and physical anhedonia, had high loadings (e.g., >0.45) on 2 factors.

We also performed an oblique rotation that resulted in a pattern of factor loadings very similar to that obtained with the orthogonal VARIMAX solution. The interfactor correlations were "positive trait schizotypy" and "nonconformity": +0.17, "positive trait schizotypy" and "social schizotypy": +0.35, and "nonconformity" and "social schizotypy": +0.35.

Factor Analysis II—The 10 Schizotypy Scales Plus Neuroticism and Extraversion. To examine the relationship between our measures of schizotypy and "normative" dimensions of personality, we repeated our factor analysis adding Eysenck's scales of Neuroticism and Extraversion, and found 4 meaningful factors that explained 70.8% of the variance (Table 4). The first factor, "positive trait schizotypy," is nearly identical to Factor 1 seen with the previous factor analysis (Table 3). Neither Neuroticism nor Extraversion loaded heavily on this factor. The third factor, "nonconformity," is nearly identical to the second factor of the previous analysis. However, the third factor from the previous analysis of only the 10 schizotypy scales is now split into two new factors, which are anchored, respectively, by Neuroticism and Extraversion. The new second factor, a "neuroticism–

Table 2. Within-Individual Interscale Correlations for 10 Self-Report Schizotypy Scales, Neuroticism, Extraversion, and Symptoms of Anxiety and Depression (n = 399)

	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Launay–Slade Hallucination	.57[e]	.63[e]	.19[e]	−.22[c]	.47[c]	.54[c]	.51[c]	.33[c]	.17[d]	.35[e]	.21[c]	.45[c]	.40[e]
2. Chapman Perceptual Aberration		.55[e]	.27[c]	−.11[b]	.44[c]	41[e]	.48[e]	.40[c]	.05	.36[c]	.29[e]	.51[e]	.46[e]
3. Chapman Magical Ideation			.26[c]	−.23[e]	.45[c]	.65[e]	.52[c]	.39[c]	.22[e]	.34[c]	.23[e]	.42[e]	.40[c]
4. Champan Social Anhedonia				13[c]	.38[e]	.11[b]	.28[e]	.44[e]	−.33[e]	.32[e]	.38[c]	.28[c]	.35[e]
5. Chapman Physical Anhedonia					.02	−.31[c]	−.18[d]	−.02	−.21[c]	−.09[a]	.21[c]	−.13[c]	−.11[b]
6. Chapman Nonconformity						.35[c]	.41[e]	.38[c]	.22[e]	.39[e]	52[c]	.36[e]	.33[e]
7. Claridge Magical Ideation							.53[e]	.32[e]	.21[c]	.35[e]	.04	.37[e]	.35[c]
8. Claridge Perceptual Aberration								.45[c]	.08	46[c]	.17[d]	.52[e]	.48[c]
9. Claridge Paranoid Ideation									−.27[e]	.59[e]	.20[e]	.49[e]	.50[e]
10. Eysenck Extraversion										−.14[c]	.01	−.05	−.11[b]
11. Eysenck Neuroticism											.07	.62[e]	.66[e]
12. Eysenck Psychoticism												.13[b]	.09[a]
13. Anxiety													.80[a]
14. Depression													

[a]$p < .10$.
[b]$p < .05$.
[c]$p < .01$.
[d]$p < .001$.
[e]$p < .0001$.

Table 3. Orthogonal Factor Analysis With VARIMAX Rotation for 10 Self-Report Schizotypy Scales

	Factors		
Schizotypy scale	1 Postivie Trait Schizotypy	2 Nonconformity	3 Social Schizotypy
Chapman Magical Ideation	*.81*	.13	.18
Launay–Slade Hallucination	*.81*	.19	.08
Claridge Magical Ideation	*.80*	–.15	.14
Chapman Perceptual Aberration	*.66*	.30	.22
Claridge Perceptual Aberration	*.65*	.01	.43
Eysenck Psychoticism	.15	*.86*	.10
Chapman Nonconformity	.50	*.62*	.23
Chapman Physical Anhedonia	–.49	*.54*	.14
Claridge Paranoid Ideation	.31	.02	*.82*
Chapman Social Anhedonia	.05	.35	*.76*

Note. Highest loading for each scale is italicized.

