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Genetic and Environmental Influences on Adult Life Outcomes: Evidence from the Texas Adoption Project

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Abstract A short mail questionnaire was sent to individuals, now adults, who had been studied over 30 years ago as children in the Texas Adoption Project. Their parents and (in many cases) siblings also described them using the same questionnaire, and the parents described themselves as well. The questionnaire was designed to obtain information about educational, occupational, and marital outcomes, as well as adult problems and personality. Results were obtained for 324 adopted and 142 biological children from the original 300 families, and for 266 parents. Although both the adopted and biological offsprings' outcomes were generally positive, those for the adopted offspring were somewhat less so. Biologically related family members tended to be more similar in their life outcomes than biologically unrelated family members, suggesting that genes were playing an important role.

Keywords Adoptions · Life outcomes · Genes · Environment · Personality traits

Introduction

Human abilities, particularly as measured by IQ tests, have long been studied by scientists seeking to assess genetic and environmental influences on behavior. Several early investigations employed adoptive families for this purpose (Burks 1928; Freeman et al. 1928; Leahy 1935), and this use has continued (see van IJzendoorn et al. 2005, for a meta-analysis of 62 studies). There has also been extensive investigation of human personality traits, using adoptive families as well as other behavior genetic designs (Bouchard and Loehlin 2001; Loehlin 1992).

Most behavior genetic studies in the domains of personality and abilities (for a review, see Plomin et al. 2001) have suggested: (1) that genetic differences between individuals make a substantial contribution to observed differences between them; (2) that the environments shared by family members make a contribution during children's early lives, but that this effect largely washes out by late adolescence; and (3) that environmental effects which differ from individual to individual within a family also make a contribution—although, in practice, estimates of such effects, because they are obtained as a residual, may be inflated by errors of measurement, trait fluctuations over time, subtrait specificities, and genotype-environment interactions of various sorts.

Life outcomes

Much less attention has been paid by behavior geneticists to the role of genes and environment in broadly defined life outcomes, such as educational, occupational, and marital success, and social adjustment. However, outcomes such as these have been a primary target of investigations focused on the adoption process itself (e.g., Raynor 1980; Seglow et al. 1972; Theis 1924/1974). Sixty-six studies of adoptee outcomes were included in a meta-analysis by Wierzbicki (1993). Most studied adjustment in childhood or adolescence, but

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some looked at adults—mostly under age 30. There have been a few recent studies of adoptees at later ages, including a British study (Collishaw et al. 1998) that assessed adoptee adjustment at age 33, and a Swedish study (Smyer et al. 1998) that involved 60 pairs of older twins (mean age 56), one of whom had been adopted away and one reared by the biological parent. Wierzbicki's meta-analysis of adoption outcome studies concluded that: (1) adoptees have more adjustment problems than biological children in similar families, although fewer than a birth mother's other children kept and reared by her; (2) the problems are predominantly of an externalizing kind (truancy, fighting, lying, stealing, substance abuse, and the like); (3) the behavioral differences between adoptees and biological children are larger for males than for females; (4) the differences are greater for adolescents than for children or adults; and (5) studies focused on the overrepresentation of adoptees in clinical populations tend to show larger effect sizes than studies focused on adoptees in the general population. More recent studies of adoptees in Canada (Lipman et al. 1993), New Zealand (Fergusson et al. 1995), The Netherlands (Verhulst and Versluis-den Bieman 1995), Great Britain (Collishaw et al. 1998), and the USA (Sharma et al. 1996, 1998) have generally found results consistent with these, although differing somewhat in the extent and severity of problems observed.

One must be careful not to overstate the extent of adoptee adjustment problems. The great majority of adoptees fall well within the normal range on adjustment measures. The fact of their overrepresentation in clinical populations may in part reflect the effect that small differences at the mean may have on proportions at the extremes, and in part a greater sensitivity of adoptive parents to emerging difficulties and more readiness to seek help for them, especially if they have some knowledge regarding the adjustment of the birth parents (Riggins-Caspers et al., 1999). Furthermore, the differences are not invariably unfavorable to adoptees: one study of U. S. adolescents found more prosocial behaviors among adoptees as well as a typical (albeit modest) excess of behavioral problems (Sharma et al. 1996).

The behavior genetics of life outcomes

One large recent behavior-genetic study, Non-shared Environment in Adolescent Development (NEAD; Reiss et al. 2000), assessed outcomes in the form of six broad dimensions of adolescent adjustment, each defined from multiple perspectives: the adolescent's self report, the views of his or her parents, and the judgments of observers of videotaped interactions. The six dimensions of adjustment included two problem areas, antisocial behavior and depressive symptoms, and four aspects of strength: autonomy, sociability, social responsibility, and cognitive agency (engagement and competence in school). These adjustment dimensions were studied in genetically informative families–families containing pairs of siblings of various degrees of genetic resemblance ranging from identical twins to unrelated stepsiblings. The presence of identical twins means that the study was capable of assessing non-additive as well as additive genetic effects.

The results of the NEAD study of adjustment differed in several ways from those typically reported in behavior-genetic studies of personality traits (Loehlin et al. 2003). First, although all the dimensions showed at least moderate genetic influence, it was quite high for some: for example, cognitive agency and social responsibility, with broad-sense heritabilities of 0.79 and 0.65, respectively. Non-additive genetic effects contributed to the genetic variance for several dimensions, for example, 0.35 for cognitive agency and 0.45 for depressive symptoms. Second, some dimensions showed quite substantial influence of shared family environment. Instead of the values of 0.10 or less typically reported for personality traits (Bouchard and Loehlin 2001), there were estimates of shared environmental effects in the 0.34–0.48 range for antisocial behavior, sociability, and autonomy. And third, instead of the non-shared environmental contributions of 0.50–0.60 typically seen for personality traits, values in the range 0.10–0.23 were obtained for the six adjustment dimensions. These were values of a magnitude that might easily reflect just measurement error and viewpoint specificities. The composites measuring the dimensions had internal-consistency reliabilities in the range 0.73–0.85, leaving almost no room for a reliable within-family environmental contribution to individual differences. It is ironic that a study intended to examine the effects of non-shared environment on adolescent development wound up with virtually no such effects to explain.

