Assortative mating for major psychiatric diagnoses in two population-based samples


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ABSTRACT

Background. Previous studies on assortment for psychiatric disorders have reported discrepant findings. We aimed to test whether there is a significant association for psychiatric diagnoses, including alcoholism, generalized anxiety disorder, major depressive disorder, panic disorder and phobias between husbands and wives in two population-based samples. We further evaluated whether marital resemblance occurs primarily within or across psychiatric disorders and if assortment for psychopathology is primary or secondary to assortment for correlated variables.

Methods. A model for mate selection addressed whether the correlation between mates for psychiatric disorders arises from direct assortment (primary homogamy) or through correlation with other variables for which assortment occurs (secondary homogamy) or through cross-variable assortment. The model accounted for within-person co-morbidity as well as across-spouse data.

Results. Findings suggested that a moderate degree of assortment exists both within and across psychiatric diagnoses. Only a small amount of the observed marital resemblance for mental illness could be explained by assortment for correlated variables such as age, religious attendance and education. Similar results were obtained for the two samples separately and confirmed in their joint analysis, revealing that the co-morbidity and assortment findings, except for the marital correlation for age, religious attendance and education, replicate across samples.

Conclusions. Significant but moderate primary assortment exists for psychiatric disorders. The bias in twin studies that have ignored the small amount of assortment is negligible.

INTRODUCTION

A number of studies have found marital resemblance for psychiatric disorders. Although most earlier studies reported high husband–wife concordance for psychiatric illness, especially for affective disorders (Merikangas, 1982), recent findings have been less consistent. Some of these recent studies show no evidence for an increased risk of psychiatric disorders – primarily affective disorders – in spouses of psychiatric patients (Heun & Maier, 1993). Others have found increased risk of psychiatric disorders (Schuckit, 1982; Reich et al. 1987; Merikangas et al. 1988; Colombo et al. 1990, for affective disorder) (Hall et al. 1983a; Hill & Hruska, 1992, for alcoholism).

All these studies, except one (Hagnell & Krietman, 1974), were based on clinical samples. In most cases, information on the psychiatric status of the spouses was obtained by the family history method (FH). The FH method has some potentially important limitations: (i) ascertainment bias (Neale et al. 1994; Neale & Kendler, 1995); and (ii) rater bias (Heath et al. 1985; Neale & Stevenson, 1989; Kendler et al. 1991; Silberg et al. 1994). Two other potential biases related to clinical samples were recognized 50
years ago by Penrose (1944): (i) mental illness leading to admission to mental hospital of one partner may precipitate a dissimilar mental disorder which leads to admission of second partner; and (ii) if one partner comes to attention of medical or social authorities and is admitted to mental hospital, a pre-existing abnormality is more apt to be noticed in the other partner. Few studies on random samples exist that deal with assortative pairing and psychiatric disorders but they focus on conduct disorder (Quinton et al. 1993) and psychological distress (Galbaud du Fort et al. 1994).

The most cited explanation for marital resemblance for psychiatric disorders is assortative mating (Garrison et al. 1968). Assortative mating means that mated pairs are more similar for some phenotypic trait than would be expected by chance (Crow & Felsenstein, 1968). A significant correlation between spouses for a particular trait or an increase in disorder in spouses of patients compared to controls is often interpreted as assortative mating (Jacob et al. 1978; Baron et al. 1981; Hall et al. 1983a; Reich et al. 1987; Merikangas et al. 1988). Assortative mating is, however, not the sole explanation for correlation between mates. Other possibilities include: marital interaction; mate selection for correlated traits; or, geographic or social stratification.

Marital interaction refers to a process of mutual influence between spouses living together (Penrose, 1944). Two studies have attacked this problem indirectly by comparing the onset of psychiatric symptoms with onset of marriage (Merikangas & Spiker, 1982; Heun & Maier, 1993). Contagion as a special case of interaction occurs when illness of a partner is a direct consequence of the breakdown of the other.

Increased prevalence of psychiatric disorders in spouses of patients may occur if mate selection occurs on the basis of correlated variables such as personality characteristics, that in turn influence the risk for psychiatric illness (Gershon et al. 1973; Merikangas & Spiker, 1982). While there is little evidence for assortment for personality characteristics (Eaves et al. 1989) it is well documented for age, education, socio-economic status, religious attendance and intelligence (Heath et al. 1985; Phillips et al. 1988; Eaves et al. 1990; Gilger, 1991). If these demographic variables correlate with illness then association between spouses for illness will result. This is known as ‘secondary’ assortment (Crow & Felsenstein, 1968; Cloninger, 1980; Fulker, 1988; Phillips, 1989).

