Spousal concordance in academic achievements and IQ: a principal component analysis

Yue Pan, Ke-Sheng Wang*

1Department of Mathematics and Statistics, College of Arts and Sciences, East Tennessee State University, Johnson City, United States; 2Department of Biostatistics and Epidemiology, College of Public Health, East Tennessee State University, Johnson City, United States. E-mail: *wangk@etsu.edu

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ABSTRACT
Assortative mating, the tendency for mate selection to occur on the basis of similar traits plays an essential role in understanding the genetic variation on academic achievements and intelligence (IQ), it is also an important mechanism explaining spousal concordance. We used a subset of The Collaborative Study on the Genetics of Alcoholism sample to study the mating patterns in 84 pairs of spouses from Caucasian families with their academic achievements (reading, spelling, arithmetic, vocabulary and comprehension) and IQ (verbal IQ, performance IQ and full scale IQ). Simple correlation analysis showed that 6 of these 8 traits revealed evidence of spousal correlation (P < 0.05). The first principal component (PC1) of husbands explains 73.61% for the variation in the eight variables, which has high loadings from reading, spelling, arithmetic, verbal IQ and full scale IQ while PC1 of wives explains 72.86% for the variation in the eight variables, which has high loadings from reading, spelling, verbal IQ and full scale IQ. There was highly significant positive correlation between spouses by PC1 (P < 0.0001). The new variable PC1 may be important in spousal concordance and mate selection in society and act upon achievements and intelligence levels.

Keywords: Academic Achievements; IQ; Spousal Concordance; Principal Component Analysis

1. INTRODUCTION
Mate selection is a major biological event and whose outcome is a substantial determinant of an individual’s return on his/her whole reproductive investment [1]. Assortative mating, the tendency for mated pairs to be more similar to each other phenotypically than would be expected if they were married or mated at random, occurs for a variety of phenotypic traits, including both genetically determined traits and environmentally determined traits [2]. Assortative mating plays an essential role on society and the individual. It will increase the population variance of a given trait and the proportion of individuals who are homozygous for the trait. At the individual level, assortative mating can influence the course and outcome of marriage, in addition to determining the genetic and biological makeup and parenting of offspring [3].

Assortative mating has been shown for height [4-6], attitude domain of personality [7-12], social factors [13,14], smoking habits [15-17], and antisocial behavior and psychiatric disorder [2,17-22]. Assortative mating, the tendency for mate selection to occur on the basis of similar traits plays an essential role in understanding the genetic variation on academic achievements and intelligence (IQ), it is also an important mechanism explaining spousal concordance. At present, assortative mating with respect to IQ has been long standing interest to researchers, there are number of analyses and studies [13, 14, 23-29]. However, few studies focus on the combination of IQ with academic achievements, and no study has been found to use principal component analysis in assessing spousal concordance of academic achievements and IQ.

In the present study, we investigated the spousal concordance with respect to eight variables which represent the people’s academic achievements and IQ using both simple correlation analysis and multivariate analysis.

2. METHODS
2.1. Subjects and Variable Selection
The Collaborative Study on the Genetics of Alcoholism
Table 1. Characteristics of husbands and wives, correlation analysis and paired-t-test.

<table>
<thead>
<tr>
<th>Variable</th>
<th>N</th>
<th>husband-mean</th>
<th>wife-mean</th>
<th>corr-coef</th>
<th>Pc</th>
<th>T</th>
<th>Pt</th>
</tr>
</thead>
<tbody>
<tr>
<td>reading(standard)</td>
<td>84</td>
<td>99.66667</td>
<td>99.2619</td>
<td>0.60115</td>
<td>&lt;0.0001</td>
<td>0.28</td>
<td>0.7784</td>
</tr>
<tr>
<td>spelling(standard)</td>
<td>84</td>
<td>93.79762</td>
<td>100.3571</td>
<td>0.5804</td>
<td>&lt;0.0001</td>
<td>-4.03</td>
<td>0.0001</td>
</tr>
<tr>
<td>arithmetic(standard)</td>
<td>84</td>
<td>101.4048</td>
<td>99.72619</td>
<td>0.33865</td>
<td>0.0016</td>
<td>0.95</td>
<td>0.3429</td>
</tr>
<tr>
<td>vocabulary(scaled)</td>
<td>84</td>
<td>10.14286</td>
<td>10.25</td>
<td>0.43152</td>
<td>&lt;0.0001</td>
<td>-0.33</td>
<td>0.7441</td>
</tr>
<tr>
<td>comprehension(scaled)</td>
<td>84</td>
<td>10.67857</td>
<td>9.92857</td>
<td>0.16864</td>
<td>0.1252</td>
<td>2.05</td>
<td>0.044</td>
</tr>
<tr>
<td>verbal IQ(scaled)</td>
<td>84</td>
<td>102.9286</td>
<td>102.2619</td>
<td>0.14197</td>
<td>0.0096</td>
<td>1.49</td>
<td>0.1404</td>
</tr>
<tr>
<td>performance IQ(scaled)</td>
<td>84</td>
<td>104.381</td>
<td>101.8691</td>
<td>0.2809</td>
<td>0.0096</td>
<td>1.49</td>
<td>0.1404</td>
</tr>
</tbody>
</table>

N = number of individuals. Corr-coef = Correlation coefficient between spouses; Pc = p-value of correlation coefficient between spouses; T = t-statistics of paired-t test. Pt = p-value of paired-t test between spouses.

