HEREDITARY AND ENVIRONMENTAL SOURCES OF TRAIT VARIATION AND COVARIATION

by

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A dissertation submitted to the Faculty of the Graduate School of the State University of New York at Buffalo in partial fulfillment of the requirements for the degree of Doctor of Philosophy

May, 1972

ABSTRACT

The twin design for estimating proportions of hereditary and environmental sources of trait variation was presented and applied to a national sample of 806 twin sets who took the National Merit Scholarship Test in 1962. Parental report of differential treatment of their twins was used to test the assumption of equivalent within family environments by zygosity. A comparison of the sum of items reflecting differential treatment reported by the parents showed that identical twins are reported to be treated more alike than fraternal twins. Correlations of the treatment difference score with twin differences on the NMSQT and CPI scores showed a small but positive relationship between differential treatment and differences in measured achievement and personality. Within each actual zygosity group, the treatment difference scores of twins whose parents were correct about the zygosity diagnosis were compared to the scores of twins whose parents misdiagnosed them. These results indicated that parental behavior towards their twins is determined largely by the degree of genetic relatedness of their twins. However, the ordering of the treatment difference score means indicated that parental belief about zygosity also determined to some small degree their treatment of their twins. Within each zygosity group, the score differences on the NMSQT and CPI scales of twins correctly and incorrectly diagnosed by their parents were also compared, and the results showed that parental belief about zygosity has a small but consistant relationship to twin differences on measured achievement and personality. This series of analyses indicated that the assumption of equal between family environments by zygosity cannot be made, and that the environmental bias is greater for personality measures than for achievement measures. The assumption of equivalent between family environments by zygosity was also tested, and it was concluded that this assumption does not introduce a serious bias in this sample. Probable ranges of proportions of trait variance due to heredity, between family and within family environment were computed for each measure. Hereditary variation generally accounted for the majority of the variation in the NMSQT scales, and the between family environmental component was generally larger that the within family component. The heritability estimates of the CPI scales were quite varied, but in general the within family environmental component was larger than the between family component.

A multivariate method by which trait covariation can be partitioned into hereditary and environmental sources was presented and applied to the NMSQT scales. Matrices of cross twin correlations and correlations among twin differences were manipulated to produce hereditary and within and between family environmental matrices. The factor structures of these three component matrices were compared to the factor structure of the NMSQT. The verbal and math-science factor in the NMSQT were found in the hereditary and the within family environmental

matrices. Only a general factor was apparent in the between family environmental matrix. This indicated that the two factors in the NMSQT are controlled by somewhat different hereditary mechanisms as well as different within family environmental influences.

TABLE OF CONTENTS

ACKNOWLEDGEMENTS

This large data set was kindly provided by Robert C. Nichols. All computer programs used in these analyses were written by him or with his assistance. I wish to thank him for his inspiration, guidance, and extreme patience. Paul R. Lohnes, J. Ronald Gentile, S.David Farr, and Jeremy D. Finn contributed many useful suggestions in the preparation of this manuscript. Hunter Breland provided the necessary supportive and encouraging environment for its completion.

CHAPTER 1

Introduction

Twins have been used for almost 100 years to investigate the relative effects of heredity and environment on human behavior. The first studies of twins (Galton,1875; Thorndike, 1905; Merriman, 1924; Lauterbach, 1925; Kramer and Lauterbach, 1928) compared like-sexed twins to unlike-sexed twins. Wilder (1904) distinguished the biological difference between fraternal and duplicate (identical) twins, but Newman (1928) was the first to recognize the importance of this distinction for psychological studies and to give a set of rules for establishing the zygosity of a set of twins. Since that time, many psychological studies of twins have been done, most comparing the degree of similarity of identical twin sets to that of like-sexed fraternal twin sets. Results of previous studies of twins have been reviewed critically by Breland and Nichols (1972).

The rationale behind twin comparisons is a simple one. Identical twins have the same genetic make-up, and thus differences between them are due only to pre and post natal environmental dissimilarities. Like-sexed fraternal twins have about half their genes in common, and differences between twins of a set are due to genetic as well as environmental differences. The extent to which identical twins raised together are more

alike on a measured trait than are like-sexed fraternal twins raised together indicates the degree of genetic influence on that trait.