Psychiatric disorders do appear to correlate with some of these demographic variables. While all lifetime rates of illnesses are expected to increase with age – simply as a result of the extended period of time in which the disorder might have started, additional age trends can be noted for some disorders. Several studies have found that rates of depressive disorders increased among successive birth cohorts throughout the century and also indicated an earlier age of onset in the most recent birth cohorts (Lavori et al. 1993; Fombonne, 1994). Similar but less pronounced patterns are observed for alcoholism (Burke et al. 1991; Prescott et al. 1994). Associations between depression or alcoholism and educational level have been reported, usually in the direction of higher rates of psychiatric disorder for lower educational levels. Religious denomination and religiosity are important predictors of problem drinking or patterns of alcohol use (Hawks & Bahr, 1992). Rates of major depression and anxiety also vary among different religious affiliations (Meador et al. 1992). None of these correlated variables has been taken into account in previous treatments of concordance for psychiatric disorders in spouses. Marital resemblance for psychiatric diagnoses could be due to assortment for any of these variables.

Mate selection may also occur across as well as within variables, and may be asymmetric with respect to gender (Kessler et al. 1994). For example, there might be cross-assortment between alcoholism in husbands with depression in wives. The risk of manifesting other forms of the spectrum of affective disorder (e.g. alcoholism) differs between spouses of patients and spouses of controls (Dunner et al. 1976; Negri et al. 1981; Merikangas & Spiker, 1982; Schuckit, 1982). The possibility of cross-assortment between psychiatric disorders and of asymmetric assortment with respect to gender relates to the issue of co-morbidity. Reports on co-morbidity between two psychiatric diagnoses are abundant, with a majority on the depressive and anxiety disorders (Regier et al. 1990; Angst, 1993). Some gender differences in co-morbidity are at odds with the gender difference in prevalence of
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In order to correctly judge the importance of assortment and cross-assortment, knowledge of heterogeneity of co-morbidity across gender is required.

Several studies discuss assortative mating in the context of morbid risk for relatives. Increased psychopathology was observed among the relatives of ill spouses compared to those of well spouses for affective disorder (Merikangas & Spiker, 1982) and alcoholism (Hill & Hruska, 1992; Hall et al. 1983b). When ill relatives are sibs and parents, it suggests that assortment or social stratification rather than marital interaction is the source of husband–wife resemblance. Furthermore, offspring of parents concordant for psychiatric disorder are at significantly greater risk than offspring with only one parent affected (Merikangas et al. 1988). Thus, assortative mating may have important consequences for the transmission of disorders. Whether the elevation of risk for offspring occurs via genetic or cultural transmission is an open question.

If significant marital correlations exist for liability to psychiatric disorders, they should be taken into account when analysing data from twin and family studies, because their effects may be confounded with shared environmental factors (Fisher, 1918; Neale & Cardon, 1992). Given assortment and familial environmental influences both act to increase the variance and covariance between MZ and DZ twins equally, the estimates of genetic influences on liability will be biased without adjustment for significant levels of assortment.

In this paper we aim to address the following questions.

1 Is there a significant association for psychiatric disorders in husbands and wives?
2 Does marital resemblance occur primarily within or across psychiatric disorders?
3 Is any assortment for psychopathology primary or secondary to assortment for correlated variables such as age, religious attendance, or education?
4 Is marital resemblance equal for two population-based samples?
5 Does the degree of any marital resemblance differ according to duration of marriage?

In order to answer these questions, some preliminary issues need to be dealt with: does co-morbidity for psychiatric disorders differ between males and females and across samples; and are psychiatric disorders significantly associated with external variables?

These questions will be addressed with data from two population-based samples of spouses with mean ages of 40 and 60 years respectively. The availability of these two cohorts, differing in age, but studied with similar methods, allows us to test the generality of our findings across a broad section of the population.

METHOD

The Virginia Twin Study of Adolescent Behavioural Development (ABD)

Spousal pairs from the ABD consists of the biological parents of school-age twins. Of the 1442 families participating in this project, which is a representative sample of the Virginia population (Meyer et al. 1996; Hewitt et al. 1997), 1254 mothers and 911 fathers were interviewed. The mean age of the mothers is 39.95 (± 1.11) years; that of the fathers is 42.74 (± 0.90) years. The study assessed current marital status and years of cohabitation in the current marriage, religious attendance, and – in a subsample – education. Data are available on 854 complete spouse pairs, who have been living together for 15 (± 6.6) years.

The Virginia Twin Registry of Adult Female Twins (AFT)

A second population-based sample in Virginia represents 2163 adult females twins from the Virginia Twin Registry, born between 1934 and 1971, taking part in a study of genetic and environmental risk factors for common psychiatric disorders (Kendler et al. 1994). The biological parents of the female twins (855 mothers and 617 fathers) were personally interviewed blindly. Their mean ages were 58.15 (± 9.45) and 59.10 (± 8.95) respectively. Marital status, duration of current marriage, religious attendance, and education were collected. In this sample the duration of marriage is approximately 35 (± 8.5) years and spousal data are available for 568 pairs.

