

## Parental treatment and the equal environment assumption in twin studies of psychiatric illness

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**SYNOPSIS** The validity of the twin method depends on the equal environment assumption (EEA) – that monozygotic (MZ) and dizygotic (DZ) twins are equally correlated in their exposure to environmental factors of aetiological importance for the trait under study. Parents may treat MZ twins more similarly than DZ twins thereby potentially violating the EEA. We tested this hypothesis for four common psychiatric disorders (major depression, generalized anxiety disorder, phobia, and alcoholism) in a population-based sample of female–female twin pairs where analyses indicate sufficient statistical power meaningfully to test the EEA. Mother's and father's beliefs about their twins' zygosity disagreed with assigned zygosity in approximately 20% of cases, often because of what they were told about their twins' zygosity at their birth. By structural equation model-fitting, we found no evidence that mother's or father's perceived zygosity influenced twin resemblance for any of the disorders. Compared to parents of DZ twins, parents of MZ twins were more likely to report that, in rearing their twins, they emphasized their similarities more than their differences. However, by model-fitting, mothers' and fathers' approach to raising twins had no significant influence on twin resemblance for the four examined psychiatric disorders. These results suggest that the differential treatment of MZ and DZ twins by their parents is unlikely to represent a significant bias in twin studies of these major psychiatric disorders.

### INTRODUCTION

Although first proposed over a hundred years ago (Galton, 1875) and in wide use for over 50 years, the twin method in medical and psychiatric disorders continues to have both its advocates (Kendler, 1983; Hrubec & Robinette, 1984) and detractors (Price, 1950; Kempthorne & Osborne, 1961). Much of the debate about the validity of the traditional twin method, as well as the more recent biometrical models for twin analysis (Neale & Cardon, 1992), has focused on the equal environment assumption (EEA) – that monozygotic (MZ) and dizygotic (DZ) twins are equally correlated for their exposure to environmental influences that are of aetiological importance for the disorder being studied. The EEA is crucial because if incorrect, the excess resemblance of MZ *versus* DZ twins, which is

attributed in the twin method to genetic factors, may be due in part to environmental effects.

Parents of MZ twins may treat their twin offspring more similarly than do parents of DZ twins (Scarr, 1968; Loehlin & Nichols, 1976). If this is true, and if the type of parental treatment in childhood for which MZ twins are more highly correlated than DZ twins significantly influences the risk for adult psychopathology, then differential parental treatment of MZ and DZ twins would violate the EEA for psychiatric twin studies.

Three different approaches have been taken to evaluate empirically the problem of differential parental treatment as a potential bias in twin studies. Unfortunately, nearly all such studies have examined normative traits (e.g. intelligence and personality) rather than psychopathology.

The most direct approach is to observe the behaviour of the twins and their parents. In the only application of this method known to us,

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Lytton (Lytton, 1977) studied the interaction between  $2\frac{1}{2}$ -year-old twins and their parents, finding that parents treated MZ twins more similarly than DZ twins. However, when parental behaviour was divided into that which was parent initiated *versus* parental behaviour in response to twin behaviour, all the excess resemblance in the parental treatment of MZ *v.* DZ twins was attributable to parental behaviour which was in response to twin behaviour.

A more indirect method to evaluate possible biases in twin studies due to differential parental treatment was proposed by Scarr (Scarr, 1968). This method assumes that parental behaviour toward twins is based in part on parental beliefs about zygosity. Parents who think that their twins are MZ will, it is assumed, tend to treat them more similarly than parents who think that their twins are DZ. Fortunately, for this method, parents are rather often mistaken in their judgement about the zygosity of their twins. The method proposed by Scarr involves a comparison of trait similarity in twins as a function both of 'real' zygosity, as assessed by the investigators, and 'perceived' zygosity as reported by the parents. If parental treatment of twins is influenced by pre-conceptions about zygosity, and if such treatment influences trait similarity in the twins, then perceived zygosity should influence twin similarity. Studies using this method have examined traits such as intelligence, attitudes, hyperactivity and personality and have found little evidence that parental perceived zygosity influences twin resemblance (Scarr, 1968; Munsinger & Douglass, 1976; Matheny, 1979; Goodman & Stevenson, 1989).

The third method to evaluate the possible bias in twin studies due to differential parental treatment of MZ and DZ twins involves directly asking parents to rate their approach to rearing their twins. In particular, parents are asked whether, in rearing their twins, they tended to emphasize the twins' similarities or their differences. We are aware of only one study, done with academically talented late adolescent twins, that used this method (Loehlin & Nichols, 1976). Compared to parents of DZ twins, parents of MZ twins were much more likely to report that they tried to treat their twins 'exactly the same'. By contrast, parents of DZ twins were more likely than parents of MZ twins to report

that, in rearing their twins, 'we have tried to treat them differently'. However, the similarity of parental treatment did not systematically relate to twin similarity for cognitive abilities, personality or vocational interests (Loehlin & Nichols, 1976).