The most appropriate and commonly reported index of twin similarity is the intra-class correlation, which is calculated separately for MZ (identical) and DZ (fraternal) twins. A product moment correlation is inappropriate for establishing the common variance within twin sets, since there is no objective way to assign one twin to the x or y variable. However, with a large sample the intra-class correlation and the product-moment correlation with random assignment of twins to the x and y variable are practically identical numerically. Fisher (1958) noted that "The intra-class correlation is not an estimate equivalent to an inter-class (product-moment) correlation, but is somewhat more accurate." (Fisher, 1958, p.212) Fisher also noted that the intra-class correlation can be directly interpreted as a variance component. "The intra-class correlation will be merely the fraction of the total variance due to that cause which observations in the same family have in common." (Fisher, 1958, p.224)

The formula for calculating the intra-class correlation for MZ or DZ twin sets is:

$$r_i = \frac{MSB - MSW}{MSB + MSW}$$

where MSB is the mean squared deviation of twin set means about

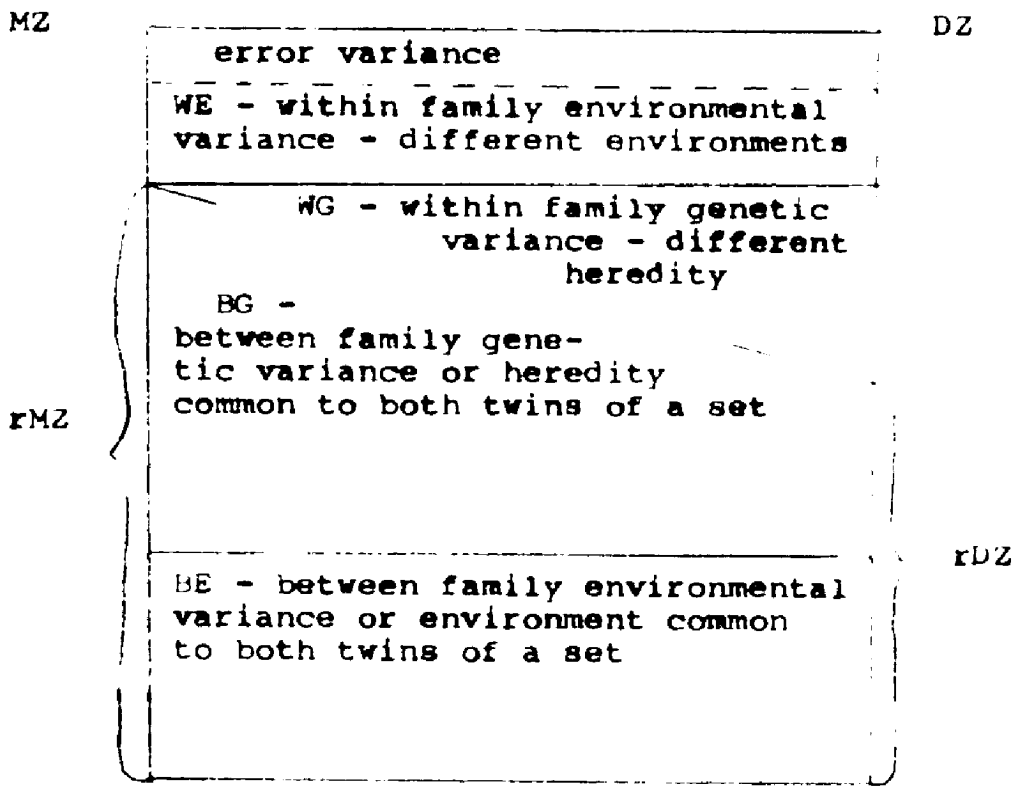
the grand mean, and MSW is the mean squared deviation of each twin about his set mean.

Nichols (1965) proposed a model by which observed twin correlations can be manipulated to provide theoretical estimates of the relative effects of heredity and environment on a measured trait. He proposed a schematic representation which describes the categories of events capable of producing individual differences on a measured trait. This diagram is shown in Figure 1. As the diagram shows, the major difference between the two kinds of twins in sources of individual differences is the presence of within family genetic variance (WG) in DZ twins which is absent in MZ twins. With certain assumptions, the proportion of variance due to WG can be represented by the difference between the two intra-class correlations. If it can be assumed that DZ twins have half their genes in common (reflected in the estimate of within family genetic variance) then the estimate of between family genetic variance (BG) can be obtained by equating it in value to WG.