Diagnostic methods

Lifetime history of alcoholism, generalized anxiety disorder (GAD), major depression (MDD), panic disorder and phobias was...
diagnosed by means of an adapted version of the Structured Clinical Interview for DSM-III-R Diagnosis (Spitzer et al. 1987). For a diagnosis of GAD a minimum duration of 1 month was required to meet the criteria (Kendler et al. 1992a). For panic disorder, a broad definition was used, cases included both: (i) those with four attacks within a 4-week period and with symptoms developing and increasing in intensity within 10 min of the beginning of the first symptom; and (ii) those with two or three of the individual panic symptoms which reached peak intensity more gradually (Kendler et al. 1993a). Phobia was defined as the presence of at least one unreasonable fear that interfered with life from four possible types: social, animal, situational and agoraphobia (Kendler et al. 1992b). As these definitions were used for previous published genetic analyses, their use here is a logical choice.

Procedure and model development

The data were summarized as tetrachoric or polychoric correlations, using Prelis 2β (Jöreskog & Sörbom, 1988). This type of categorical data summary assumes an underlying normal distribution for each of the variables. The tetrachoric correlation between disorders is a measure of the degree of co-morbidity of these disorders. If two disorders appear together more often than expected based on chance, the tetrachoric correlation is significantly different from zero. To study assortment between several disorders at once, the matrix of spousal correlations needs to be decomposed into: (i) the matrix of correlations between disorders within husbands (RH); (ii) the matrix of correlations between disorders within wives (RW); and (iii) the matrix of correlations between the disorders of husbands and the disorders of wives (M). This latter matrix can be modelled with a delta path matrix (D matrix) (Pearson, 1902; Aitken, 1934; Cloninger, 1980; van Eerdewegh, 1982; Carey, 1986) and can be thought of as the direct assortment effects or ‘the correlations between husbands and wives after the correlation due to assortment for other, correlated variables has been partialled out’. The pattern of this matrix can inform us about the mechanisms of assortment. The different possibilities are illustrated in an example with two disorders, alcoholism and major depression. A • represents a significant correlation. If spouses both receive diagnoses of alcoholism more often than expected by chance, then the D matrix would look like Fig. 1. If people with the same disorder tend to marry each other (within-variable or direct assortment) then the D matrix would be as in Fig. 2. However, if male alcoholics tend to marry females with depression (cross-variable or heterotypic assortment), the pattern of significant correlations shown in Fig. 3 will be observed. If both within-variable and across-variable assortment exists at the same time the pattern will be as shown in Fig. 4.

In the discussion that follows both within-disorder and cross-disorder assortment are referred to as primary assortment. It is possible that the assortment process does not operate on the level of psychopathology but for a correlated variable (secondary assortment). For example, if people tend to marry people of a similar age and if age is significantly correlated with psychopathology, disorders of husbands and wives are...
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<table>
<thead>
<tr>
<th>Husbands/wives</th>
<th>Alc</th>
<th>MDD</th>
<th>Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alc</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MDD</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Fig. 5. D matrix if people tend to marry people of a similar age and if age is significantly correlated with psychopathology disorders.

correlated. The corresponding D matrix would be as in Fig. 5.

Fig. 6 offers a graphical representation of this model for the variables analysed in this paper. The correlations between five psychiatric disorders within husbands and wives are estimated respectively in matrices RH and RW. The delta path matrix D of direct assortment effects is estimated (D is free, full model) from the matrix of marital correlations M by ‘correcting’ it for the correlations between disorders in husbands and in wives.

The pattern of the D matrix indicates which variables are directly involved in mate selection. For example, if marital assortment occurs on a trait by trait basis, e.g. alcoholics marry alcoholics, men with GAD marry women with GAD etc., only the diagonal elements of the D matrix will be significant (model I). If, however, assortment occurs across traits, e.g. men with alcoholism tend to marry women with major depression, the off-diagonal element in the D matrix is different from zero, but the diagonal elements are zero (model II). When men with a psychiatric disorder tend not to marry other psychiatric women more than expected by chance, the elements of the D matrix will be insignificantly different from zero (model III). On the other hand, if marital resemblance were solely due to a correlated variable, such as educational level, then all the elements in the D matrix will be zero, except for the correlations with, and the direct assortment for, this correlated variable. This would suggest that the spousal correlations for psychiatric disorders result solely from the assortment for such a secondary variable, the correlations between this variable and psychiatric disorders and the correlations between psychiatric disorders within husbands or within wives.

Separate analyses were done with age and religious attendance (model IV), and with age and education (model V), because of the large difference in sample size for education. Information on educational level was only gathered in the second wave of interviewing of the ABD (N = 517). In models IV and V, the block

Fig. 6. Model for assortment of five psychiatric disorders. Assortment is modelled both disorder-specific and across disorders. RH is the covariance matrix for husbands, RW is the covariance matrix for wives, D is the delta path matrix of direct assortment effects.
in the D matrix that reflects the associations within and across psychiatric diagnoses is fixed to zero to test whether the assortment for psychiatric diagnoses could be attributed to secondary assortment for age and either religious attendance or education. The other parameters— the marital assortment for and the correlations between these external variables and the psychiatric diagnoses— were estimated. This model has the same degrees of freedom as model III for primary assortment. If assortment for psychiatric diagnoses is secondary to the external variables, the $\chi^2$ difference on moving to models IV or V should be non-significant.