### The present report

In this report, we evaluate whether differential parental treatment of MZ *v.* DZ twins represents a significant bias for twin studies of adult psychopathology. In an epidemiological sample of adult female-female twin pairs and their parents, we evaluate this potential bias using two of the methods outlined above. First, we examine the relationship between perceived parental zygosity and twin resemblance for four major and relatively common psychiatric disorders in women: major depression, generalized anxiety disorder, phobia and alcoholism. Secondly, we examine whether the parental approach to rearing twins, as assessed at personal interview, significantly differed in parents of MZ *v.* DZ twins, and if so, whether this approach relates systematically to twin similarity for the major psychiatric disorders examined.

## METHOD

### Sample and diagnostic methods

As part of a longitudinal study of the genetic and environmental risk factors for common psychiatric disorders in women, we personally interviewed 2163 female twins from the population-based Virginia Twin Registry, where both members had previously returned mailed questionnaires (Kendler *et al.* 1992*a*; Walters *et al.* 1992; Kendler *et al.* 1993*a*). The refusal rate during the personal interview phase of this project was 8%. Eighty-nine per cent of the interviews were conducted face-to-face and 11% by phone.

When interviewing twins, we requested names and addresses of living biological parents, thereby identifying 1698 parents of the 1033 twin pairs where both members had been assessed. Attempts were then made to interview these parents, of whom 26 were deceased upon contact, 33 were judged by us or their children as too medically ill or demented to be interviewed, 5 were lost to follow-up and 2 turned out to be adoptive parents. Of the remaining 1632 available

parents, 1472 or 90.2% were successfully interviewed while 160 or 9.8% refused. Of those interviewed, 855 were mothers and 617 were fathers. Of the completed interviews, 92% were performed face-to-face while 8% were done on the telephone. The average age at evaluation of the 1472 parents was  $58.6 \pm 9.3$  years.

All interviews were conducted by individuals with Master's degrees in Social Work or at least 2 years clinical experience, who had undergone 80 h of initial training with subsequent follow-up training sessions. All interviews were conducted by individuals with no prior contact with another family member, so that in complete families (both twins and both parents), four different interviewers were required. This report focuses on complete twin pairs with known zygosity with interviewed mothers (853 pairs) or interviewed fathers (615 pairs).

The interview with the twins included, in modified form, sections of the Structured Clinical Interview for DSM-III-R (Spitzer *et al.* 1987) for major depression, generalized anxiety disorder and alcohol dependence. Phobias were assessed by an adaptation of the Phobic Disorders section of the Diagnostic Interview Schedule (DIS) Version III-A (Robins & Helzer, 1985), which in turn was based on the DSM-III criteria (American Psychiatric Association, 1980). The diagnoses of major depression and generalized anxiety disorder were based on a blind review by K.S.K. using DSM-III-R criteria (American Psychiatric Association, 1987), of the interview protocols. Phobia was defined as the presence of one of 17 specific fears which the respondent considered to be irrational and which, in the interviewer's judgement, produced objective behavioural interference with the respondent's life. To maximize our statistical power for the study of 'alcoholism', we included cases meeting either the criteria for alcohol dependence as defined by DSM-III-R (American Psychiatric Association, 1987) or 'problem drinking' in which the respondent admits to having had, or being considered by others as having, a significant 'drinking' problem not limited to single isolated incidents. A multiple threshold model indicates that in these data problem drinking reflects a milder disturbance on the same liability dimension that influences alcohol dependence (Kendler *et al.* 1992a). We have reanalysed the data using the

DSM-III-R definition of alcohol dependence, and the results do not differ qualitatively from those reported below. We also assessed bulimia nervosa in this sample (Kendler *et al.* 1991). However, because of its rarity and moderate heritability, power calculations indicated that our tests for the EEA with this disorder would have low power. Therefore, they are not reported here.

### Zygosity determination

All zygosity information from assessed twin pairs was reviewed by two experienced twin researchers blind to information about their psychiatric status. Information reviewed included responses to questions about physical similarity, frequency of confusion as children by parents, teachers and strangers, and whether, as children, the twin and her co-twin were as alike as 'two peas in a pod', or only of 'normal family likeness'. Furthermore, in over 80% of the pairs, photographs were available on both members. On the basis of this review, twin pairs were classified into five groups: definitely MZ, definitely DZ, probably MZ, probably DZ and zygosity uncertain. Disagreement between the two raters was resolved by consensus. We attempted to obtain blood samples from both members of the pairs in the final three categories and were successful in 119 of the 186 pairs so classified. Zygosity was determined by the examination of DNA polymorphisms, using eight highly informative probes, which, if all identical, produced a probability of monozygosity of 0.9997 (Spence *et al.* 1988). Final zygosity determination used blood samples where available and otherwise a definite or probable zygosity diagnosis. DNA methods validated our zygosity diagnosis in 87 of 105 (83%) twin pairs in the 'probable' category. DNA or previously obtained blood-group based zygosity diagnoses confirmed our assignment in 26 of 26 pairs in the 'definite' category. The error rate in zygosity assignment in the total sample is almost certainly less than 2%.