Although the NEAD study examined important aspects of adjustment during adolescence with a genetically informative design, the question remains: Would similar or different results emerge if one looked at adult life outcomes, such as education, occupation, or marriage; or problems with anxiety and depression or drugs and alcohol; or general qualities of life, such as sociability, social responsibility, or independence? Problem areas have received a fair amount of attention from behavior geneticists (Farmer 2004; McGue and Iacono 2004), but normal outcomes have received much less. We, therefore, elected to take at least an initial look at genetic and environmental contributions

to adult life outcomes in the families of the Texas Adoption Project—recognizing, however, that in an adoption study we would be limited in our ability to detect non-additive genetic effects.

The Texas Adoption Project

The Texas Adoption Project began over 30 years ago with 300 families, each of which had adopted a child from a church-related residential facility for unwed mothers (Horn et al. 1979). All these children were placed in their adoptive families within a few days of birth, and were permanently adopted. Many of the families also contained one or more children born to the adoptive parents, or other adopted children.

The adoptees, whose ages ranged from 3 to 14 years at the time of testing, and all other available children in the family were administered an IQ test by a psychologist, and were rated on 24 bipolar trait scales by a parent (usually the mother). The adoptive parents were given IQ and personality tests as well. In a follow-up about 10 years later, as adolescents or young adults, the children from 181 of the 300 families received IQ and personality tests, and were rated again on the 24 traits by a parent (Loehlin et al. 1987).

Some 15 years later, about 25 years after the initial study, one or both parents in 160 of the original families were interviewed. The interview focused on the life histories and present status of the children in the family. However, we wished to obtain at least some information from families we had been unable to interview personally, as well as to obtain the children's own perspectives on their lives. Therefore we undertook a study using a brief mail questionnaire. A one-page questionnaire was sent to the children, now mostly in their late thirties or early forties, to provide their own perspectives on their lives, and to siblings, to provide additional viewpoints. Finally, the same questionnaire was mailed to the parents, requesting them to use it to describe the life outcomes of each of their children.

The present paper combines the ratings from these various viewpoints—parents, siblings, self—to obtain a consensus view of each individual's life outcomes, and addresses two main questions about these: (1) do they differ systematically for individuals who entered these families via birth or via adoption? And (2) are the outcomes more similar in the case of individuals in the same family who share genes than in the case of individuals who shared family life but were genetically unrelated?

Based on prior research, we expected to find at least some differences in adult outcome between biological and adopted children, a greater similarity between biologically related than among biologically unrelated family members, and a substantial genetic influence upon measures of adult functioning and personality characteristics. The extent to which shared family environments would affect adult life outcomes was uncertain.

Method

Participants and mailings

A one-page questionnaire was sent by mail, along with an accompanying letter, to the participants, all of whom were members of the original 300 adoptive families. The mailings were done in several stages. Initially, the questionnaire was sent to the children in the adoptive families (now adults) whose addresses were obtained from their parents in the interviews. Next, the questionnaire was mailed to children from non-interviewed families, using addresses obtained via driver's license records from the State of Texas Department of Public Safety. In both cases, in multiple-child families the questionnaire contained two additional items, one asking whether the raters would be willing to fill out a similar scale describing siblings, and the other, whether they would be willing to have their siblings rate them. Most responded ''yes'' to both questions, and, if consent was mutual, questionnaires were sent to each; in all, 133 sibling ratings were obtained from families with more than one child in the study. In a few cases, additional addresses of siblings were obtained from the respondents, and questionnaires mailed to them.

Finally, in a third phase, copies of the same rating scale were mailed to all parents for whom we had addresses, asking each of them to fill out a questionnaire to describe each of their children, and in addition to fill one out describing him- or herself.

Each main mailing was accompanied by up to five postcards. One was sent 2 days prior to the main mailing, alerting respondents to the forthcoming mailing (and assuring them that it would not be a solicitation for funds!). A second postcard was mailed to everyone 2 days after the main mailing, inquiring if they had received it, urging them to respond, and thanking them if they had already done so. A separate ''thank you'' postcard was sent to respondents on receipt of their questionnaires. Two additional reminder postcards were sent to non-responders two weeks and one month after the initial mailing, unless we had been notified by the post office of the non-deliverability of

previous mailings. About a month later, a letter containing another set of questionnaires was sent to non-responders, in case they had forgotten or mislaid the originals.

These mailings and their outcomes are summarized in Table 1.

As the table shows, we mailed out altogether over 1,200 sets of questionnaires. In about three-fifths of the cases (60.9%), filled-out questionnaires came back. We had a few explicit refusals (1.1%). A number of mailings were returned by the Post Office for no-longer valid addresses (13.6%). Of the remaining 24.3% of cases, presumably some never reached their intended recipients, some went directly into wastebaskets, and the rest lay for some indeterminate period of time in ''to do'' piles.

Questionnaire

The questionnaire is shown as Fig. 1.

The items on this questionnaire represented an attempt to assess several aspects of life adjustment on a simple, one-page form. There were two items concerning academic achievement: highest level of education completed, and excellent vs. poor student in junior high and high school. Three occupational status items included current job, its level of responsibility, and the stability of occupational history. Two items dealt with marriage—current marital status and stability and happiness of marriage or similar relationship. Two items dealt with closeness to parents during school years. Two dealt with adjustment in junior high and high school, one with peers (isolated vs. many friends) and one with authorities (often in trouble vs. never in trouble). Three items covered personal problems in recent years, of an internalizing (happy and secure vs. anxious and depressed) or an externalizing kind (drug and alcohol problems and trouble with the law). Finally, the person being rated was judged on five personality attributes: sociability, independence, social responsibility, conscientiousness, and agreeableness. These were chosen to cover roughly the ground of the adjustment dimensions of the NEAD study (Reiss et al. 2000), as well as four of the Big Five personality traits (e.g., John 1990). The first three personality ratings correspond approximately to the sociability, autonomy, and social responsibility dimensions of the NEAD study, and the last two to the conscientiousness and agreeableness dimensions of the Big Five. (The sociability and anxious/depressed items relate to extraversion and neuroticism, respectively; the fifth of the Big Five, openness, is not explicitly addressed.)