Each of these hypotheses may be evaluated by comparing the increase in $\chi^2$ to the increase in the degrees of freedom. The analyses were done on both samples separately and then a joint analysis was conducted to test whether direct or indirect assortment for psychiatric diagnoses was equal for the two samples. All models were run using the statistical modelling package Mx (Neale, 1997).

RESULTS

Prevalence rates for psychiatric disorders

Prevalence rates for lifetime major psychiatric disorders are shown for the two samples in Table 1. These rates are generally higher for the AFT sample than for the ABD, rates in wives agree with those published by Kendler et al. 1992a, b, c, d, 1993a) for adult female twins. Comparing the two samples, prevalence rates are significantly higher in the younger ABD sample for GAD and MDD for both husbands and wives and significantly lower for phobias (especially social phobia) in wives of ABD twins compared with wives of AFT twins. Table 1 also presents the prevalence rates of husbands and wives given that their wives and husbands respectively are also affected with the same psychiatric disorder. For all disorders, except for GAD in the AFT sample, rates increase when spouses are affected as well.

The rates presented above are based on the biological parents that have their spouse interviewed as well, because this sample will be used for the further analyses of marital resemblance. This sample may not be representative of the total population. We, therefore, looked at the lifetime prevalence rates for the husbands and wives whose partner was not interviewed. For the ABD sample, the single interviewed subjects showed markedly higher rates for all major psychiatric disorders. This increased psychopathology may reflect the causes or consequences of divorce which is ten times more frequent in this subsample (28.1% versus 3.5% for husbands, 40.3% versus 3.6% for wives). No such differences in prevalence rates were observed for the AFT sample, except for MDD in wives. This is consistent with the low divorce rate in this sample, although there still is a threefold increase of divorce in wives (6.9% versus 4.3% in husbands 22.6% versus 7.6% in wives).

Co-morbidity between psychiatric diagnoses

All the within-person correlations between the five major psychiatric diagnoses were significantly different from zero in both the ABD and the AFT sample (Table 2). There is a highly significant within-person correlation between GAD and MDD for husbands (0.576 for the ABD sample, 0.640 for the AFT sample) and wives (0.582 for the ABD sample, 0.709 for the AFT sample). Most of the other within-person cross-pathology correlations vary between 0.15 and 0.45. While the polychoric correlations between GAD, MDD and panic disorder are higher for the AFT sample than for the ABD,
the opposite is true for the correlations between alcoholism and any other psychiatric diagnoses for both wives and husbands.

Heterogeneity of co-morbidity for psychiatric diagnoses

The correlation matrix of major psychiatric diagnoses of the ABD husbands is not significantly different from that of the AFT husbands ($\chi^2_{10} = 6.943, P = 0.731$). Similarly, constraining the correlation matrix for the ABD wives to that of the AFT wives does not result in a significantly poorer fit ($\chi^2_{10} = 14.885, P = 0.136$). Within each sample, no difference is found between the correlation matrices of five major psychiatric diagnoses of husbands and wives ($\chi^2_{10} = 7.584, P = 0.669$ for the ABD sample, $\chi^2_{10} = 10.443, P = 0.403$ for the AFT sample). Therefore, there is no evidence for heterogeneity of co-morbidity for major psychiatric diagnoses according to gender or sample.

Marital correlations for psychiatric diagnoses and correlates

Significant associations between spouses are observed for each of the five major psychiatric diagnoses, except phobias, for the ABD sample as shown in the correlation matrix in Table 3. Correlations across disorders range between 0.00 to 0.20 across spouses. The highest correlations are between alcoholism in husbands and GAD in wives, and between MDD in husbands and all other diagnoses in wives. For the AFT sample, within-disorder assortment correlations for diagnoses are generally lower and are

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Table 2. Within-person correlations for major psychiatric disorders in parents of ABD and AFT twins