In our interview with the parents of the twins, we asked 'In your opinion, are your twin daughters definitely identical, probably identical, probably fraternal, definitely fraternal or not sure what kind of twin they are?'. For the purposes of the present analyses, we reduced this variable to three categories 'identical' (definite

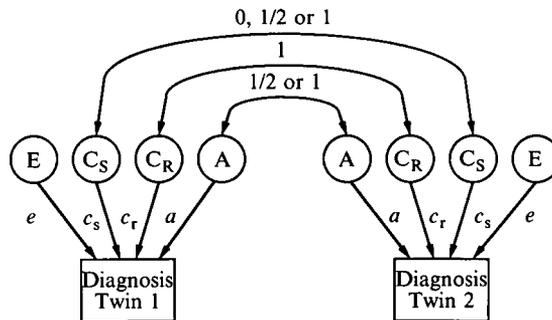


FIG. 1. A path diagram of the model used for analysing the impact of perceived zygosity and parental approach to rearing twins on twin resemblance for psychiatric disorders. Four sources of variation in liability to the disorder are considered: additive genetic effects (A), specified common or familial environment ( $C_S$ ), residual common environment ( $C_R$ ) and individual-specific environment (E). The path coefficients associated with these sources of variation are, respectively:  $a$ ,  $c_s$ ,  $c_r$  and  $e$ . Specified family environment here reflects the effects of 'perceived zygosity' – that parents of twins who think their twins are MZ will treat their twins more similarly than parents who think their twins are DZ – or 'parental approach to rearing twins' – how much parents in raising the twins tried to emphasize their similarities *v.* their differences. Residual common environment is, by definition, assumed to be perfectly correlated in all twin pairs. Additive genetic effects are perfectly correlated in MZ twins and correlated  $\frac{1}{2}$  in DZ twins. This diagram specifically models the effect of perceived zygosity where the correlation between the specified family environment of the twins is set at 0 if perceived by their parents to be DZ twins,  $\frac{1}{2}$  if the parents are unsure of the zygosity and 1.0 if the twins are perceived to be MZ twins. As outlined in the text, the model for analysing the parental approach to rearing twins only differs in that this correlation may take on five rather than three values.

+probable), 'don't know' and 'fraternal' (definite+probable). To understand more of how the parents formed their opinion about the zygosity of their twins, we also asked 'Did the doctor who delivered the twins tell you that the twins were identical or fraternal?'

Our interview with parents also contained the following question.

Next we're interested in learning how you approached raising twins. Some parents of twins like to emphasize the similarity of their twins by doing such things as dressing them alike. Other parents of twins like to stress their differences. Would you say you nearly always emphasized their similarity, usually emphasized their similarity, usually emphasized their differences or nearly always emphasized their differences?

A small number of parents responded that they equally emphasized their differences and similarities and so, in our analyses, responses to this item were divided into five classes: (i) nearly always emphasized similarity; (ii) usually emphasized similarity; (iii) equal; (iv) usually emphasized differences; and (v) nearly always emphasized differences.

### Reliability of measures

Inter-rater reliability of the diagnostic assessments was measured in 53 randomly chosen twins assessed at a single interview by two raters.

Chance corrected agreement ( $\kappa$ ) (Cohen, 1960) for the diagnoses used in this report was as follows: major depression ( $0.96 \pm 0.04$ ); generalized anxiety disorder ( $0.77 \pm 0.10$ ); phobia ( $0.73 \pm 0.10$ ); and alcoholism ( $1.00 \pm 0.05$ ). Reliability of the two measures obtained on parents was not directly assessed. However, we examined agreement in mothers and fathers in the 567 twin families where we succeeded in interviewing both parents. Since both perceived zygosity and parental approach to raising twins are treated as semi-continuous measures in our analyses, the most appropriate statistic with which to assess spouse agreement is the polychoric correlation. Perceived zygosity was highly correlated in spouses ( $r = 0.92 \pm 0.02$ ) while the correlation in parental rearing approach, while highly significant, was more modest:  $r = 0.51 \pm 0.04$ .

### Method of analysis

As outlined in Fig. 1, one of us (M.C.N.) has developed, using the software package Mx (Neale, 1991), a method of testing for the presence of violations of the EEA by including in the standard twin model a 'specified' form of familial environment. In this model, the psychiatric disorders under examination are assumed to result from an underlying multifactorial, normally distributed liability (Falconer, 1965). In such a model, the resemblance

in twin pairs for a disorder is expressed as a tetrachoric correlation (Pearson, 1901), or correlation of liability (Falconer, 1965). In the present study, the specified environment was indexed by perceived parental zygosity or the parental approach to rearing twins. On the hypothetical scale of perceived parental zygosity, we assigned twins considered by their parents to be identical a score of 1.0, pairs considered to be fraternal a score of 0 and pairs where the parent reported they did not know their zygosity as 0.50. The model for any given disorder was then fit directly, separately for each parent, to six  $2 \times 2$  contingency tables cross-classifying the affection status of twin 1 and twin 2, three each for MZ and DZ twins, each divided into pairs with a score of 0, 0.5 and 1 on our scale of specified familial environment.