Thus within the scope of a one-page questionnaire we attempted to include items covering a fairly broad range of life outcomes—educational, occupational, and marital—as well as a number of dimensions of personal and social adjustment. Some of these (e.g., trouble with authorities) were assessed separately for adolescence and adulthood. Closeness to parents was included to get at one aspect of socialization history.

Covering a wide field of adjustment meant that we could not expect to measure any one of these aspects with great precision, but we elected to cast a fairly broad net and rely upon the agreement among informants—self, parents, siblings—to insure that we were obtaining something that went beyond sheer measurement error.

The item on the questionnaire that asked for a description of the ratee's current job proved to present some difficulties. It was often left blank, or answered so vaguely (''self-employed''; ''in computers''; ''works for X company'') as to yield much missing data for scores

Table 1 Mailing and return of questionnaires

Mailing	Total sent	Post office returned	Explicitly declined	No response	Completed response	% Completed
Offspring from Interviewed families	374	47	1	65	261	69.8
Offspring from Non-interviewed families	170	20	3	59	88	51.8
Siblings	176	0	0	43	133	75.6
Parents from Interviewed families	312	54	4	56	198	63.5
Parents from Non-interviewed families	196	46	6	76	68	34.7
Total	1,228	167	14	299	748	
% Of total		13.6	1.1	24.3	60.9	

Note: These figures represent sets of questionnaires sent out or returned. ''Completed response'' means at least one questionnaire completed and returned. The figures for parents from interviewed families, except for completed responses, are approximations based on records kept in a different form

Fig. 1 Questionnaire

Code No._____

RATING SCALE

Rater: _____ Person rated:_____ Date_____

Below, describe the person being rated (named above) by filling in the blank or circling the number that best reflects your opinion. If you have no information at all concerning an item, simply omit it. If you have further comments, or need to explain any of your answers, feel free to use the margins or the back of the page.

(1) Highest level of education completed (check one): __less than HS grad; __HS grad or GED; __1 or 2 yrs college; __3 or 4 yrs college; __college grad; __post-grad work.

(2) School adjustment during junior high and high school

poor student	1 2 3 4 5 6 7 8 9	excellent student
isolated	1 2 3 4 5 6 7 8 9	many friends
often in trouble	1 2 3 4 5 6 7 8 9	never in trouble

(3) Emotional closeness to parents: During his or her school years, was

very close to father	1 2 3 4 5 6 7 8 9	very distant from father
very close to mother	1 2 3 4 5 6 7 8 9	very distant from mother

(4) Current or most recent job (describe)_____

little responsibility	1 2 3 4 5 6 7 8 9	much responsibility

(5) Employment history (since finishing school):

many job changes	1 2 3 4 5 6 7 8 9	highly stable

(6) Currently is: __single; __living together; __married; __separated; __divorced; __widowed

(7) History of marriage (or similar relationships—omit if none):

very unstable and/or unhappy	1 2 3 4 5 6 7 8 9	very stable and happy

(8) Personal problems in recent years:

no drug or alcohol problems	1 2 3 4 5 6 7 8 9	serious drug or alcohol problems
always happy and secure	1 2 3 4 5 6 7 8 9	often anxious or depressed
never in trouble with the law	1 2 3 4 5 6 7 8 9	often in trouble with the law

(9) Current personality:

few friends, little social activity	1 2 3 4 5 6 7 8 9	lots of friends & social activity
very dependent on others	1 2 3 4 5 6 7 8 9	independent, self-reliant
immature, selfish	1 2 3 4 5 6 7 8 9	mature, helpful
erratic, undependable	1 2 3 4 5 6 7 8 9	conscientious, reliable
hostile, disagreeable	1 2 3 4 5 6 7 8 9	pleasant, agreeable

based upon it. The item has consequently been omitted from the analyses in the present paper; items on job responsibility and stability of occupational history remain as measures of occupational outcome.

The data

All data from the questionnaires were entered twice into computer data files, and any discrepancies checked and resolved. The basic analyses of this paper are based on assigning to each person a single score for each item, the mean rating obtained from all individuals rating him on the item (including himself). The number of rating scales filled out per individual ranged from 1 to 5, with the distribution shown in Table 2.

As Table 2 shows, 466 individuals of the offspring generation were described in 1,171 questionnaires, an average of 2.5 raters each. In addition, self-ratings were obtained for 130 mothers and 136 fathers. In only a small fraction of cases in the offspring generation (12%, not shown in table) was there solely a self-rating.

The division of the offspring generation of the Texas Adoption Project according to sex, adoptive status, and whether they were or were not included in the present study is shown in Table 3. It will be seen that slightly over two-thirds were included, the proportion being a little higher among the biological children than the

Table 2 Numbers of ratings per individual

Raters	Frequency	Questionnaires
1	110	110
2	146	292
3	95	285
4	91	364
5	24	120
Total	466	1,171

Table 3 Offspring from original 300 families who were included and not included in this study, by adoptive status and sex

Measure	Included	Not included	% Included
Adopted			
Male	173	83	67.7
Female	151	78	65.9
Biological			
Male	78	26	75.0
Female	64	27	70.3
Total	466	214	68.5

adopted children. The sexes were about equally represented, with a slight excess of males; adopted offspring outnumbered biological offspring about two to one.

Statistical analyses

The details of the statistical analyses will be described in the Results section of the paper, in connection with the specific questions addressed. Most results are reported for the individual items of the questionnaire. The means of the adopted and biological groups on these items were compared by analysis of variance. Differences in the intraclass correlations of genetically related and unrelated members of adoptive families were evaluated via a bootstrap approach (Efron and Tibshirani 1993). Finally, structural equation models were fit to the combined data of the child and parent generations to estimate genetic and environmental contributions to the 18 life outcome items.

Results

Selection

In a longitudinal study spanning over 30 years in which only about two-thirds of the original sample are successfully located, the question arises as to whether those measured in the present phase of the study are systematically different from those who were for one reason or another lost to follow-up. One way of addressing this question is to compare the scores at the time of original testing of these groups. Such a comparison is made in Table 4.

This table compares the scores on several variables at the original testing for individuals for whom we did and did not have at least one set of ratings in the present study. (The numbers are slightly lower than those in Table 3, because some respondents were missing data on some of the variables in the original study.)