<table>
<thead>
<tr>
<th></th>
<th>Alcoholism</th>
<th>GAD</th>
<th>MDD</th>
<th>Panic</th>
<th>Phobias</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABD</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alcoholism</td>
<td>0.399***</td>
<td>0.341***</td>
<td>0.276***</td>
<td>0.284***</td>
<td></td>
</tr>
<tr>
<td>GAD</td>
<td>0.295***</td>
<td>0.582***</td>
<td>0.372***</td>
<td>0.394***</td>
<td></td>
</tr>
<tr>
<td>MDD</td>
<td>0.341***</td>
<td>0.576***</td>
<td>0.310***</td>
<td>0.304***</td>
<td></td>
</tr>
<tr>
<td>Panic</td>
<td>0.283***</td>
<td>0.314***</td>
<td>0.396***</td>
<td>0.371***</td>
<td></td>
</tr>
<tr>
<td>Phobias</td>
<td>0.249***</td>
<td>0.220***</td>
<td>0.181***</td>
<td>0.276***</td>
<td></td>
</tr>
<tr>
<td>AFT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alcoholism</td>
<td>0.378***</td>
<td>0.313***</td>
<td>0.076*</td>
<td>0.095*</td>
<td></td>
</tr>
<tr>
<td>GAD</td>
<td>0.125***</td>
<td>0.709***</td>
<td>0.471***</td>
<td>0.228***</td>
<td></td>
</tr>
<tr>
<td>MDD</td>
<td>0.185***</td>
<td>0.640***</td>
<td>0.367***</td>
<td>0.227***</td>
<td></td>
</tr>
<tr>
<td>Panic</td>
<td>0.267***</td>
<td>0.483***</td>
<td>0.467***</td>
<td>0.516***</td>
<td></td>
</tr>
<tr>
<td>Phobias</td>
<td>0.194***</td>
<td>0.312***</td>
<td>0.149***</td>
<td>0.344***</td>
<td></td>
</tr>
</tbody>
</table>

Within-father correlations below the diagonal, within-mother correlations above the diagonal: * $P \leq 0.05$; ** $P \leq 0.001$.

Table 3. Observed marital correlations between major psychiatric disorders in parents of ABD and AFT twins

<table>
<thead>
<tr>
<th></th>
<th>Alcoholism</th>
<th>GAD</th>
<th>MDD</th>
<th>Panic</th>
<th>Phobias</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABD</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alcoholism</td>
<td>0.119***</td>
<td>0.064</td>
<td>0.190***</td>
<td>0.029</td>
<td>0.005</td>
</tr>
<tr>
<td>GAD</td>
<td>0.209***</td>
<td>0.208***</td>
<td>0.207***</td>
<td>0.119***</td>
<td>0.133***</td>
</tr>
<tr>
<td>MDD</td>
<td>0.132***</td>
<td>0.088*</td>
<td>0.162***</td>
<td>0.117***</td>
<td>0.109***</td>
</tr>
<tr>
<td>Panic</td>
<td>0.064</td>
<td>0.092*</td>
<td>0.151***</td>
<td>0.219***</td>
<td>0.102*</td>
</tr>
<tr>
<td>Phobias</td>
<td>-0.079***</td>
<td>0.130***</td>
<td>0.221***</td>
<td>-0.016</td>
<td>0.064</td>
</tr>
<tr>
<td>AFT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alcoholism</td>
<td>0.068</td>
<td>0.213***</td>
<td>0.267***</td>
<td>-0.047</td>
<td>-0.078</td>
</tr>
<tr>
<td>GAD</td>
<td>0.107*</td>
<td>-0.014</td>
<td>0.169***</td>
<td>0.116*</td>
<td>-0.006</td>
</tr>
<tr>
<td>MDD</td>
<td>0.251***</td>
<td>0.014</td>
<td>0.121*</td>
<td>-0.190***</td>
<td>0.074</td>
</tr>
<tr>
<td>Panic</td>
<td>0.002</td>
<td>0.114*</td>
<td>0.015</td>
<td>0.138***</td>
<td>0.062</td>
</tr>
<tr>
<td>Phobias</td>
<td>0.003</td>
<td>0.140***</td>
<td>0.033</td>
<td>0.028</td>
<td>0.071</td>
</tr>
</tbody>
</table>

Husbands diagnoses on columns, wives diagnoses on rows: * $P \leq 0.05$; ** $P \leq 0.001$. 

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significant only for MDD and panic disorder. Some cross-disorder correlations are higher than within-disorder correlations, particularly between alcoholism in husbands and MDD in wives, and between alcoholism in wives and both GAD and MDD in husbands.

In agreement with previous studies, highly significant marital correlations are found in both the ABD and AFT samples for age (0.748 versus 0.930), religious attendance (0.739 versus 0.655), and educational level (0.578 versus 0.557) respectively.

Correlations between psychiatric disorders and correlates

Table 4 presents the correlations between psychiatric diagnoses and sociodemographic variables. There are low but significant negative correlations between age and most psychiatric diagnoses within spouses in both samples. Significant associations are found between disorders and religious attendance. Alcoholics and those diagnosed with phobias and panic disorder attend church services less often than non-alcoholics and non-phobics. Correlations between religious attendance and MDD are also negative and significant for husbands in the ABD sample and for wives in the AFT sample. Educational level is found to correlate negatively with alcoholism and MDD in the ABD sample but these correlations were non-significant or positive in the AFT sample. Lower educational level was moderately associated with panic disorder and phobias. Because of their significant associations with psychiatric disorders, age, religious attendance and education will be considered as correlates in the modelling of assortment for psychiatric diagnoses.