The strategy for analysing our data on parental approach to rearing twins was similar except that the scale of specified family environment had five categories (with their assigned value): nearly always emphasized similarity (1.0); usually emphasized similarity (0.75); equal (0.50); usually emphasized differences (0.25); and nearly always emphasized differences (0.00). For these analyses, the model was fit to ten  $2 \times 2$  contingency tables, five each for MZ and DZ twins, each divided into pairs with a score of 0.0, 0.25, 0.5, 0.75 and 1.0 on the scale of specified family environment.

The full model for these analyses, as seen in Fig. 1, includes the standard estimates of A, additive genetic effects, and E or individual specific environment. In addition, estimates were available for the specified common or family environment ( $C_S$ ) (i.e. the effect of perceived parental zygosity or parental approach to rearing twins) and the remaining residual common environment ( $C_R$ ). The proportions of variance in liability due to these four sets of factors are termed  $a^2$ ,  $e^2$ ,  $c_s^2$  and  $c_r^2$ , respectively. For parent perceived zygosity, the model assumes that being considered MZ twins results in an excess twin similarity in liability by an amount equal to  $c_s^2$ . Being of uncertain zygosity contributes  $\frac{1}{2}c_s^2$  to twin similarity. The model assumes that being considered a DZ twin makes no additional contribution to twin similarity. Since we have previously demonstrated that additive genetic effects were prominent for all these disorders (Kendler *et al.* 1992*a, b, c, d*), we considered

two tests for the validity of the EEA: (i) the full or  $AC_S C_R E$  model *v.* the  $AC_R E$  model; and (ii) the  $AC_S E$  *v.* the AE model. The fit of these models was evaluated by Akaike's information criterion (AIC) (Akaike, 1987), which we calculate as  $\chi^2$  minus twice the degrees of freedom. The better the overall balance of goodness of fit and parsimony, the more negative is the AIC.

We performed power analyses to examine the utility of our test for the EEA. We assumed the value of  $a^2$  estimated for each disorder in the final model and further assumed that  $a^2 + e^2 = 0.80$ . We then estimated the power of our sample to reject, by a  $\chi^2$  difference test with 1 df at an alpha level of 0.05, the  $AC_R E$  model against the full or  $AC_S C_R E$  model for four combinations of values of  $c_s^2$  and  $c_r^2$ :  $c_s^2 = 0.05$  and  $c_r^2 = 0.15$ ,  $c_s^2 = c_r^2 = 0.10$ ,  $c_s^2 = 0.15$  and  $c_r^2 = 0.05$ , and  $c_s^2 = 0.20$  and  $c_r^2 = 0$ .

## RESULTS

In the 853 twin pairs with an interviewed mother, the mean ( $\pm$ ) s.d. of their age at interview was  $29.3 \pm 7.3$  years. In the 1706 twins from these pairs, the lifetime prevalence of the disorders considered here was: major depression, 30.3%; generalized anxiety disorder, 22.8%; phobia, 29.5%; and broadly defined 'alcoholism', 17.6%. Results were similar for the members of the 615 pairs with an interviewed father.

### Perceived zygosity *v.* true zygosity

The relationship between the zygosity assigned to the pair and zygosity as perceived by the mothers and fathers of the twin pair is seen in Table 1. In the 853 pairs of known zygosity where the mother was interviewed, the twin pair was correctly classified by the mother in 719 (84.2%) of them. The parallel figure in the 615 pairs with an interviewed father was 483 or 78.5%.

Errors in zygosity assignments by the parents were not symmetric. While 69 pairs that we classified as MZ were considered by their mothers to be DZ, only 10 pairs judged by us to be DZ were considered to be MZ by their mother. A similar pattern was seen with fathers.

Table 2 examines mothers who knew the zygosity of their twin offspring and recalled being told their zygosity at birth. The Table compares the mother's report of the zygosity

Table 1. Perceived zygosity in mothers ( $N = 853$ ) and fathers ( $N = 615$ ) versus assigned zygosity in female-female twin pairs

Assigned zygosity	Mother's perceived zygosity						Father's perceived zygosity					
	Identical		Fraternal		Don't know*		Identical		Fraternal		Don't know*	
	<i>N</i>	%	<i>N</i>	%	<i>N</i>	%	<i>N</i>	%	<i>N</i>	%	<i>N</i>	%
MZ	391	78.2	69	13.8	40	8.0	272	73.7	69	18.7	28	7.6
DZ	10	2.8	328	92.9	15	4.3	7	2.8	211	85.8	28	11.4

\* Includes a small number of missing values.