Table 4. Orthogonal Factor Analysis With VARIMAX Rotation for 10 Self-Report Schizotypy Scales and Scales for Neuroticism and Extraversion

	Factors			
Scale	1 Positive Trait Schizotypy	2 Neuroticism–Paranoid Ideation	3 Nonconformity	4 Extraversion
Chapman Magical Ideation	*.81*	.19	.15	.04
Launay–Slade Hallucination	*.78*	.17	.17	.04
Claridge Magical Ideation	*.73*	.30	–.12	.16
Chapman Perceptual Aberration	*.70*	.15	.28	–.15
Claridge Perceptual Aberration	*.59*	.50	.08	0
Eysenck Neuroticism	.21	*.88*	.02	–.10
Claridge Paranoid Ideation	.29	*.70*	.14	–.37
Eysenck Psychoticism	.19	–.06	*.85*	–.09
Chapman Nonconformity	.38	.40	*.66*	.21
Chapman Physical Anhedonia	–.52	.07	*.56*	–.11
Eysenck Extraversion	.22	–.11	.07	*.89*
Chapman Social Anhedonia	.21	.25	.45	–*.59*

Note. Highest loading for each scale is italicized.

paranoid ideation" factor, has high loadings on Neuroticism and Claridge's paranoid ideation scale. The new fourth factor, best termed "extraversion," has high positive loadings on Extraversion and high negative loadings on Chapman's social anhedonia scale.

An oblique rotation with these scales resulted in a very similar pattern of

factor loadings. The "positive trait schizotypy" factor was substantially and positively correlated with the "neuroticism–paranoid ideation" factor (+0.47) and the "nonconformity" factor (+0.29). The "neuroticism–paranoid ideation" factor was also positively correlated with the "nonconformity" factor (+0.29). By contrast, all the factor intercorrelations involving the "extraversion" factor were quite small (between –0.16 and +0.11).

Factor Analysis III—The 10 Schizotypy Scales Plus Symptoms of Anxiety and Depression. To understand the relationship between self-report schizotypy and symptoms of anxiety and depression, we added to our 10 self-report indices of schizotypy, our symptoms of depression and anxiety. A factor analysis yielded 4 meaningful factors, explaining 71.9% of the variance (see Table 5). The first, "positive trait" schizotypy; third, "nonconformity"; and fourth, "social schizotypy," factors are very similar to the three factors obtained in our first factor analysis (Table 3). The new second factor, "psychiatric distress," is dominated by very high loadings on depression and anxiety. The two perceptual aberration scales load much higher on this factor (e.g., > +0.40) than did the two magical ideation scales (i.e., < +0.22).

An oblique rotation of the 4-factor solution for these 12 scales produced a pattern of factor loadings nearly identical to that found with VARIMAX rotation. "Positive trait schizotypy" was highly positively correlated with the "psychiatric distress" factor (+0.45). All the other factor intercorrelations were positive and of modest magnitude (i.e., between +0.24 and +0.34).

Twin Correlations for the 10 Schizotypy Scales. The correlations in MZ twins for the 10 self-report schizotypy scales were uniformly statistically significant and with the exception of the perceptual aberration scales of Chapman and Claridge, substantially exceeded those found in DZ twins

Table 5. Orthogonal Factor Analysis With VARIMAX Rotation for 10 Self-Report Schizotypy Scales and Scales for Anxiety and Depression

Scale	Factors			
	1 Positive Trait Schizotypy	2 Psychiatric Distress	3 Nonconformity	4 Social Schizotypy
Claridge Magical Ideation	*.80*	.17	–.10	.11
Chapman Magical Ideation	*.79*	.21	.16	.16
Launay–Slade Hallucination	*.74*	.32	.23	.02
Claridge Perceptual Aberration	*.58*	.41	.05	.28
Chapman Perceptual Aberration	*.54*	.49	.35	.02
Anxiety	.27	*.87*	.04	.17
Depression	.20	*.86*	–.02	.26
Eysenck Psychoticism	.15	–.06	*.81*	.26
Chapman Physical Anhedonia	–.55	.11	*.60*	–.05
Chapman Nonconformity	.46	.15	*.59*	.29
Chapman Social Anhedonia	.04	.14	.30	*.83*
Claridge Paranoid Ideation	.23	.44	.05	*.66*

Note. Highest loading for each scale is italicized.