Primary assortment for major psychiatric diagnoses

Since the heterogeneity test for the two samples did not reveal significant differences, except for model II, only results of the joint analysis are presented in Table 5. The full model (0) fixing all within- and cross-assortment parameters to be equal across the two samples fitted the data well. All the cross-assortment parameters could be fixed to zero without significant loss of fit to the ABD data (I). Fixing only the within-variable assortment parameters to zero, but allowing for cross-variable assortment also resulted in a non-significant $\chi^2$ (II). Discarding both the within-disorder and cross-disorder assortment parameters resulted in a significant increase of the $\chi^2$ (III). This multivariate test suggests that there is evidence of assortment for psychiatric diagnoses based on two population-based samples. Because within-assortment and cross-assortment parameters are correlated, there is not enough power to resolve which is active.

Secondary assortment for major psychiatric diagnoses

Because some of the psychiatric diagnoses are significantly associated with age, religious attendance or education, and since significant marital correlations exist for these variables, the question is whether the resulting husband–wife correlations for psychiatric diagnoses can be entirely explained by these associations. First, the secondary assortment model was applied to psychiatric diagnoses, age and religious attendance (IV). The $\chi^2$ for this model is only slightly smaller than the $\chi^2$ for the primary assortment model (III) (120.439 versus 128.218) suggesting that assortment for age and religious attendance is only responsible for a small part of the assortment for psychiatric diagnoses. A similar model was fitted to the correlation matrices of the five psychiatric diagnoses, education and age. This model was compared with model III* on subset of the ABD sample. The $\chi^2$ between models V and III (114.632 versus 112.631) is almost identical. Assortment for education and age therefore does not explain assortment for psychiatric diagnoses. In summary, adding correlates to the model reduces the $\chi^2$ but the effect is small for age and religious attendance and non-existent for age and education. Thus, only a small amount of the assortment for psychiatric diagnoses could be attributed to secondary assortment for age, and religious attendance. This result holds for both population-based samples.

Marital interaction versus assortative mating

To explore whether marital interaction rather than assortative mating could explain the correlations between partners, we compared the age of onset of the psychiatric disorder with the age of marriage. If the first appearance of the mental illness precedes the marriage, there is little evidence for marital interaction. If, how-
ever, most people have first onset of disorders after marriage, marital interaction may explain husband–wife similarities, although assortment for pre-morbid characteristics is also plausible. The age of marriage is slightly higher in the younger ABD sample than the AFT sample. The percentage of the parents of ABD twins reporting onset of psychiatric disorder before marriage varies between 38.1% and 86.9% according to the diagnosis in question. While marital interaction seems unlikely to have influenced spouse similarity for alcoholism and phobias, it cannot be excluded as a cause of marital resemblance for GAD, MDD and panic disorder. On the other hand, in the AFT sample most reports of first onset postdate marriage, except for phobias. For the other four diagnoses, between 10.2% and 47.9% have age of onset before age of marriage.

It should be noted that the AFT sample is 20 years older on average and, therefore, the time during which onset might have occurred after marriage is much longer than in the younger sample. This is also reflected in the larger standard deviations of the ages of onset. Marital interaction might partly explain the marital resemblance for all diagnoses except for phobias. In addition to this exploratory analysis a logistic regression was performed with duration of marriage as independent variable and concordance for psychiatric illness in spouses as the dependent variables. For both samples, duration of marriage did not contribute independently to the concordance for any psychiatric disorder.

**DISCUSSION**

The primary goals of this report were to test whether there is marital resemblance for psychiatric disorders in two population-based samples and, if so, whether the assortment is mediated by other variables. Models for assortment were fitted to spousal data on psychiatric diagnoses and correlated variables. These models require estimation of within-

---

**Table 4. Polychoric correlations for major psychiatric disorders and correlates in parents of ABD and AFT twins**

<table>
<thead>
<tr>
<th></th>
<th>Father</th>
<th></th>
<th>Mother</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Age</td>
<td>Rel</td>
<td>Educ</td>
</tr>
<tr>
<td>ABD</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alcoholism</td>
<td>-0.110***</td>
<td>-0.114***</td>
<td>-0.338***</td>
</tr>
<tr>
<td>GAD</td>
<td>-0.075*</td>
<td>0.027</td>
<td>-0.070</td>
</tr>
<tr>
<td>MDD</td>
<td>-0.036*</td>
<td>-0.073*</td>
<td>-0.088*</td>
</tr>
<tr>
<td>Panic</td>
<td>-0.139***</td>
<td>-0.211***</td>
<td>-0.014</td>
</tr>
<tr>
<td>Phobias</td>
<td>-0.075***</td>
<td>-0.151***</td>
<td>-0.064</td>
</tr>
<tr>
<td>AFT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alcoholism</td>
<td>-0.073</td>
<td>-0.238***</td>
<td>-0.038</td>
</tr>
<tr>
<td>GAD</td>
<td>-0.128*</td>
<td>-0.045</td>
<td>-0.015</td>
</tr>
<tr>
<td>MDD</td>
<td>-0.168***</td>
<td>0.021</td>
<td>0.140*</td>
</tr>
<tr>
<td>Panic</td>
<td>-0.026</td>
<td>-0.169***</td>
<td>-0.087</td>
</tr>
<tr>
<td>Phobias</td>
<td>-0.094*</td>
<td>-0.183***</td>
<td>-0.089*</td>
</tr>
</tbody>
</table>

Rel, religious attendance; Educ, education. * $P < 0.05$; *** $P < 0.001$.