Table 2. Mothers' recall of zygosity of twins assigned by delivering physician as a function of their belief about the twins' zygosity and their true zygosity\*

	True/perceived zygosity							
	MZ/MZ <i>n</i> = 338		MZ/DZ <i>n</i> = 60		DZ/MZ <i>n</i> = 10		DZ/DZ <i>n</i> = 248	
	<i>N</i>	%	<i>N</i>	%	<i>N</i>	%	<i>N</i>	%
Told identical	316	93.5	7	11.7	9	90.0	37	14.9
Told fraternal	22	6.5	53	88.3	1	10.0	211	85.1

\* This Table excludes mothers who did not know the zygosity of their twins ( $N = 55$ ) and who stated they did not know or were not told the zygosity of their twins at birth ( $N = 142$ ).

assigned to the twins at birth, the mother's current belief about the zygosity of her twins, and the zygosity assigned by the project. In twins diagnosed by us as MZ, 93.5% of mothers who considered them as MZ recalled being told they were identical at birth compared to 11.7% of those who reported them as DZ ( $\chi^2 = 223.1$ ,  $df = 1$ ,  $P = 0.000$ ). In twins considered by us to be DZ, 90% of the mothers who reported them as MZ recalled being told they were identical at birth, compared to 14.9% of those who reported them as DZ ( $\chi^2 = 37.0$ ,  $df = 1$ ,  $P = 0.000$ ). Similar results are seen in fathers.

### Power analyses

Prior to model-fitting, we examined the power of our analyses to uncover violations of the EEA. Power was examined as a function of the proportion of variance in disease liability due to the specified family environment in mothers (either parental perceived zygosity or parental rearing). For perceived zygosity, we could detect, with 80% power, a violation of the EEA that accounted for 5% of the variance in liability to major depression or alcoholism, 15% of the variance in liability to generalized anxiety

disorder and 20% of the variance in liability to phobias (Table 3). Our analyses showed less power for examining the approach to rearing, 80% power being achieved when the special environment accounted for 5% of the variance for alcoholism and 15% of the variance for major depression. At 20% of the variance, the maximal value examined, we had only 68 and 57% power, respectively, to detect a special environment that influenced the liability to generalized anxiety disorder and to phobia, respectively. Parallel analyses were conducted in fathers with similar results, except that power was proportionally less due to smaller sample size.

### Model fitting with perceived zygosity

We then examined, by model-fitting, whether perceived zygosity of the mother or father influenced twin resemblance for major depression, generalized anxiety disorder, phobia, and broadly defined alcoholism. The results with mother's perceived zygosity are seen in Table 4. For all disorders, the fit of the  $AC_{RE}$  model, as assessed by the AIC, was superior to that of the full or  $AC_{SE}$  model. In fact, for all disorders,

Table 3. Power analyses of the test for the equal environment assumption (EEA) using parental perceived zygosity and parental approach to rearing as a function of the specific disorder and the proportion of variance in liability accounted for by the 'specified' common environment

Disorder	Power of perceived zygosity				Power of approach to rearing			
	5	% Variance			5	% Variance		
		10	15	20		10	15	20
Major depression	0.81	0.89	0.95	0.98	0.71	0.76	0.81	0.86
General anxiety disorder	0.59	0.72	0.83	0.90	0.49	0.54	0.61	0.68
Phobia	0.42	0.57	0.72	0.84	0.32	0.39	0.47	0.57
Alcoholism	0.98	0.99	0.99	0.99	0.95	0.96	0.96	0.97

\* Assuming a two-tailed test and  $P < 0.05$ .

Table 4. Model fitting results for perceived zygosity of mother as a form of specified family environment for major depression, generalized anxiety disorder, phobia, and alcoholism

Disorder	$\chi^2$ or AIC	Fit of the model in $\chi^2$ units				Parameter estimates of best-fit model by AIC	
		$AC_s C_R E$ df = 14	$AC_R E$ df = 15	$AC_s E$ df = 15	AE df = 16	$a^2$	$e^2$
		Major depression	$\chi^2$ AIC	16.97 -11.03	17.87 -12.14	16.99 -13.00	17.86* -14.14
Generalized anxiety disorder	$\chi^2$ AIC	13.26 -14.74	13.26 -16.74	13.26 -16.74	13.26* -18.74	0.39	0.62
Phobia	$\chi^2$ AIC	10.34 -17.61	10.34 -19.61	10.48 -19.52	10.48* -21.52	0.29	0.71
Alcoholism	$\chi^2$ AIC	13.56 -14.44	13.56 -16.44	13.87 -16.13	13.87* -18.13	0.63	0.37

\* Best fit model by AIC (Akaike, 1987).  
The models fitted imposed an equal threshold constraint, estimating a single threshold for all 6 tables.