Table 6. Twin Correlations and Parameter Estimates From Model Fitting for Putative Self-Report Indices of Schizotypy

Scale	Correlation MZ (n = 68–70)	Correlation DZ (n = 58–59)	Parameter estimates for best fitting model[a] a^2	c^2	e^2
Launay–Slade Hallucination	.400[f]	.178	.398	0	.602
Chapman Perceptual Aberration	.268[f]	.233[b]	0	.248	.752
Chapman Magical Ideation	.568[f]	.340[b]	.558	0	.442
Chapman Social Anhedonia	.705[f]	.226[b]	.675	0	.325
Chapman Physical Anhedonia	.566[f]	.326[c]	.567	0	.433
Chapman Nonconformity	.592[f]	.324[c]	.581	0	.419
Claridge Magical Ideation	.422[c]	.286[c]	.453	0	.547
Claridge Perceptual Aberration	.282[c]	.299[c]	0	.288	.712
Claridge Paranoid Ideation	.409[c]	.284[c]	.437	0	.563
Eysenck Psychoticism	.323[d]	.044	.289	0	.711

[a]As determined by Akaike's information criterion (1987); a^2 = additive genetic variance; c^2 = common environment; e^2 = individual specific environment.
[b]$p < .10$.
[c]$p < .05$
[d]$p < .01$
[e]$p < .001$.
[f]$p < .0001$.

(Table 6). Table 6 also gives the parameter estimates from the best-fitting twin model. Significant genetic effects are seen for 8 of the 10 scales. Only in the two perceptual aberration scales does twin resemblance appear to result from common environmental factors. For the other 8 scales, the best-fitting model suggests that twin resemblance results from additive genetic effects, with heritabilities ranging from 0.29 to 0.68.

Table 7 presents the twin correlations for the 3 "schizotypal" factors from each of the three factor analyses. For the first factor analysis, MZ twin correlations were high and similar for all 3 factors (between 0.55 and 0.63) and at least twice as great as that found in the DZ twins. As expected, twin correlations for the "positive trait schizotypy" factor and the "nonconformity" factor, as obtained by the 3-factor analyses, are similar. For the "social schizotypy/extraversion" factor, the DZ twin correlations were higher in the first than in the second and third analyses. The results of model fitting are also seen in Table 7. No evidence for common environment effect was found for any of the factors. By contrast, additive genetic effects were found for all 3 factors from all analyses. Estimates of heritability were uniformly high (e.g., >0.50).

DISCUSSION

THE STRUCTURE OF SELF-REPORT SCHIZOTYPY

We sought, in a sample of over 400 twins from the population-based Virginia Twin Register, to address 4 questions about self-report measures of schizotypy. First, we wanted to clarify the relationship between the various

Table 7. Twin Correlations and Parameter Estimates From Model Fitting for Schizotypal Factors

Factor Analysis	Schizotypy Factor	Correlation MZ (n = 66–67)	Correlation DZ (n = 58)	Parameter estimates for best fitting model[a] a^2	c^2	e^2
1	Positive Trait Schizotypy	.624[d]	.330[b]	.624	0	.376
	Nonconformity	.549[d]	.142	.522	0	.478
	Social Schizotypy	.625[d]	.340[c]	.605	0	.395
2	Positive Trait Schizotypy	.609[d]	.336[c]	.603	0	.397
	Nonconformity	.600[d]	.168	.567	0	.434
	Extraversion	.736[d]	.138	.690	0	.310
3	Positive Trait Schizotypy	.631[d]	.334[b]	.626	0	.374
	Nonconformity	.554[d]	.208	.538	0	.462
	Social Schizotypy	.679[d]	.194	.629	0	.371

[a]As determined by Akaike's information criterion (1987): a^2 = additive genetic variance; c^2 = common environment; e^2 = individual specific environment.
[b]$p < .05$.
[c]$p < .01$.
[d]$p < .0001$.