Differences within sets of identical twins are due to different environmental experiences to which the twins were exposed. An estimate of the within family environmental variance (WE) can be computed by comparing the identical twin correlation to unity. The remaining environmental variance component, variance due to different environments between

Figure 1

Sources of Variance in Twin Data



The two vertical lines are of unit length and represent the total variance of a measured variable in MZ and DZ twins. The horizontal lines divide these variances into proportions attributable to genetic and environmental influences. Each of these proportions is divided into between family (influences that affect both twins of a set in the same way) and within family (influences with different effects on the two twins of a set) components. The intra-class correlations indicate the proportion of variance common to twins of a set and are, thus, operational measures of the between family variances BE + BG. (adapted from Nichols, 1965, p. 232.)

families (BE), can be calculated by subtracting the estimate of BG from the DZ correlation. On the basis of twin data alone, error cannot be separated from WE. However, correction of the intra-class correlations for attenuation due to unreliability will eliminate error variance from the diagram. The four theoretical variance components, then, can be calculated as follows:

$$WE = 1 - rMZ$$

$$BG = rMZ - rDZ$$

$$BE = WG$$

$$BE = rDZ - BG$$

$$H = WG + BG$$

Assumptions of the Twin Method

The assumptions on which the above formulas are based may not be entirely justifiable in any given instance, and they deserve careful consideration. The four major assumptions of the twin method are as follows:

1. Any greater behavioral similarity of MZ twins over DZ twins is the result of their greater genetic similarity. This assumption is implied when the proportion of variance due to within family genetic influences is calculated by subtracting the DZ correlation from the MZ correlation. There are two classes of environmental variables that might invalidate this assumption: (a) Environmental influences on the trait in question that produce more similar effects for MZ than for DZ twins. For example, MZ twins tend to dress alike, to spend more time together, and to be more frequently mistaken for each other than do DZ twins (Smith, 1965; Wilson, 1934; Scarr, 1969). To the extent that such variables influence the trait under investigation, WE will be underestimated and WG overestimated by the formulas given above. (b) Environmental influences on the trait in question that produce more similar effects for DZ than for MZ twins. For example, there may be more prenatal competition for blood and nutrients for MZ than for DZ twins (Price, 1950). The effect of some postnatal environmental influences may make DZ twins more alike. For example, the DZ twin that is genetically more extreme on some trait may

be subjected to pressures to conform to the more normal twin. Vandenberg (1967) has suggested that some parents of twins tend to magnify differences within MZ sets; parents of DZ twins may minimize these differences. To the extent that these variables influence the trait under investigation, WG will be underestimated by the formulas given above.

2. Environmental influences affecting twins are not different from those affecting more typical family configurations. Choice of the twin design assumes that inferences may be made from them concerning human behavior generally. It is likely that both MZ and DZ twins share more common experiences within a family than do ordinary siblings (Wilson, 1934), if only because the twins are the same age. To the extent that these more common experiences influence the trait being studied, WE will be underestimated and BE will be overestimated by using only a twin sample. In terms of Figure 1, violations of this assumption will spuriously raise (or conceivably lower) both rMZ and rDZ, altering the proportions of variance attributed to WE and BE without affecting the estimates of the genetic variance.

3. Random mating for the trait exists in the population, and all genetic variance is additive. These two assumptions allow for the calculation of WG = BG, and heritability as 2 (rMZ - rDZ).

Assortative mating, the preferential mating of like

phenotypes (or, in the case of negative assortative mating, the preferential mating of unlike phenotypes) clearly occurrs for intelligence and some personality traits. To the extent that the phenotype of the parents indicates their genotype, that is, to the extent that the trait is heritable, the genotypes of the parents will be more similar than those of two people chosen at random from the population. An increase in genetic similarity of the parents will increase the genetic similarity of their offspring. Positive assortative mating for heritable traits reduces the within family genetic variance, and increases the population genetic variance. Using the formula WG = BG, then, will underestimate BG, and 2 (rMZ - rDZ) will underestimate heritability.

The effect of assortative mating on heritability estimates is dependent on the heritability of the trait and on the observed phenotypic correlation between mates on that trait. Spuhler (1967) has summarized the correlation between mates for selected measures reported in the literature. His summary is reported in Table 1.