Table 5. Model fitting results for perceived zygosity of father as a form of specified family environment for major depression, generalized anxiety disorder, phobia, and alcoholism

Disorder	$\chi^2$ or AIC	Fit of the model in $\chi^2$ units				Parameter estimates of best-fitting model by AIC	
		$AC_s C_R E$ df = 14	$AC_R E$ df = 15	$AC_s E$ df = 15	AE df = 16	$a^2$	$e^2$
		Major depression	$\chi^2$ AIC	21.06 -6.94	21.76 -8.24	21.69 -8.31	21.98* -10.02
Generalized anxiety disorder	$\chi^2$ AIC	25.38 -2.62	25.44 -4.56	25.38 -4.62	25.44* -6.56	0.39	0.61
Phobia	$\chi^2$ AIC	23.27 -4.73	23.92 -6.08	23.27 -6.73	23.27* -8.73	0.15	0.85
Alcoholism	$\chi^2$ AIC	15.64 -12.36	15.64 -14.36	16.28 -13.73	16.28* -15.73	0.61	0.39

\* Best fit model by AIC (Akaike, 1987).  
The models fitted imposed an equal threshold constraint, estimating a single threshold for all 6 tables.

the deterioration in fit with setting  $C_s$  to zero was less than one  $\chi^2$  unit. This pattern of results suggests that the specified common environment

( $C_s$ ), here indexed by maternal perceived zygosity, did not influence twin resemblance for the disorders examined. A similar pattern of

Table 6. *Mother and father's approach to rearing twins by the twins' assigned zygosity*

Response	Mother				Father*			
	MZ pairs N = 500		DZ pairs N = 353		MZ pairs N = 361		DZ pairs N = 241	
	N	%	N	%	N	%	N	%
Nearly always emphasized similarity	152	30.4	45	12.8	101	28.0	29	12.0
Usually emphasized similarity	150	30.0	87	24.7	126	34.9	56	23.2
Equally emphasized both†	10	2.0	10	2.8	16	4.4	18	7.5
Usually emphasized differences	132	26.4	120	34.0	73	20.2	83	34.4
Always emphasized differences	56	11.2	91	25.8	45	12.5	55	22.8

\* Response to item missing for 13 fathers.

† Not given as an option but volunteered as a response by a small number of parents.

Table 7. *Model fitting results for mother's approach to rearing twins as a form of specified family environment for major depression, generalized anxiety disorder, phobia, and alcoholism*

Disorder	$\chi^2$ or AIC	Fit of the model in $\chi^2$ units				Parameter estimates of best-fit model by AIC	
		AC <sub>s</sub> C <sub>r</sub> E df = 26	AC <sub>r</sub> E df = 27	AC <sub>s</sub> E df = 27	AE df = 28	a <sup>2</sup>	e <sup>2</sup>
Major depression	$\chi^2$	25.86	26.23	25.86	26.23*	0.45	0.55
	AIC	-26.14	-27.77	-28.14	-29.77		
Generalized anxiety disorder	$\chi^2$	49.84	49.84	49.84	49.84*	0.39	0.62
	AIC	-2.16	-4.16	-4.16	-6.16		
Phobia	$\chi^2$	36.79	38.47	38.48	38.48*	0.29	0.71
	AIC	-15.21	-15.53	-15.52	-17.52		
Alcoholism	$\chi^2$	31.56	31.56	31.88	31.88*	0.63	0.37
	AIC	-20.44	-22.44	-22.12	-24.12		

\* Best fit model by AIC (Akaike, 1987).

The models fitted imposed an equal threshold constraint, estimating a single threshold for all 10 tables.

results was obtained when comparing the fit of the AC<sub>s</sub>E model to that of the AE model. For all the disorders, the best fit by AIC was provided by the AE model. The result of model-fitting with father's perceived zygosity, given in Table 5, is similar to that found in mothers.

**Parental approach to the rearing of twins**

Parents varied widely in their reported approach to rearing twins (Table 6). Furthermore, there was a highly significant association between our zygosity assignment and the reported approach to raising twins in mothers (Wilcoxon Rank Sum test  $Z = 7.67, P = 0.0000$ ) and fathers (Wilcoxon Rank Sum test  $Z = 6.51, P = 0.0000$ ) (Table 6). Both parents were much more likely to report emphasizing similarities in MZ twins and differences in DZ twins.

A similar significant relationship was found

between parental perceived zygosity and their approach to raising twins. We investigated, by logistic regression, the relative importance of true *versus* perceived zygosity in predicting the parental approach to rearing twins. In mothers, perceived zygosity strongly predicted rearing approach ( $b = +0.88, \chi^2 = 12.52, df = 1, P = 0.0004$ ) while true zygosity did not ( $b = +0.23, \chi^2 = 0.78, df = 1, NS$ ). In fathers, both perceived zygosity ( $b = +0.61, \chi^2 = 5.23, df = 1, P = 0.02$ ) and true zygosity ( $b = +0.70, \chi^2 = 6.47, df = 1, P = 0.01$ ) significantly predicted rearing behaviour.