measures of schizotypy. Our results argue strongly against a unidimensional view of self-report schizotypy. Factor analysis yielded evidence for 3 separate dimensions of self-report schizotypy: "positive trait schizotypy," "nonconformity," and "social schizotypy"

This pattern of factors bears important resemblances with those reported previously in student populations. In their factor analyses of different combinations of self-report schizotypy scales, Muntaner et al. (1988), Bentall et al. (1989), and Raine and Allbutt (1989) all found a factor similar to what we term "positive trait schizotypy" (dominated by high loadings on perceptual aberration, hallucinatory predisposition, and magical thinking scales) and another similar to what we term "social schizotypy," containing Chapman's social anhedonia scale. Since these investigators did not use Chapman's social nonconformity scale, it is not suprising that none found a schizotypal dimension similar to what we termed "nonconformity." The closest parallel was the third factor of Muntaner et al. (1988), which was dominated by Eysenck's Psychoticism scale. There were, however, several modest differences between our results and those previously obtained on student samples. In particular, both Muntaner et al. (1988) and Bentall et al. (1989) found that Chapman's physical anhedonia scale loaded on what we would term the "social schizotypy" rather than on a "nonconformity" dimension.

Our results are also broadly consistent with previous results of Chapman et al. (1982), who, in a large sample of college students, found results suggestive of "positive trait schizotypy" and "nonconformity" factors: very high intercorrelations between magical ideation and perceptual aberration, on the one hand, and impulsive nonconformity and Psychoticism, on the

other, with much lower correlations between these pairs of scales. In other large samples of students, Chapman and colleagues have reported similar results (Chapman et al., 1980, 1984; Eckblad & Chapman, 1983). Our results confirm and extend those we reported earlier in a subsample of the twins reported here (Kendler et al., 1991), where we found, in 58 twins, evidence for "positive trait schizotypy" and "social schizotypy" factors.

Our findings also support previous suggestions that schizotypal symptoms as proposed in the DSM-III and DSM-III-R (American Psychiatric Association, 1980, 1987) represent more than one psychopathological dimension. Kendler, Gruenberg, and Tsuang (1983) proposed that the DSM-III criteria for schizotypal personality disorder were divisible into "negative schizotypal symptoms," which would include social isolation and suspiciousness; and "positive schizotypal symptoms," which would include magical thinking and illusions. Siever and Gunderson (1983) proposed a related schema, dividing DSM-III schizotypal symptoms into "cognitive–perceptual" and "social–interpersonal." Although neither of these two schemes, nor the schizotypal criterion for DSM-III or DSM-III-R, includes symptoms that parallel our "nonconformity" factor, there is a strong similarity between our "positive trait schizotypy" factor and "positive schizotypal symptoms" and "cognitive–perceptual" symptoms, and between our "social schizotypy" factor and "negative schizotypal" or "social–interpersonal" symptoms. It is also of interest to compare our results with studies that have examined the power of the individual schizotypal symptoms and signs to discriminate individuals with schizotypal personality disorder from other patient groups (Jacobsberg, Hymowitz, Barasch, & Frances, 1986; Widiger, Frances, & Trull, 1987). These studies, which found that both "positive" and "negative" schizotypal features were important for identifying individuals with schizotypal personality disorder in a clinical setting, suggest that current criteria for schizotypal personality disorder tend to identify individuals with high levels of *both* "positive trait" and "social" schizotypy.

SCHIZOTYPY, NORMAL PERSONALITY VARIATION, AND SYMPTOMS OF ANXIETY AND DEPRESSION

We next sought to examine the relationship between the dimensions of self-report schizotypy and the "normative" personality dimensions of neuroticism and extraversion. Consistent with the prediction of previous personality theorists (e.g., Cloninger, 1986), we found a "positive trait schizotypy" factor that was clearly separable from the dimensions of neuroticism and extraversion. In fact, extraversion had very low correlations with all of the "positive trait" schizotypy scales, and an oblique rotation revealed that the "positive trait" and "extraversion" factors were nearly uncorrelated in the general population. By contrast, extraversion was closely related to the concept of "social schizotypy."