Table 4 Means at original testing for individuals included and not included in this study

Measure	Included	Not included	ES[a]
IQ	112.1	110.2	0.17
Personality			
Extraverted	47.7	48.6	–0.11
Well socialized	32.6	32.5	0.02
Emotionally stable	48.1	48.1	0.00
Family SES[b]	169.0*	159.0	0.41
*N*s	383–465	192–207	

[a] ES = effect size (difference between means, in pooled standard deviation units)

[b] An arbitrarily scaled equally-weighted composite of father's education, mother's education and father's occupational level

* Higher, at $P \leq 0.05$, via ANOVA including adoptive status, sex, and interaction

There is evidence in the table that individuals from families of lower socioeconomic status (SES) were significantly less likely to be reached at follow-up; the effect size of 0.41 would be described in Cohen's (1977) terms as between small (.20) and medium (.50). A similar difference was observed at the 10-year follow-up, with better-educated parents somewhat more likely to participate (Loehlin et al. 1987). The same might be a factor in the higher participation of the biological than the adopted children in the present study—the former group, as we shall see, achieved a somewhat higher level of education. For the children's IQ and personality variables, the difference between groups at the time of the original testing is small and statistically non-significant, although the direction of difference for IQs is that which one would predict from parents' SES. None of the interactions with sex or adoptive status was statistically significant. Thus attrition in the present sample does not appear to confront us with severe interpretational problems.

Adopted versus biological children: means

Do adopted children differ from biological children in adoptive families? Table 5 presents the answer, and the answer is: ''Yes, on average, but not very much.'' The larger of the effect sizes (third column) are mostly in the range conventionally designated as ''small'' (i.e., around 0.20; Cohen 1977). The typical difference between the adopted and the biological children in these families, even on the traits for which the differences are relatively large, is only about one quarter to a third of the within-group standard deviation. One should not take the probabilities attached to these differences too literally, because responses to the rating scales were often far from normally distributed (although usually similar in both groups). The asterisks

Table 5 Mean composite ratings received according to adoptive status, and their reliabilities

Rating scale	Status		ES	Reliability
	Adopted	Biological		
High level of education	4.05	4.42*	0.27	0.97
Excellent student in HS	6.65	7.10*	0.26	0.86
Many friends in HS	7.14	7.24	0.07	0.72
Never in trouble in HS	6.95	7.68*	0.39	0.73
Distant from father	3.96	3.64	–0.17	0.55
Distant from mother	3.67*	3.23	–0.24	0.51
Job responsibility	7.76	7.96	0.15	0.64
Job stability	6.69	7.30*	0.29	0.81
Marital status	1.47	1.49	0.03	0.89
Stable, happy marriage	6.69	7.03	0.16	0.82
Drug or alcohol problem	2.07	1.78	–0.15	0.86
Anxious or depressed	3.80*	3.26	–0.29	0.74
In trouble with the law	1.73	1.52	–0.14	0.86
Lots of friends & social activity	6.53	6.92*	0.21	0.67
Independent, self-reliant	7.30	7.64*	0.22	0.65
Mature, helpful	7.30	7.64*	0.22	0.67
Conscientious, reliable	7.50	7.88*	0.25	0.70
Pleasant, agreeable	7.37	7.77*	0.29	0.68
N	292–323	129–142		

Note: ES = effect size (difference between means, in pooled standard deviation units). Reliability via intraclass correlation among raters for individuals rated by at least 2 raters. See Fig. 1 for full rating scales—marital status recoded as 1 = married or widowed, 2 = single or living together, 3 = separated or divorced

* Higher, at $P \leq 0.05$, via ANOVA including adoptive status, sex, and interaction

in the table may still be helpful for descriptive purposes.

Table 5 suggests that, based on the combined ratings received by each individual, the biological children within these families were more often judged to be excellent students and never in trouble in high school (although similar in number of friends), and went on to a higher level of education. As adults, they were rated as having more friends and social activity, as being more independent, mature, conscientious, and agreeable, and to have had more stable employment records. By contrast, the adopted children were rated as having been less close to their mothers, and to be more often anxious or depressed.

These average differences should not be misread as saying that the adopted children were poor students in high school, erratic in their jobs, or immature, undependable, and disagreeable as adults. Far from it. Their average ratings were above the scale midpoints in the favorable direction on all these dimensions. The adoptees were on average rated as good students in high school, and as mature, conscientious, and agreeable adults—only somewhat less so than the biological children in these families. Although there were some individuals among the adoptees judged to be seriously maladjusted, most were not.

Sex differences

The significant differences in means between males and females (not shown in the table) were not especially surprising. The women were rated higher on having been a good student and not in trouble in high school. The men were rated significantly higher (although not very high) on recent problems with drugs or alcohol and having been distant from father as a child. More important, perhaps, there were no significant interactions between sex and adoptive status in their effects on any of the 18 traits, so the effects of adoptive status in Table 5 admit of straightforward interpretation.

Consistency among raters

The fourth column of Table 5 shows that these ratings are reliably distinguishing among individuals, in the sense of inter-rater agreement. The internal consistency reliabilities were estimated via the intraclass correlation among raters, based on individuals with more than one rating. Agreement varied from measures like educational level and marital status, for which agreement among raters was high, to measures like distance from mother and father during childhood, for which agreement was considerably lower (although there was still *some*).

Correlations between family members sharing and not sharing genes: siblings

Adoptive families provide important evidence concerning the relative influence of genes and family environment on psychological traits: important evidence, not completely decisive evidence—no single empirical study standing alone can be expected to provide this. In the present case, we are asking if the life outcomes of family members who share roughly half the genes varying in the population are more alike than the life outcomes of family members who do not. Do parents tend to resemble their biological more than their adopted children? Are genetically related siblings more alike than genetically unrelated children reared together?