Inbreeding, the mating of people with some degree of common ancestry, has the same effect of increasing the similarity of the offspring. However, in the case of inbreeding, all segregating loci are affected, whereas in assortative mating, only those loci associated with the trait are affected. It is unlikely that inbreeding plays an important role in

TABLE 1

ASSORTATIVE MATING FOR INTELLIGENCE TEST SCORES, PERSONALITY RATINGS, AND MISCELLANEOUS CHARACTERISTICS

(Tetrachoric correlations are shown without signs.)

Item	*Source*	*N pairs*	*r*
Intelligence scores			
Stanford-Binet	Burks, 1928	174	.47 ± .04
Otis	Freeman *et al.*, 1928	150	.49 ± .04
Army Alpha	Jones, 1928	105	.60 ± .04
Progressive Matrices	Halperin, 1946	324	.76
Various tests	Smith, 1941	433	.19 ± .03
Vocabulary	Carter, 1932	108	.21 ± .06
Arithmetic	Carter, 1932	108	.03 ± .06
Mental Grade	Penrose, 1933	100	.44
Personality ratings			
Neurotic Tendency	Hoffeditz, 1934	100	.16 ± .07
Neurotic Tendency	Terman and Buttenwieser, 1935	126	.11 ± .06
Neurotic Tendency	Terman and Buttenwieser, 1935	215	.22 ± .04
Neurotic Tendency	Willoughby, 1928	100	.27 ± .05
Self-sufficiency	Hoffeditz, 1934	100	.09 ± .07
Self-sufficiency	Terman and Buttenwieser, 1935	215	.12 ± .04
Self-sufficiency	Terman and Buttenwieser, 1935	126	.02 ± .06
Dominance	Hoffeditz, 1934	100	.15 ± .07
Dominance	Terman and Buttenwieser, 1935	126	.24 ± .06
Dominance	Terman and Buttenwieser, 1935	215	.29 ± .04
Introversion-extroversion	Terman and Buttenwieser, 1935	126	.02 ± .06
Introversion-extroversion	Terman and Buttenwieser, 1935	215	.16 ± .04
Miscellaneous			
Temperament	Burgess and Wallin, 1944	316	.22
Insanity	Goring, 1909	1433	.06
Criminality	Goring, 1909	474	.20

from Spuhler, 1967, p. 262.

most twin samples, however.

Genetic variance can be reduced to two parts, that accounted for by the additive effects of the genes, and a non-additive component, which includes dominance and epistasis effects. This non-additive effect arises from the additional effects of combining genes into pairs or into groups of pairs. Dominance is the interaction of genes at more than one locus. Existence of dominance and epistasis increases the genetic variance over that which is accounted for by the additive effects of the spearate genes influencing the trait.

Falconer (1960) showed how these genetic components explain variance within and between twin sets. From Table 2 it can be seen that doubling the difference between the the MZ and DZ correlations provides an estimate of $V_A = 1\frac{1}{2}V_D$, which is an overestimate of heritability. Existence of epistasis will cause the heritability estimate to be further overestimated. Unfortunately, the precise amount of non-additive variance in human trait variation is unknown, and their effects cannot be investigated by the twin method alone. Positive assortative mating will decrease the bias introduced by dominance, however. If the DZ twins share more than half their genes, the joint probability of their being identical at two loci is greater than .25. As this

Table 2

Composition of the Components of Variance

Between and Within Pairs of Twins *

	Between Pairs (r)	Within Pairs (1 - r)
Identicals	$V_A + V_D + V_{Ec}$	V_{Ew}
Fraternals	$\frac{1}{2}V_A + \frac{1}{4}V_D + V_{Ec}$	$\frac{1}{2}V_A + \frac{3}{4}V_D + V_{Ew}$
Difference	$\frac{1}{2}V_A + \frac{1}{4}V_D$	$\frac{1}{2}V_A + \frac{1}{4}V_D$

where V_A is additive genetic variance

V_D is dominance variance

V_{Ec} is common environmental variance, assumed to be the same for both kinds of twins

V_{Ew} is variance due to different environments, assumed to be the same for both kinds of twins

*Adapted from Falconer, 1960, p. 184

probability approaches .50, the biasing effect of dominance on the heritability estimate will disappear.