**Table 5. Model fitting results for comparison of assortment for major psychiatric diagnoses in parents of ABD twins and parents of AFT twins**

<table>
<thead>
<tr>
<th></th>
<th>Father</th>
<th></th>
<th>Mother</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\chi^2$</td>
<td>df</td>
<td>$P$</td>
</tr>
<tr>
<td>Alcoholism, GAD, MDD, panic, phobias</td>
<td>49.979</td>
<td>55</td>
<td>0.666</td>
</tr>
<tr>
<td>I</td>
<td>87.811</td>
<td>75</td>
<td>0.148</td>
</tr>
<tr>
<td>II</td>
<td>53.793</td>
<td>60</td>
<td>0.701</td>
</tr>
<tr>
<td>III</td>
<td>128.218</td>
<td>80</td>
<td>0.001</td>
</tr>
<tr>
<td>III*</td>
<td>112.631</td>
<td>80</td>
<td>0.010</td>
</tr>
<tr>
<td>Alcoholism, GAD, MDD, panic, phobias, age, religious attendance</td>
<td>120.439</td>
<td>80</td>
<td>0.002</td>
</tr>
<tr>
<td>IV</td>
<td>124.32</td>
<td>80</td>
<td>0.007</td>
</tr>
</tbody>
</table>

0, Equal assortment for two samples for diagnoses; I, no cross-assortment for diagnoses; II, no within-assortment for diagnoses; III, test for primary assortment for diagnoses; III*, test for primary assortment for diagnoses on the subsample with non-missing education data; IV, test for secondary assortment on religious attendance and age; and V, test for secondary assortment on education and age.
husband, within-wife and husband–wife correlations of psychiatric disorders and their correlates. We shall examine each of our main findings in turn.

First, in both samples we found significant associations between partners for most psychiatric diagnoses in the range of 0.05 to 0.22 in accord with previous findings (Hagnell & Krietman, 1974; Baron et al. 1981; Reich et al. 1987). We confirmed that highly significant husband–wife correlations exist for age, religious attendance and education in agreement with estimates based on other large studies (Heath et al. 1985; Eaves et al. 1990; Gilger, 1991). Also, significant associations were observed between psychiatric diagnoses and age, religious attendance and education in both samples, as was expected from previous studies (Hawks & Bahr, 1992; Meador et al. 1992).

Secondly, our results suggested that a moderate degree of marital resemblance exists between most psychiatric diagnoses. While not every correlation between disorders in wives and husbands was significant, the combined effects of within- and cross-assortment were significant for the major diagnoses in both samples.

Thirdly, when correlated variables such as age, religious attendance and education were included, it appeared that some of the observed marital resemblance for psychiatric disorders was a result of assortment for these correlated variables. For both samples, models including correlates almost always fitted the data slightly better than models including only psychiatric diagnoses. This is the first study to attribute some of the spousal associations to assortment for correlated variables. This illustrates that marital resemblance does not necessarily imply assortative mating for the measured variables directly; it can also be explained by assortment for correlated variables, or by marital interaction or contagion.

Fourthly, although some differences exist between the two samples, the results of the joint analysis of both samples suggest that most of the differences are not significant. Comparing cross-assortment versus within-assortment and primary versus secondary assortment further confirmed that some cross- and within-assortment exists for major psychiatric diagnoses and that only a small part of it can be partly explained by assortment for correlated variables.

Fifthly, we found no evidence for gender heterogeneity or sample differences in co-morbidity for psychiatric diagnoses. As far as we know, this stability of the the co-morbidity for several major psychiatric diagnoses has not been reported elsewhere. Only a few recent studies address gender differences in co-morbidity for psychiatric disorders (Kessler et al. 1994) but none formally tests for heterogeneity. Despite well documented cohort effects, especially for major depression (Burke et al. 1991; Lavori et al. 1993; Fombonne, 1994), changes in rates for individual disorders do not necessarily imply changes in the co-aggregation of these disorders within individuals.

Sixthly, marital interaction could not be excluded as cause of husband–wife similarities in the present samples, based on the percentage of individuals first diagnosed with a psychiatric disorder past the age of marriage. This was in particular the case for GAD, MDD and panic disorder, and more so in the AFT than in the ABD sample. These results are similar to previous studies on the rare coexistence of psychiatric diagnoses in partners before marriage (Merikangas & Spiker, 1982; Heun & Maier, 1993). Better resolution of marital interaction and assortative mating might be achieved with twin–spouse or longitudinal data (Heath, 1987).