Table 6 provides the evidence for biologically related and unrelated sibships. There were 33 sibships for which ratings were available for two or more

Table 6 Intraclass correlations in biologically unrelated and related sibships

Rating scale	Unrelated	Related	Bootstrap *p*
High level of education	0.19	0.43	0.14
Excellent student in HS	0.05	0.28	0.08
Many friends in HS	0.19	0.38	0.10
Never in trouble in HS	0.04	0.19	0.28
Distant from father	0.21	0.58	0.01
Distant from mother	0.25	0.26	0.50
Job responsibility	0.08	0.31	0.12
Job stability	0.04	0.16	0.21
Marital status	0.09	0.20	0.27
Stable, happy marriage	0.14	0.09	0.34
Drug or alcohol problem	0.01	0.13	0.39
Anxious or depressed	0.08	0.23	0.17
In trouble with the law	0.00	0.24	0.30
Lots of friends & social activity	0.21	0.27	0.38
Independent, self-reliant	0.01	0.52	0.00
Mature, helpful	0.06	0.29	0.04
Conscientious, reliable	0.03	0.38	0.02
Pleasant, agreeable	0.07	0.15	0.27
N of sibships	163	33	

Note: Correlations based on composite ratings, in sibships with at least 2 members in.the designated category. Bootstrap *p* is proportion of bootstrap samples showing no difference or a difference in the opposite direction. See Fig. 1 for full rating scales; see note to Table 5 for recoding of marital status

individuals who were both biological offspring of the adoptive parents, and whom we expect, therefore, to share on average one-half their segregating genes. There were 163 sibships in which there were two or more unrelated individuals. We obtained the latter by taking all the adopted children in a family, plus one biological child, if available, selected at random if there was more than one. For computational convenience in the bootstrap comparisons (see below), we used only data that were reasonably complete (defined as at least 15 of the 18 items scored by at least one rater), and replaced the few remaining missing items with mean values over the item for the sex and adoptive status subgroup in question.

Table 6 indicates that for 17 of the 18 items the intraclass correlation among biologically related siblings was higher than the intraclass correlation among unrelated siblings, although the correlations are not very high, and thus the differences often small. The exceptional item was ''stable, happy marriage'' (and there the correlations did not differ much). Overall, the median correlation for the unrelated siblings was 0.08, with about two-thirds of the correlations in the neighborhood of zero, i.e., within the range plus or minus 0.10. The median for related siblings was 0.26. Only one of the correlations for the related sibs fell below 0.10.

Also shown in the table is a comparison of the intraclass correlations via the bootstrap principle (Efron and Tibshirani 1993). In this approach, random samples of size *n* (''bootstrap samples'') are repeatedly drawn with replacement from a data matrix of *n* rows—i.e., after drawing a case, it is returned to the pool and may be drawn again. The statistics of interest are calculated for each sample, and the variation of these statistics across samples is used as an estimate of what the sampling error of the statistic would be if one had drawn random samples of this size in the usual way from an infinite population whose distribution was like that of the sample.

The process was repeated for 1,000 pairs of bootstrap samples, and the number of cases recorded in which the intraclass correlation for biological sibships exceeded that for adoptive sibships. From these, the bootstrap probabilities in the last column of Table 6 were calculated. They may be interpreted as the proportion of the time that one would expect to observe no difference or a difference in the opposite direction from that appearing in the table, if one were drawing random samples of this size from populations like these.

It will be observed that even with these not-too-large samples (especially of biological sibships), one can for several traits reject a null hypothesis of no difference between the groups. Notably, the probability of a difference in the observed direction occurring by chance was less than 0.05 for distance from the father, and for the traits independent, mature, and conscientious.

Parent-child pairs sharing and not sharing genes

Parents and their biological offspring, like biological siblings, share genes. Does this make them more alike than parents and their adopted children, who do not?

The relevant data are provided in Table 7. This table gives correlations between the father's or mother's rating of themselves and the child's combined rating. Because the parent ratings are based on a single rater, we may expect these correlations to be less dependable than those for the siblings—although, offsetting this, the samples are somewhat larger, as they now include single-child families. The correlations are ordinary Pearson correlations, with the parent multiply entered, paired with each child. As before, cases with fewer than 15 of the 18 items complete were excluded for the bootstrap calculations, and the few remaining missing items replaced with group means.

Table 7 Correlations between parents and biologically unrelated and related offspring

Rating scale	Father–child			Mother–child		
	Unrel.	Rel.	*P*	Unrel.	Rel.	*P*
High level of education	0.12	0.44	0.00	0.19	0.27	0.28
Excellent student in HS	0.04	0.20	0.11	0.14	0.11	0.42
Many friends in HS	0.22	0.45	0.02	0.02	0.35	0.01
Never in trouble in HS	0.06	0.10	0.41	–0.05	–0.09	0.33
Distant from father	0.31	0.21	0.25	0.02	0.04	0.45
Distant from mother	0.18	0.28	0.22	0.14	0.15	0.44
Job responsibility	0.08	0.12	0.32	0.10	0.15	0.42
Job stability	–0.04	0.05	0.24	–0.01	0.27	0.02
Marital status	0.01	0.21	0.07	0.06	0.04	0.41
Stable, happy marriage	–0.11	–0.05	0.25	0.01	0.34	0.01
Drug or alcohol problem	0.11	0.24	0.24	–0.04	0.12	0.11
Anxious or depressed	0.17	0.11	0.31	0.11	0.30	0.06
In trouble with the law	0.09	0.02	0.26	0.01	–0.06	0.10
Lots of friends & social activity	0.06	0.12	0.30	0.01	0.34	0.00
Independent, self-reliant	–0.04	0.10	0.06	0.13	0.44	0.01
Mature, helpful	0.13	0.09	0.36	0.22	0.24	0.47
Conscientious, reliable	0.08	0.17	0.19	0.09	0.23	0.14
Pleasant, agreeable	0.10	0.15	0.39	0.21	0.14	0.27
N pairs	214	95		206	90	

Note: Correlations between parent self-rating and child composite rating. Unrel. = Adopted child; Rel. = Biological child; *p* = bootstrap *p*, the proportion of bootstrap samples showing no difference or a difference in the opposite direction. See Fig. 1 for full rating scales; see note to Table 5 for recoding of marital status

Table 7 shows father-child and mother-child correlations for unrelated and related pairs in the adoptive families. For 13 of 18 traits, the father–offspring correlation is positive and larger for the related pairs, and for 13 of 18 traits this is so for the mothers. As in the case of the sibs, most of the father–child and the mother–child correlations are not far from zero for the unrelated pairs: The median correlations are 0.08 and 0.08 for fathers and mothers, and just short of two-thirds of the cases lie in the plus-or-minus 0.10 range. For the related pairings, the medians are 0.14 and 0.21, respectively, and two-thirds of the cases lie above 0.10.