The separation between neuroticism and "positive trait schizotypy," by contrast, was less clear. Paranoid ideation loaded most highly on the same factor as neuroticism. The correlation between neuroticism and every putative schizotypy scale (except physical anhedonia) exceeded +0.30. An oblique factor rotation produced very similar "positive trait schizotypy" and "neuroticism–paranoid ideation" factors that were substantially corre-

lated with one another (i.e., +0.47). Although "positive trait schizotypy" and neuroticism are clearly separable, they are, in the general population, significantly intercorrelated.

Two previous studies have examined, in student populations, the relationship between Eysenck's personality dimensions and schizotypal traits (Bentall et al., 1989; Muntaner et al., 1988). Both studies found that extraversion had a substantial negative correlation with social anhedonia and an expected high negative loading on what we would term the "social schizotypy" factor. Similar to our own results, both studies also found correlations between neuroticism and Chapman's magical thinking and perceptual aberration scales of around +0.35, and substantially higher correlations between neuroticism and Claridge's schizotypy scales. However, in their factor analyses, Mutaner et al. (1988) found the neuroticism loaded heavily on their first, or "positive trait schizotypy," factor, whereas Bentall et al. (1989) found it to load primarily on a second factor related to putative MMPI indices of schizotypy.

Our third goal was to clarify the relationship between self-report measures of schizotypy and symptoms of anxiety and depression. On factor analysis, the two symptom measures loading together on a "psychiatric distress" factor that was clearly separate from the dimensions of "positive trait schizotypy," "nonconformity," and "social schizotypy." However, an oblique rotation produced nearly identical factors with a substantial correlation between "positive trait schizotypy" and "psychiatric distress," and considerably lower correlations between "psychiatric distress" and "nonconformity" and "social schizotypy."

Our fourth and final goal was to explore, using the twin method, the causes of interindividual variation in our self-report measures of schizotypy. We began by looking at the 10 individual scales. Consistent with the two previous twin studies of self-report schizotypy (Claridge and Hewitt, 1987, Kendler et al., 1987a), we found a substantial role for genetic factors in many of our scales. An interesting pattern emerged from the results of the twin model fitting. For the scales making up the "nonconformity" and "social schizotypy" factors, twin resemblance appeared to be due solely to genetic factors, and estimates of heritability were usually substantial (e.g., >0.35). By contrast, the 5 scales making up the "positive trait schizotypy" factor was divisible into two groups. For the two magical ideation scales and the Launey–Slade Hallucination scale, twin resemblance was due entirely to genetic factors with high heritability estimates (i.e., >0.45). By contrast, in the two perceptual aberration scales, twin resemblance appeared to result entirely from shared environmental factors. Although these 5 scales consistently loaded together in the factor analyses, these result suggest that the etiologic factors may meaningfully differ between the perceptual aberration and other scales in the "positive trait schizotypy" factor.

When models were fit to the factor scores rather than the individual scales scores, the results were somewhat more homogeneous. No evidence was found for common environment and estimates of heritability were between 0.50 and 0.70.

In accord with the previous literature, this study suggests that, in nonclinical populations, genetic factors significantly influence levels of self-report schizotypy. Our results cannot directly address the question of how

the genetic factors responsible for variation in self-report schizotypy in the general population are related to genetic factors that influence the liability to schizophrenia or other major psychiatric disorders. Limited evidence from clinical studies suggests that the deviant but nonpsychotic relatives of schizophrenics are more often characterized by high levels of "social schizotypy" than by "positive trait schizotypy" or "impulsive nonconformity," but that they may be even better characterized by signs such as poor rapport, flat affect, and odd behavior (Kendler, 1985, Kendler, Gruenberg, & Tsuang, 1983; Siever & Gunderson, 1983). Further research will be needed to evaluate proposals that the criteria for schizotypal personality disorder be modified to maximally identify relatives of schizophrenic probands (Siever & Gunderson, 1983). We have argued elsewhere that the criteria chosen for schizotypal personality disorder will, in large part, reflect the construct of the syndrome, which may be viewed from either a "clinical" or "familial" perspective (Kendler, 1985). This report makes clear that future investigators wishing to address this question would be well advised to utilize several measures of schizotypy that reflect, at least, the different factors here identified.