**Model fitting and parental rearing**

We then examined whether this substantial difference in parental treatment of MZ and DZ twins might represent a violation of the EEA for major psychiatric disorders. For mothers (Table

Table 8. Model fitting results for father's approach to rearing twins as a form of specified family environment for major depression, generalized anxiety disorder, phobia, and alcoholism

Disorder	$\chi^2$ or AIC	Fit of the model in $\chi^2$ units				Parameter estimates of best-fit model by AIC	
		AC <sub>S</sub> C <sub>R</sub> E df = 26	AC <sub>R</sub> E df = 27	AC <sub>S</sub> E df = 27	AE df = 28	a <sup>2</sup>	e <sup>2</sup>
Major depression	$\chi^2$	38.83	39.05	39.05	39.05*	0.42	0.58
	AIC	-13.18	-14.95	-14.95	-16.95		
Generalized anxiety disorder	$\chi^2$	43.06	43.06	43.06	43.06*	0.39	0.62
	AIC	-8.94	-10.94	-10.94	-12.94		
Phobia	$\chi^2$	26.65	26.67	26.67	26.67*	0.15	0.85
	AIC	-25.35	-27.33	-26.74	-29.33		
Alcoholism	$\chi^2$	44.75	44.75	45.38	45.38*	0.61	0.39
	AIC	-7.26	-9.26	-8.62	-10.62		

\* Best fit model by AIC (Akaike, 1987).

The models fitted imposed an equal threshold constraint, estimating a single threshold for all 10 tables.

7), the fit of the AC<sub>R</sub>E model, as indicated by the AIC, was superior to that of the AC<sub>S</sub>C<sub>R</sub>E model for all disorders. Similarly, the fit of the AE model was consistently superior to that of the AC<sub>S</sub>E model. The same pattern of results was obtained when examining the father's report on his approach to rearing twins (Table 8).

## DISCUSSION

The validity of twin studies, which are a major source of information about the role of genetic factors in the aetiology of psychiatric disorders, is dependent on the EEA. While a substantial literature evaluating the EEA has accumulated over the last two decades (Scarr, 1968; Munsinger & Douglass, 1976; Lytton, 1977; Matheny, 1979; Kendler, 1983; Goodman & Stevenson, 1989; Lykken *et al.* 1990; Morris-Yates *et al.* 1990; Rose *et al.* 1990), only a small number of studies have focused specifically on psychiatric disorders. In this report, we evaluate, for the first time to our knowledge, one major potential violation of the EEA in twin studies of psychiatric disorders: the parental rearing of twins.

### Perceived parental zygosity

First, we considered perceived zygosity by the parents as a 'proxy' for the parental approach to rearing twins. If parents who consider their twins as MZ feel they 'ought' to treat the twins particularly similarly, and such treatment influences twin similarity for psychiatric disorders,

then parental perceived zygosity should influence twin similarity for these disorders.

Because we assessed parental approach to the rearing of twins, we were able to test this hypothesis. For both mothers and fathers, perceived zygosity significantly predicted their approach to rearing. In accord with previous studies, we found that a substantial number of parents (in this study between 15 and 20%) were incorrect about the zygosity of their twin offspring (Scarr, 1968; Loehlin & Nichols, 1976; Munsinger & Douglass, 1976; Matheny, 1979; Scarr & Carter-Saltzman, 1979). Consistent with some (Lytton, 1977; Matheny, 1979), but not other reports (Scarr, 1968; Munsinger & Douglass, 1976), these disagreements were not symmetric in this sample; more MZ twins were considered to be DZ than vice-versa.

Exploring reasons for erroneous parental beliefs about zygosity, our results suggest that such beliefs often seem to stem from statements made by physicians at the time of the twins' birth. These errors probably arise from the wide-spread but incorrect belief that all twins with two placentas are DZ (they may be dichorionic MZ twins) and that all twins with one placenta are MZ twins (they may be DZ twins with fused placenta) (Cunningham *et al.* 1989).

Model fitting clearly showed no effect on twin resemblance for either mother's or father's perceived zygosity. For each disorder, the specified common environmental path that reflected the effect of mother's perceived zygosity

on twin resemblance for the disorder could be set to zero with little or no deterioration in fit of the model.

### Parental approach to rearing twins

We tested directly whether the reported parental approach to rearing twins influenced twin similarity for the psychiatric disorders examined. In accord with previous evidence both by self-report (Loehlin & Nichols, 1976) and direct observation (Lytton, 1977), parents of MZ twins and parents of DZ twins reported considerable differences in their approach to rearing twins. While parents of MZ twins tended to emphasize the similarity of their twins when rearing them, parents of DZ twins reported that they tended to emphasize their differences. For both mothers and fathers, controlling for true zygosity, this approach to rearing was influenced by beliefs about their twins' zygosity. The tendency for parents of MZ twins to treat their offspring more similarly than parents of DZ twins is, therefore, unlikely to result entirely from a greater similarity in behaviour as children of MZ *v.* DZ twins.

While these results may seem like *prima facie* evidence for rejecting the twin method, such a step would be premature. Differential parental treatment of MZ and DZ twins would invalidate twin studies of psychiatric disorders *only if* the type of parental treatment for which MZ twins were more similarly exposed than DZ twins influenced the risk for the psychiatric disorders under examination. In testing this key hypothesis, we found no evidence that twin similarity for psychiatric illness was influenced by their mother's or their father's approach to rearing twins. Attempting to treat twins similarly or differently appeared to be unrelated to the tendency for the twins to resemble one another for their risk for the major psychiatric disorders examined.