As in the case of the sibling groups, bootstrap evaluations were carried out; the number of times related pairs were more highly correlated than unrelated pairs was tabulated over 1,000 paired bootstrap samples. In at least 95% of the bootstrap samples, fathers resembled their biological children more than their adopted children for level of education and having many friends in high school, and in at least 90% of the samples for marital status and independence. Mothers resembled their biological children more than their adopted children at least 95% of the time for having many friends in high school, for job and marital stability, and for being sociable and independent as adults, and at least 90% of the time for being anxious and depressed.

Spouse correlations

Correlations between spouses can affect the genetic correlations among biological siblings—and may affect environmentally based correlations as well, if these are a result of direct causal influences of parents on their children. Correlations between spouses, based on their self-reports, are given in Table 8.

As can be seen from the table, the spouse correlations are moderate: for the personality dimensions they run about 0.30, for educational level, a little higher, 0.46. For being in trouble with the law or having problems with drugs and alcohol, the spouse correlations are essentially zero—of course, restriction of range is probably involved here, since the adoptive parents were screened by the adoption agency, and in the presence of such problems would likely not have had a child placed with them. The –0.04 correlation for marital status should be ignored as misleading—in 94 of 104 couples, both agreed that they were married. In the other 10, one was (re-)married and one was not, leading to the artifactual small negative *r*. It is of mild interest that ratings of the happiness of their marriage are correlated only 0.28 between spouses—they are in most cases describing the same marriage, although, of course, from different points of view. Restriction of range may also be relevant here, as unhappy couples, at least at the time of adoption, would have been selected against by the adoption agency. Note that the number of intact couples is being reduced at these ages by the death or disability of one spouse.

Table 8 Spouse correlations

Rating scale	*r*	Rating scale	*r*
High level of education	0.46	Stable, happy marriage	0.28
Excellent student in HS	0.09	Drug or alcohol problem	–0.04
Many friends in HS	0.26	Anxious or depressed	0.18
Never in trouble in HS	–0.10	In trouble with the law	–0.01
Distant from father	0.00	Lots of friends & social activity	0.37
Distant from mother	0.12	Independent, self-reliant	0.33
Job responsibility	0.16	Mature, helpful	0.29
Job stability	–0.08	Conscientious, reliable	0.30
Marital status	–0.04	Pleasant, agreeable	0.32

Note: Pearson correlations between self-ratings of adoptive parents. *N*: 104 spouse pairs

Genes and environment: model fitting

To integrate the information from the sibling, parent–child, and spouse correlations into a simple, overall estimate of the relative effects of genes and environment upon these traits, we fitted structural equation models. Figure 2 shows path diagrams of the models to be fitted to the data from the biological and adoptive relationships in Tables 6–8.

These models are based on a number of assumptions. To the extent that the assumptions are reasonable, the results will provide meaningful estimates of the effects of genes and of shared and unshared environments on these traits. The estimates cannot be expected to be very precise or general, because the samples are selected, the sample sizes are not large, and the precision of measurement is well short of ideal. Nevertheless, the estimates can provide an economical summary of what these data have to say about the degree to which genes and environments account for individual variation on these traits. This does not give us a detailed story of how genes and environments act and interact to shape traits during development, but it tells us something about the outcome of this developmental history.

Figure 2 shows on the left a biological sibship and on the right an adoptive one. It will be seen that the first assumption being made is that the two are the same in their environmental paths, but in the biological sibship there are also genetic paths connecting parents and offspring. (The biological parents of the adopted children are not shown in the diagram, but the two sets of parents are assumed to be uncorrelated. This is probably not exactly true, but the degree of departure from it is unlikely to introduce gross error.) The models essentially estimate three parameters. Two are environmental: one of them, p, represents the effect of a parent's trait on the corresponding trait of a child. This might reflect, for example, the imitation of the parent by the child, or deliberate instruction, as when a conscientious parent attempts to instill corresponding values in his or her child, or the outcomes of other interpersonal interactions, as when parental hostility results in a hostile child. A second environmental parameter, c, represents the effects of the environment that the children share, other than their parents' specific trait. Peers, schools, neighborhoods, the general atmosphere of the home, would be included here.

The genetic path represented is that between a parent's genotype and the phenotype of his or her child, a theoretical value of ½ h. The ½ represents the path from parent's genotype to child's genotype, and the h the path from child's genotype to child's phenotype.

At the top of the diagram, correlations between the spouses' phenotypes, or in the case of the biological families, among their phenotypes and genotypes as well, are shown by the two-headed arrows. The correlations are derived on the assumption of phenotypic assortative mating; that is, it is assumed that when similar people marry each other (to the modest extent that they do), it is on the basis of their own characteristics rather than those of their families. Thus

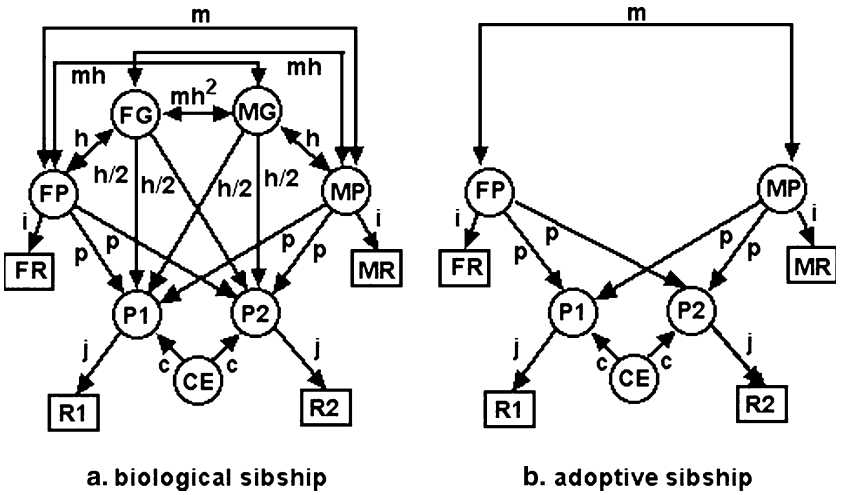

Fig. 2 Path diagrams: (**a**) biological parents and children; (**b**) adoptive parents and children. FG, FP, FR = father's genotype, phenotype, and rating for a trait; MG, MP, MR = same for mother; P1, P2, R1, R2, phenotypes and trait ratings of two children; CE = common environment of children (other than that due to parents' trait). Paths: c = effect of CE on trait; p = environmental effect of parent's phenotype on child's trait; h = effect of genotype on trait; m = correlation between spouses for trait; i, j = square roots of reliabilities of trait ratings in parent and child generations

spouses' genotypes will be less correlated than their phenotypes by a factor of h^2.