LIMITATIONS

The results presented here should be interpreted in light of several potentially significant methodologic limitations. First, in our statistical analyses, we treated results from both members of a twin pair as independent observations. This approach will not bias observed correlations or the factor analyses that are based thereon. However, depending on the degree to which the twins are correlated for the traits in question, it will result in an overestimation of the true degrees of freedom and hence an underestimation of the probability of a type I error for our regression analyses. Because a substantial proportion of our sample were DZ twins, where trait correlations were quite modest, our underestimation of type I error rates were, for most comparisons, probably small.

Second, our results are based entirely on self-report measures whereas the evidence for a genetic relationship between schizotypy and schizophrenia is based on studies using clinical interviews. In fact, Claridge, Robinson, and Birchall (1983) found that relatives of schizophrenics scored significantly *lower* on his self-report schizotypy scale than did relatives of neurotic patients. More recently, Lenzenweger and Loranger (1989) have found that the risk for schizophrenia in relatives is significantly related to the subject's self-report levels of perceptual aberration. Furthermore, we found very high correlations between "positive symptom schizotypy," as rated on clinical interview, and "positive trait schizotypy," as assessed by self-report questionnaire (Kendler et al., 1991). However, results of this report reflect only self-report "paper-and-pencil" measures of schizotypy, and may or may not apply to schizotypy as assessed by personal interview.

Third, for the purposes of model fitting, the sample sizes of twins included in this report were quite small. Power analyses of the twin method (Martin, Eaves, Kearsey, & Davies, 1978) suggest that with this sample, we have very little power to detect moderate common environmental effects given the presence of significant genetic effects. Our inability to detect

common environmental effects for most of our scales should only be taken as evidence that, for those scales, a very large common environmental effect is unlikely. Our small sample size also made it impossible to explore sex-dependent genetic models with any statistical power. Given the evidence that males tend to have higher levels of self-report schizotypy, it would be of considerable interest to determine whether the genetic or environmental factors influencing schizotypy were the same across genders. Preliminary analyses do not support a major difference in the genes influencing "positive trait" and "social" schizotypy in males and females but do suggest a possible sex-dependent genetic effect for "nonconformity." The heritability estimates for nonconformity may be inflated by combining same- and opposite-sex DZ pairs in a single analysis.

Fourth, we used shortened versions of several of the schizotypy scales. The reduction in reliability that usually accompanies scale reduction should attentuate heritability estimates. Thus, the evidence for genetic influences on many of the scales might have been even larger had the entire original scale been used.

Finally, a full understanding of the interrelationship between our three schizotypal factors would require a genetic multivariate analysis in which the covariation between these factors was "decomposed" into its genetic and environmental components (Kendler, Heath, Martin, & Eaves, 1987b). However, our current sample size is insufficient to meaningfully permit such an analysis. To detect more subtle common environmental effects, to analyze possible sex-dependent genetic models, and to perform a more definitive multivariate genetic analysis, a larger twin sample will be required.

CONCLUSIONS

Schizotypy as assessed by a series of self-report instruments is not a unidimensional concept. One dimension, "positive trait schizotypy," taps the tendency to have "psychotic-like" or "unusual" ideas and/or perceptions. A second, termed "nonconformity," reflects the tendency to have unconventional or asocial beliefs and impulsive personality traits. A third dimension, "social schizotypy," reflects the inability to find pleasure in human companionship and the tendency to be suspicious of others. The first two dimensions appear to be separable from the major personality dimensions of neuroticism and extraversion, although most putative schizotypy scales have at least moderate correlations with neuroticism. "Social schizotypy," by contrast, is closely related to the personality dimension of extraversion. All three dimensions are separable from self-report symptoms of anxiety and depression.

Genetic factors appear important for all individual scales except perceptual aberration. Genetic analysis of the 3 factors revealed important genetic influences for all of them and no evidence for an effect of common or familial environment. Further research is needed to determine whether the genetic factors that influence one or more of these schizotypy factors are closely related to the genetic liability to schizophrenia and/or other major psychiatric disorders. Finally, these results support previous hypotheses

that current criteria for schizotypal personality disorder contain items from several separable personality dimensions.

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