4. An important factor in twin research is obtaining accurate diagnosis of twin sets as MZ or DZ. This is done by comparing the twins of a set on a number of different characteristics known to be genetically determined. If the twins are definitely unlike on any one genetically determined characteristic, they are diagnosed as DZ. If the twins are alike on a number of genetically determined characteristics, it is probable that they are MZ. However, there is always the possibility that DZ twins may be alike on the observed characteristics by chance. The probability of erroneous diagnosis of DZ twins as MZ depends on the number of characteristics examined, the gene frequency in the population from which the twins are sampled, and the parental genotype. Accurate diagnosis of zygosity is essential to the twin method, since misclassified twin sets will artificially reduce the difference between the observed intraclass correlations for MZ and DZ twins.

The characteristics most frequently used for diagnosis in psychological studies are hair color, texture and curliness; eye color; height; skin complexion; ear lobe attachment; mid-digital hair; PTC tasting; fingerprints; and general facial physiogamy. Some recent studies have relied almost exclusively on blood groups for diagnosis. Blood groups

have the desirable characteristics of very high penetrance of the genotype, high reliability of measurement and apparently complete independence of the behavioral traits under investigation. If carefully done, the major errors in blood diagnosis are the misclassification of DZ twins who are alike on all measured blood groups by chance. Maynard-Smith and Penrose (1955) have tabled the probability of chance similarity for various blood groups, and from their data errors of misclassification in Caucasian populations may be estimated as about 2%.

Nichols and Bilbro (1965) compared the accuracy of zygosity diagnosis based on questionnaire reports of observable physical characteristics with blood diagnosis, and found the questionnaire diagnosis to be about 93% accurate. They concluded that diagnosis on the basis of readily observable physical characteristics could easily be accomplished with about this degree of accuracy. However, some MZ twins do not look exactly alike, and would be misclassified as DZ, despite most careful observations.

Blood diagnosis tends to misclassify some DZ twins as MZ (about 2%) and diagnosis on the basis of observable physical characteristics tends to misclassify some MZ twins as DZ (about 7%). Twin correlations can be corrected for any assumed degree of misclassification by the following formulas.

$$r_{MZ\ true} = \frac{r_{MZ\ observed} - (r_{DZ}\ E_{MZ})}{1 - E_{MZ}}$$

and

$$r_{DZ\ true} = \frac{r_{DZ\ observed} - (r_{MZ}\ E_{DZ})}{1 - E_{DZ}}$$

where E_{DZ} is the proportion of DZ twins erroneously diagnosed

E_{MZ} is the proportion of MZ twins erroneously diagnosed

Adjustments for Assumptions

Loehlin (in press) has proposed an expansion of the formulas for estimating variance components from twin data by the addition of constants that make adjustments for deviations from the assumptions previously discussed. These constants may be set to reasonable values based upon additional observations or theory, or they may be varied systematically to study their effect upon estimates of variance components for any given trait. The formulas for the estimation of hereditary and environmental variance components proposed by Loehlin are as follows:*

$$WE = K1\ (1 - rMZ)$$

$$WG = (1 - K2\ rDZ) - WE$$

$$BG = K3\ WG$$

$$BE = (K2\ rDZ) - BG$$

where K1 is a constant which reflects the effect of differential environmental similarity of MZ twins as compared to ordinary siblings,

K2 is a constant which reflects the effect of differential environmental similarity of DZ twins as compared to ordinary siblings, and

K3 is a constant which adjusts for the degree of assortative mating, genetic dominance and epistasis.

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* The twin correlations should first be corrected for attenuation and probable errors of zygosity diagnosis.

For greater ease in computing heritability estimates from twin data, Loehlin's formulas may be altered in a manner that does not affect his logic. These are the formulas which will be used in further calculations:

$$WE = K1\ (1 - rMZ)$$

$$WG = (1 - rDZ) - WE$$

$$BG = K3\ WG$$

$$BE = rDZ - BG$$

K1 has been redefined as a constant which reflects the differential within family environments of MZ and DZ twins. This value, the theoretical ratio of WE for DZ sets to WE for MZ sets, can be investigated with a twin sample alone, and it is the only environmental adjustment which affects estimates of heritability. The observation that twins in general may have more similar environments than do singletons will alter the relative proportions of BE and WE, but will not affect the estimates of genetic components. In the case where MZ twins have more similar environments than do DZ twins, K1 will be greater than unity. In the case that MZ twins have less similar environments than do DZ twins, the value will be less than unity.