Other assumptions incorporated in the model are that heritability is stable over generations and adult ages in this population; that the genetic effects are primarily additive in nature; that the effects, both genetic and environmental, of mothers and fathers on their children are equal in magnitude; and that ratings imperfectly estimate the actual traits, and to a different degree for single and multiple ratings (the paths *i* and *j* allow for this—they are different for the self-ratings of the parents and the composite ratings of the children, and are set to the square roots of the respective reliabilities, the latter from Table 5, and the former adjusted to values for a single rater).

It can hardly be the case that all of the above assumptions are exactly true for every trait, but to the extent that they are reasonable approximations, they allow a convenient summary of the implications of the data. Small deviations should not greatly affect the summaries, and if some of the assumptions are seriously wrong for some traits—say, much of the genetic variance for a trait is non-additive, or the effects of mothers and fathers very different, we would, in the first case, simply have a genetic component in the unexplained variance, and in the second, a poorly fitting model.

The Fig. 2 models were fitted to the parent-child, sibling, and spouse correlations. The model-fitting program used, LISREL 8.7, provides overall goodness-of-fit χ^2, and *t*-tests for individual parameters, but we do not present these, because the model-fitting conditions fall well short of justifying formal statistical inference: we are fitting to correlations rather than covariances; the multivariate normality of the data is questionable (a number of the rating dimensions are markedly skewed); and we are fitting to correlations based on different subsets of the data (only some of the families have biological children, for example); thus the correlations are based on differing numbers of cases. However, taken at face value, the model fits were good to excellent by conventional criteria, so there is no counterindication to using the parameter estimates, as we do here, in a descriptive spirit.

Table 9 shows estimates of the three variance components p^2, h^2 and c^2 from fitting the models of Fig. 2 to the parent-offspring, sibling and spouse correlations in Tables 6–8. The first, p^2, which reflects the environmental effect of a parent's trait on the same trait of the child, tends to be negligible in size for most of the traits. It is mildly interesting that the only two appreciable values in this column are for the traits "distant from father" and "distant from mother." Parents who were close to or distant from their own parents had children who were close to or distant from them, via an environmental mechanism.

The second column, h^2, suggests that for most of the 18 traits the reason for resemblance among family members is shared genes. The heritabilities are not very high. Only five—many friends in high school, distance from father, job stability, independence, and conscientiousness—are 0.40 or above, and three— distance from mother, trouble with the law, and agreeableness—are less than 0.10. Distance from father and from mother provide a curious contrast: on the face of it, distance from father reflects inherited personality characteristics, whereas distance from mother does not.

The variance components c^2 in the third column reflect the shared environments of siblings. On the whole, they tend to be larger than those for direct parental environmental influence, but smaller than those for the effect of the genes. There are 16 values less than 0.10 in the p^2 column, 3 in the h^2 column, and 12 in the c^2 column. One should probably not take the trait-to-trait differences among these numbers very seriously, but it is interesting that distance from father shows up again, as the largest value in the column—the characteristics of the father are an environmental factor that siblings share. Distance from mother shows some of this, but to a lesser degree. Other moderate shared environmental effects include level of education, job responsibility, and degree of social activity; however, in all three cases the estimate of the genetic

Table 9 Results from fitting Fig. 2 model—estimates of one genetic and two environmental variance components

Rating scale	p^2	h^2	c^2
High level of education	0.01	0.33	0.14
Excellent student in HS	0.01	0.21	0.05
Many friends in HS	0.02	0.46	0.09
Never in trouble in HS	0.00	0.12	0.06
Distant from father	0.10	0.45	0.28
Distant from mother	0.10	0.06	0.20
Job responsibility	0.01	0.31	0.13
Job stability	0.00	0.56	0.02
Marital status	0.00	0.22	0.10
Stable, happy marriage	0.00	0.31	0.09
Drug or alcohol problem	0.00	0.34	0.00
Anxious or depressed	0.03	0.21	0.05
In trouble with the law	0.00	0.01	0.08
Lots of friends & social activity	0.00	0.31	0.24
Independent, self-reliant	0.00	0.73	0.08
Mature, helpful	0.03	0.21	0.05
Conscientious, reliable	0.01	0.47	0.08
Pleasant, agreeable	0.02	0.07	0.04

Note: p^2 = parental influence, h^2 = additive effect of genes, c^2 = shared environment of siblings, other than parents' trait. See Fig. 1 for full rating scales

contribution is larger than the shared environmental one.

Discussion

To summarize the design of the study: one-page questionnaires for rating various life outcomes were mailed to individuals, now adults, who as children had been assessed in the Texas Adoption Project. The same rating scales were sent to the parents and a number of siblings of these individuals, in order to obtain views of important aspects of the participants' current and past lives from multiple perspectives. Because of the unique characteristics of this sample—including biological children of the adoptive parents as well as adopted children—these ratings enable us to examine two kinds of questions. First, we can ask how the education, jobs, marriages, and personalities of the adopted children turned out as compared with those of biological children in these families. This is a matter of considerable interest to those concerned in one way or another with the adoption process. Second, we can address issues related to heredity and environment: Were the life outcomes of biologically related individuals in these families more similar than those of biologically unrelated individuals? What can this tell us about the roles of genes and environment in accounting for differences among the life outcomes of individuals? (Note that we are accounting for *differences* among individuals. Obviously, both genes and environments are essential for any life outcomes at all.)

With respect to the first question above, there were indeed a number of average differences between the biological and adopted children, although the effect sizes were not large, seldom exceeding one-third of a standard deviation. The biological children in these families were on average rated as having been better students in high school, as having received more education, and as having jobs of greater responsibility and more stable occupational histories. By contrast, the adopted children were rated as having more problems: they were more often anxious or depressed, and had had more trouble with the law. They were also rated as having fewer friends and less social activity, and as being less independent, mature, conscientious and agreeable. For other characteristics, such as marital status and number of friends in high school, there was little difference between the two groups. It was not that the adopted children received unfavorable ratings from their parents, their siblings, and themselves; it was just that their ratings were somewhat less favorable than those of the biological children.