### Implications

Our findings are consistent with the hypothesis that the twin method applied to psychiatric disorders can provide useful and accurate assessments of the aetiological role of genetic and environmental factors. These results are also compatible with three further lines of evidence from this same twin sample. First, we obtained measures of the similarity of childhood en-

vironment in these twins (Loehlin & Nichols, 1976). While MZ twins reported considerably more similar childhood environments as assessed by these items (Kendler *et al.* 1991), we could find no consistent relationship between these measures of environmental similarity and similarity for clinically diagnosed major depression (Kendler *et al.* 1992*a*), phobia (Kendler *et al.* 1992*c*), generalized anxiety disorder (Kendler *et al.* 1992*d*), or alcoholism (Kendler *et al.* 1992*b*). Secondly, we also assessed in this twin sample the frequency with which the twins currently saw one another and found that, consistent with previous studies (Kendler *et al.* 1986, 1992*a*; Rose *et al.* 1990), as adults, MZ twins were in significantly more frequent contact with each other than were DZ twins. However, controlling for zygosity, we could find no consistent relationship between frequency of contact and similarity for any of the disorders examined (Kendler *et al.* 1992*a, c, d*) except alcoholism (Kendler *et al.* 1992*b*). However, for alcoholism, it is plausible that phenotypic similarity might influence frequency of contact, rather than the other way around (Lykken *et al.* 1990; Rose *et al.* 1990). Thirdly, using the same model as in this report, we recently found that the perceived zygosity of the twins themselves had no impact on the similarity of the twins for the psychiatric disorders examined (Kendler *et al.* 1993*b*).

While other studies evaluating the EEA for psychiatric symptoms or disorders have generally confirmed the validity of this hypothesis (Kendler, 1983; Kendler *et al.* 1986; Heath *et al.* 1989; Morris-Yates *et al.* 1990), this has not been a universal phenomenon (Clifford *et al.* 1984; Kaprio *et al.* 1990). Psychiatric twin researchers would be well advised to continue to test the EEA rather than to assume its validity.

### Limitations

The results of this report should be interpreted in the context of three potentially significant methodological limitations. First, because of the size of our sample and fiscal limitations, only a minority of our zygosity diagnoses were based on blood group or DNA polymorphisms. However, since our validation results suggested our error rate was very low (Kendler *et al.* 1992*a*), it is unlikely that our zygosity assignment substantially biased our evaluation of the EEA. To test this further, we repeated our model fitting

only in twins with biologically based zygosity diagnoses ( $N = 110$  for mothers and 80 for fathers). These results replicated our analyses on the complete sample with one exception: perceived zygosity by mothers and fathers appeared to influence twin resemblance for phobias. While this may be a substantive result, suggesting caution in the interpretation of twin studies of phobias, this conclusion is premature for the following three reasons. (i) An effect of parental belief about zygosity on twin resemblance would most likely be mediated by parental behaviour; however, no effect on twin resemblance for phobia was seen when parental behaviour was directly assessed in this subsample. (ii) We found no effect of the twin's belief about zygosity on resemblance for phobia (Kendler *et al.* 1993b). (iii) The number of twins in this subsample is quite small for structural equation modelling, reducing the stability of any solution. Two positive results out of 16 analyses could be the result of chance factors.

Secondly, the lifetime prevalence rates for several disorders in our sample were higher than in most previous population-based samples. While these issues have been discussed in detail elsewhere (Kendler *et al.* 1992a, c), our high rates are probably due to a combination of factors including the breadth of the DSM-III and DSM-III-R definitions used (American Psychiatric Association, 1980, 1987), the youth of our sample, the use of professional rather than lay interviewers, and specific statements in the interview used to augment memory for lifetime disorders.

Thirdly, the validity of the perceived zygosity of the parents or retrospective parental reporting of their approach to rearing their twins can be questioned (Robbins, 1963). Parental judgement about zygosity may reflect not their belief when the twins were being reared, but rather knowledge or attitudes more recently acquired. Parental recall of their approach to rearing the twins could be inaccurate and may, for example, reflect current parental perceptions about the similarity of their twins. Alternatively, parental recall of their treatment of the twins may be accurate, but the causal attribution may be incorrect. Rather than similar parental treatment making twins more alike, parental behaviour may be in response to the similarity of the twins' behaviour (Lytton, 1977). However, we present

evidence above which argues against this as a complete explanation of the observed findings. While perceived zygosity and the reported approach to rearing the twins were both substantially correlated in the mothers and fathers of the twins, these findings could be due to correlated biases. However, most such biases would be expected to augment rather than reduce the relationship between our measures of parental treatment and twin similarity for psychiatric illness.

This work was supported by grants MH-40828 from the United States National Institute of Mental Health and AA-09095 from the United States National Institute of Alcohol Abuse and Alcoholism. The Virginia Twin Registry, established and maintained by Drs W. Nance and L. Corey, is supported by the United States National Institutes of Health grants HD-26746 and NS-25630. Leroy Thacker assisted in the data analysis.

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