(COGA) is a multisite collaboration with the goal of identifying genes contributing to alcoholism and related phenotypes [30]. A total of 2,282 individuals from 262 multiplex alcoholic families are available for genetic analyses. Phenotypes include alcohol dependence, personal traits, academic achievements and IQ.

In order to conduct the analysis for achievement and intelligence variables, we chose 8 variables in the COGA data sets which represent the spouses’ standard achievements and intelligence level, as measured by the Wechsler Adult Intelligence Scale-Revised (WAIS-R). The WAIS [31,32] is a traditional intelligence test with high test-retest reliability, stability across different age spans, concurrent and predictive validity and substantial heritability [33]. The 8 variables are reading (standard), spelling (standard), arithmetic (standard), vocabulary (scaled), comprehension (scaled), verbal IQ (VIQ), performance IQ (PIQ) and full scale IQ (FSIQ) [34,35]. From the 262 multiplex families, we found 84 independent Caucasian spouse pairs with these 8 achievement and intelligence variables (Table 1).

3.2. Spousal Concordance Based on Simple Correlation Analysis

Pearson correlation (Table 1) showed that husbands and wives had significant positive correlation for reading ($r = 0.60115, P < 0.001$), spelling ($r = 0.58040, P < 0.001$), arithmetic ($r = 0.33865, P = 0.0016$), vocabulary ($r = 0.43152, P < 0.001$), verbal IQ ($r = 0.27463, P = 0.0115$) and full scale IQ ($r = 0.28090, P = 0.0096$) but no significant correlations for comprehension ($r = 0.16864, P = 0.1252$) and performance IQ ($r = 0.14197, P = 0.1977$).

3.3. Spousal Concordance Based on Correlation Analysis using PC Scores

Because most of the variables were significantly correlated with each other, we used principal component analysis (PCA) to generate first and second principal components (PC1 and PC2), which are independent each other. Table 2 showed the principal component loadings for PC1 and PC2 in husband and wife groups. We found that there was a 86.37% of accumulative contribution ratio for male spouses by PC1 and PC2 while there was a 87.99% of accumulative contribution ratio for female spouses by PC1 and PC2 while there was a 87.99% of accumulative contribution ratio for male spouses by PC1 and PC2 while there was a 87.99% of accumulative contribution ratio for female spouses by PC1 and PC2, which revealed that PC1 and PC2 could explain 86.37% (PC1 = 73.61%, PC2 = 12.76%) of the achievements and intelligence in male spouses while 87.99% (PC1 = 72.86%, PC2 = 15.13%) of the achievements and intelligence in female spouses.

In the PC1 cases, for husband variables, PC1 has high loadings from spelling (0.488106), reading (0.432491),
Table 2. Principal components loadings for husbands and wives.

<table>
<thead>
<tr>
<th>Husband variables</th>
<th>PC1</th>
<th>PC2</th>
</tr>
</thead>
<tbody>
<tr>
<td>reading (standard)</td>
<td>0.432491</td>
<td>−0.196181</td>
</tr>
<tr>
<td>spelling (standard)</td>
<td>0.488106</td>
<td>−0.442378</td>
</tr>
<tr>
<td>arithmetic (standard)</td>
<td>0.394913</td>
<td>−0.458365</td>
</tr>
<tr>
<td>vocabulary (scaled)</td>
<td>0.081872</td>
<td>0.068215</td>
</tr>
<tr>
<td>comprehension (scaled)</td>
<td>0.071645</td>
<td>0.108926</td>
</tr>
<tr>
<td>verbal IQ (scaled)</td>
<td>0.422952</td>
<td>0.489498</td>
</tr>
<tr>
<td>performance IQ (scaled)</td>
<td>0.271721</td>
<td>0.309194</td>
</tr>
<tr>
<td>full scale IQ (scaled)</td>
<td>0.392671</td>
<td>0.451651</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Wife variables</th>
<th>PC1</th>
<th>PC2</th>
</tr>
</thead>
<tbody>
<tr>
<td>reading (standard)</td>
<td>0.470387</td>
<td>−0.460293</td>
</tr>
<tr>
<td>spelling (standard)</td>
<td>0.480109</td>
<td>−0.442682</td>
</tr>
<tr>
<td>arithmetic (standard)</td>
<td>0.356364</td>
<td>0.068955</td>
</tr>
<tr>
<td>vocabulary (scaled)</td>
<td>0.07925</td>
<td>0.009375</td>
</tr>
<tr>
<td>comprehension (scaled)</td>
<td>0.059798</td>
<td>0.047292</td>
</tr>
<tr>
<td>verbal IQ (scaled)</td>
<td>0.396589</td>
<td>0.119958</td>
</tr>
<tr>
<td>performance IQ (scaled)</td>
<td>0.315482</td>
<td>0.658417</td>
</tr>
<tr>
<td>full scale IQ (scaled)</td>
<td>0.393151</td>
<td>0.370378</td>
</tr>
</tbody>
</table>