Such an average difference between these groups of offspring can be interpreted in two ways. First, it might be all or in part due to the genes supplied by the two sets of parents. The genetic parents of the adopted children were *prima facie* less well adjusted in their lives than the parents who supplied the genes to the biological children, a hypothesis supported by the differences in scores of the two groups of mothers on the Minnesota Multiphasic Personality Inventory (Loehlin et al. 1982).

A second possible interpretation might emphasize environmental or interpersonal factors, such as emotional insecurity due to a sense of being abandoned by their birth mothers, or less positive expectations by the adoptive parents, or the like. Such possibilities are often discussed in the adoption literature (e.g., Brodzinsky and Schechter 1990).

Although this second category of interpretations cannot be completely ruled out, we note several limitations of such arguments. First, the adoptees in the present study did not begin under a cloud. At the time of the initial testing, the adopted children were rated as favorably by their parents as the biological children (Loehlin et al. 1990). If their later rating was lower, they apparently did something to earn it. Secondly, the psychological effects of adoption as such do not provide an explanation of why individual adopted children tend to resemble their birth mothers (Loehlin et al. 1987). And third, the patterns of parent-child and sibling resemblance in the present study lend themselves more readily to interpretation in terms of the genes than in terms of special environmental factors affecting adoptees. The latter factors, if powerful, and if varying from family to family as a result of parental beliefs and attitudes about adoption, might be expected to produce correlations among the adopted children in a family—correlations that were for the most part not observed.

What family correlations were observed, and how are they consistent with genetic hypotheses? First, on the whole, biologically related individuals tended to be more alike than non-biologically related individuals, suggesting a role of the genes in influencing life outcomes. The differences were not large, but on 17 of the 18 rating scales, for example, the intraclass correlations for biological sibships exceeded those for adoptive sibships, the latter being mostly close to zero (median = 0.08).

The parent-offspring correlations show similar tendencies, although less clearly. It should be remembered that we did not have multiple-informant ratings for the parents, just single self-ratings. Less reliable ratings would tend to attenuate correlations.

No doubt for a number of characteristics there is also restriction of range among adoptive parents (Stoolmiller 1999), again tending to reduce correlations. Nevertheless, two-thirds of the parent-offspring correlations under 0.10 were for adoptive relationships, and four-fifths of the correlations above 0.20 were for biological ones.

These general tendencies were supported by the model fitting. Estimates of the two environmental parameters p^2 and c^2 tended to be smaller than those for the genetic parameter, h^2. Indeed, the estimates of p^2 were frequently zero, to two decimal places, and for only two of 18 measures did they exceed 0.03. This implies, among other things, that direct imitation of parents by their children is at best a minor factor in life outcomes, at least in populations like this one.

Estimates of c^2, the environmental effects shared by siblings, ran a little higher, with a number of estimates in the 0.10 to 0.30 range. Siblings do seem to share features of their environments that produce lasting correlations among them for at least some outcomes, although not very high correlations.

The estimates of h^2, the effect of genes on various life outcomes, were for the most part substantially higher, with over half of them 0.25 or above. Among the outcomes that appeared to be most influenced by the genes were occupational stability and responsibility, personality traits such as independence and conscientiousness, having had many friends in high school, and being close to or distant from one's father during the school years.

How do our findings compare with those of previous studies in the literature? In general, they agree with the many studies that find adoptees to have somewhat less satisfactory outcomes than children born into similar family circumstances, and they extend this finding well into the adult years, into the 30s and 40s. Our data are consistent with the view that the primary factor involved is the genes: the adoptees come into their new families with some degree of genetic disadvantage relative to the children born into these families, that expresses itself gradually over time. It is usually not a severe handicap. Although there are exceptions, for the most part the adoptees are regarded by themselves, their parents, and their siblings as reasonably well adjusted, but not quite as much so as the biological children who shared these family environments.

How do our results compare specifically with those of the NEAD study (Loehlin et al. 2003; Reiss et al. 2000), which looked at genetic and environmental components of several dimensions of adjustment, but among adolescents and using a different design?

Our overall estimates of the effects of the genes on adjustment are somewhat lower than theirs, but theirs included non-additive genetic variance, because they had identical twins in their sample. For additive genetic variance alone, their estimates ranged from 0.05 to 0.44 across six dimensions, ours from 0.01 to 0.73 across the seven ratings intended to correspond to their dimensions. The heritabilities of individual traits did not match up especially closely: NEAD Antisocial behavior 0.33, TAP Drug or alcohol problem 0.34 and In trouble with the law 0.01; NEAD Depressive symptoms 0.05, TAP Anxious or depressed 0.21; NEAD Cognitive agency 0.44, TAP Excellent student in high school 0.21; NEAD Sociability 0.44, TAP Lots of friends and social activity 0.31; NEAD Autonomy 0.33, TAP Independent, self-reliant 0.73; NEAD Social responsibility 0.41, TAP Mature, helpful 0.21 (TAP figures from Table 9; NEAD figures from Loehlin et al. 2003, Table 6). Of course, extremely close agreement should not be expected: the NEAD figures are for adolescents, ours for adults; the NEAD composites are based on extensive batteries of interviews, questionnaires, and observations, ours on one-item ratings. Also, the populations are different, as the NEAD study includes stepfamilies resulting from remarriages, whereas ours were all infant adoptees; and the NEAD sample is nationwide, whereas ours originated in Texas.

How about the Big Five personality traits (or rather, the four of the Big Five that are represented in our questionnaire)? Existing research, mostly twin studies based on self-report questionnaires, suggests broad heritabilities largely in the 0.40s and 0.50s, tending not to vary much across the four dimensions, except that Agreeableness may be at the low end (Bouchard and Loehlin, 2001, Table 3). Our narrow heritabilities are in the range 0.07–0.47 for the corresponding four trait ratings, with Agreeableness the lowest.

On the whole, then, our results are reasonably consistent with other findings in the behavior genetic and adoption literatures, and they suggest that differences in adult outcomes, not only in adolescent adjustment, are likely to reflect the enduring influence of the genes.

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