Earlier reports on marital resemblance for psychiatric disorders were discrepant in their findings. Some showed evidence for an increased risk of psychiatric disorders in spouses of psychiatric patients (Baron et al. 1981; Merikangas & Spiker, 1982; Reich et al. 1987; Merikangas et al. 1988; Colombo et al. 1990, for affective disorder) (Rimmer & Winokur, 1972; Jacob et al. 1978; Hall et al. 1983a, for alcoholism), others did not (Negri et al. 1981; Heun & Maier, 1993). This study confirmed that husband–wife correlations for psychiatric disorder are significant, but small.

Two methodological aspects of this study strengthen this finding. First, both samples are much larger than those in previous – mostly clinical – studies which generally do not exceed 100 pairs because probands are selected through hospitalization. Secondly, in most earlier reports assessment was based on medical records or self-report questionnaire using widely variable diagnostic approaches. However, a trend towards
less evidence for assortative mating of psychiatric disorders in more recent studies is followed in the present study. Factors that may explain this trend include moving from clinical samples to population samples, and the use of personal interview and universally agreed diagnostic criteria.

The implications of a significant degree of assortment for fitting genetic models to twin data – to study genetic and environmental influences on psychiatric disorders – in which we commonly ignore assortment are twofold. If we fit a model with additive genetic and specific environmental causes of variation (an AE model; see Neale & Cardon, 1992), our estimate of the genetic variance ($h^2$) is biased upward. This bias however remains fairly small, and for a marital correlation of 0.2 amounts to up to 3%. Fitting the standard ACE model which includes common environmental effects ($c^2$) as another source of familial resemblance, bias is more substantial. For a marital correlation of 0.2, $c^2$ is estimated between 0.002 and 0.14 depending on the true value of $h^2$. Complementary to the upward bias of common environmental effects, there is a downward bias in the estimate of the additive genetic variance. Given the moderate estimates of heritability for psychiatric disorders (0.3 to 0.6) the bias in estimates reported to date is likely to be very small. With the levels of assortment found in this study we can thus be fairly confident about the results obtained from twin studies.

Although consequences of assortative mating are minimal with regard to results of psychiatric twin research, implications for clinical practice should not be ignored. Assortative mating increases the variance for a trait leading to an increase in the prevalence for a trait with less than 50% prevalence in the population (Vanyukov et al. 1996). Likewise assortative mating could elevate co-morbidity. However, the low levels of assortative mating found here suggest only a small impact on the prevalence, the co-morbidity and thus on the continuation of these disorders in future generations.

**Limitations**

The results of this study should be interpreted in the light of four possible limitations. First, although both samples are substantially large and population-based, the study of assortment necessarily confines the sample to married pairs who may not be representative of the population. As shown earlier, prevalence of psychiatric disorders are markedly higher in both men and women whose partner was not interviewed. This is consistent with increased psychopathology in divorced parents, as the rate of divorce in the parents without interviewed partner was very much higher. In addition, the couples in these studies were selected because they had produced and reared twins (at least to age 8). For most disorders, twins do not show higher prevalence rates than the parents (Table 1). The exception is alcoholism, where there is a significantly higher rate in the twins, so estimates of marital resemblance from samples that include non-reproducing couples might differ. For the purposes of examining the consequences of assortment for genetic variation, this limitation is not a problem because assortment in reproducing couples drives the process.

Secondly, our results should be interpreted in the context of the statistical power of the sample. Although we are dealing with two large population-based samples, the frequency of individuals diagnosed with a particular psychiatric disorder is still low. One of the consequences is that the polychoric correlations of these diagnoses are imprecise and should, therefore, be interpreted with caution. In addition, despite our large sample sizes, power was less than might be expected because: (i) second-order statistics (correlations) were used; and (ii) the standard errors of such statistics are known to be greater for categorical data than for continuous measures (Neale et al. 1994). Furthermore, the reliability of cross-sectional assessments of psychiatric diagnoses at one point in time is only moderate (Kendler et al. 1993b). Also, cross-sectional data do not allow us to distinguish the effects of marital interaction from assortative mating.

Thirdly, the present data cannot resolve whether mate selection has been determined by the phenotype or by the social background. We showed that assortment for psychiatric disorders is to a small degree secondary to assortment for correlated variables, but the question remains as to whether the positive marital correlation for age, education and religiosity arises from ‘phenotypic’ assortative mating (individuals prefer to marry or are more likely to encounter
each other because they have similar phenotypes) or from social homogamy (a tendency for individuals from similar social backgrounds to marry each other) (Heath & Eaves, 1985). These two mechanisms of mate selection have rather different genetic and social consequences (Vanyukov et al. 1996). Data on the spouses of twins or siblings are needed to answer this question.

Fourthly, it should be recognized that age, religious attendance and education may not be the only variables for which significant assortement exists and that are significantly correlated with psychiatric diagnoses. One can think of social attitudes, socio-economic background, geographical location as primary assortment variables. Addition of these variables might remove all evidence of primary assortement for psychiatric status. Also, assortement may not be consistent for different subgroups, e.g. early versus late marriage, or from one religious group to another.

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Assortative mating for major psychiatric diagnoses

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