PC1 = First principal component. PC2 = Second principal component.

4. DISCUSSION

The present analyses provide evidence of significant spousal concordance in academic achievements and IQ measured by WAIS-R. Simple correlation analyses showed that 6 (reading, spelling, arithmetic, vocabulary, verbal IQ and full scale IQ) of 8 traits in academic achievements and IQ showed evidence of spousal correlation ($P < 0.05$), while correlation analysis based on the first principal component score (PC1 value) of 8 traits further revealed highly significant spousal resemblance ($P < 0.0001$).

Academic achievements and intelligence, which considered as important hereditary factors, have been commonly observed and studied in genetics. Assortative mating by achievement or intelligence traits between spouses, has been received much less attention despite its potential importance as an indicator of mutual mate choice [13,14, 23-29, 36]. It can affect the genetic structure of a population by increasing genetic variance and also homozygosity, although only when few loci are involved. It has been reported that all observed assortative mating in IQ and personal traits might well be due to initial assortment [25]. Some indirect evidence is presented that assortative mating may codetermine patterns of affectedness in dyslexia families with regarding to reading and spelling [26]. Another study that measured verbal and nonverbal intelligence showed that couples were similar in almost all the measured traits, even after controlling for age and education level and there was moderate similarity in education and verbal intelligence possibly due to assortative mating [16]. Wainwright et al. (2005) used the univariate analysis to indicate a positive phenotypic assortative mating and the phenotypic and genetic correlations between the Queensland Core Skills Test (QCST) and Verbal IQ were significantly stronger than the phenotypic and genetic correlations between the QCST and performance IQ [29].

This study has several strengths. First, we examined 8 traits in academic achievements and IQ and found 6 of them showed significant spousal correlations. Secondly, we used PC score to test the relationship for academic achievements and IQ between spouses. PCA is a useful statistical technique that has found application in fields such as face recognition and image compression, and is a common technique for finding patterns in data of high dimension [37]. However, instead of using PCA to study the achievements and IQ, other methods like univariate analysis have been used to indicate a positive phenotypic assortative mating [29] or ANCOVA for studying IQ in verbal IQ (0.422952), arithmetic (0.394913) and full scale IQ (0.392671). For wife variables, PC1 has high loadings from reading (0.470387), spelling (0.480109), verbal IQ (0.396589) and full scale IQ (0.393151). In the PC2 cases, for husband variables, PC2 has high loadings from spelling (−0.442378), arithmetic (−0.458365), verbal IQ (0.489498) and full scale IQ (0.451651). For wife variables, PC2 has high loadings from performance IQ (0.658417), reading (−0.460293), spelling (−0.442682) and full scale IQ (0.370378).

Figure 1 showed there was a highly significant positive correlation between the PC1 values of paired husbands and wives ($r = 0.515$, $P < 0.0001$, $n = 84$); whereas the relationship in PC2 between husbands and wives was weak ($r = 0.1952$, $P = 0.0752$).
childhood [28]. To our knowledge, our analysis using PCA represents the first attempt to assess spousal concordance in academic achievements and IQ. It has been suggested that spouse similarity was found for temperament, personality and psychiatric symptomatology that were largely independent highlights the necessity of simultaneous assessment of psychiatric domains in the search for the underlying characteristics conditioning nonrandom mate selection [11].

The findings of this study also have several limitations. The sample size is not large and the sample analyzed was not a random population sample collected with the primary goal of analyzing IQ. However, the mean and standard deviation for IQ among the COGA sample and the sibling correlation for the IQ measures, do not deviate considerably from published reports on unselected samples [34].

In conclusion, the study confirms and extends previous studies relating to the spousal concordance in academic achievements and IQ. Regardless of the causes, the presence of spousal concordance on achievements and IQ aspects has important implications for genetic studies in future research. An analysis of assortative mating for academic achievements and IQ may help us to understand the complex genetic and environmental contributions to academic achievements and intelligence.

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