K3, the adjustment factor which accounts for violation of the assumptions of random mating and purely additive genetic effects, is the same as that suggested by Loehlin.

If assortative mating can be shown for the trait, WG must be multiplied by some constant K3, to yield an estimate of BG. In the case of positive assortative mating, this constant will be greater than unity. In the case of negative assortative mating, it will be less than unity. The resulting heritability estimate, derived from the sum of the BG and WG components, can then be considered as the upper limit to the true population heritability, since it may be somewhat inflated due to dominance and epistasis effects.

CHAPTER 2

Sampling Procedure and Simple Data Description

In the spring of 1962, the National Merit Scholarship Qualifying Test was administered to 596,241 high school juniors throughout the United States. As part of the general information collected from this sample, each participant was asked if he or she had a twin. A total of 1507 pairs of participants reported the same last name, address, high school and sex.

Each twin was then sent a questionnaire developed by Nichols and Bilbro (1965) to determine their zygosity. The questionnaire included items concerning the twins' physical characteristics and the frequency of their being mistaken for one another. A copy of this questionnaire is reproduced in Appendix 1. Seventy-nine per cent returned this zygosity questionnaire.

All twins who returned the zygosity questionnaire were then sent a package of questionnaire materials which required about three hours to answer. Complete packets were obtained from 72% of this sample. Questionnaires were also sent to the twins' mother, teacher and friend. The data used in the present study were taken from only the student and parent questionnaires, which have been reporduced in Appendices 2 and 3. The present sample includes 489 identical twin sets and 317 fraternal twin sets.

This sample is not a random sample of all twins who were born in 1945-6, however. Students of lower ability are not as likely to have taken the NMSQT, and therefore were missed by this sampling procedure. The restriction that both co-twins attend the same school excluded sets reared apart, as well as twins with great ability differences such that one twin of a set was in a different grade level or attended a special school. While it is expected that there are approximately equal numbers of identical twins as like sexed fraternal twins in the population, the present sample includes a disproportionate number of identical twins. Likewize, as often is the case with mailed questionnaires, more females responded than did males.

Two sets of dependent variables were chosen from those available. The five NMSQT subscales and the NMSQT selection score were obtained from the testing program. Included with the student questionnaire was the California Psychological Inventory. All 18 original scales of the CPI (Gough, 1967) were scored, as well as 6 additional scales: Rigidity (Rehfisch, 1958), Managerial (Goodstein and Schrader, 1963), Aquiescence and Social Desirability (Dicken, 1963), and Factor I, Value Orientation and Factor II, Person Orientation (Nichols and Schnell, 1963).

Means and standard deviations of average twin set scores on all dependent variables are shown in Table 3.

Table 3

Means and Standard Deviations of Average Twin Set Scores on the NMSQT and CPI

(NMZ = 489, NDZ = 317)

Scale	Mean MZ	S.D. MZ	Mean DZ	S.D. DZ
NMSQT Scales				
English Usage	19.54	4.44	20.05	3.93
Mathematics Usage	20.99	5.88	21.42	5.45
Social Studies Reading	20.59	4.58	20.58	4.28
Natural Science Reading	19.75	5.33	20.32	4.94
Word Usage	20.97	4.67	21.10	4.14
Selection Score	101.84	21.45	103.47	19.62
CPI Scales				
Dominance	27.12	5.19	27.48	4.74
Capacity for Status	18.45	3.43	18.57	3.55
Sociability	24.48	4.38	24.34	4.18
Social Presence	33.68	4.78	33.59	4.58
Self Acceptance	20.97	3.25	21.14	3.03
Sense of Well Being	36.06	4.00	35.51	3.79
Responsibility	32.42	3.66	32.58	3.33
Socialization	40.56	4.37	40.17	4.21
Self Control	29.32	6.97	28.37	6.07
Tolerance	22.48	4.18	22.59	3.98
Good Impression	17.19	5.09	16.37	4.74
Communality	26.26	1.60	26.30	1.28
Achievement via Conform.	27.57	3.76	26.97	3.44
Achievement via Indepen.	19.60	3.78	19.55	3.42
Intellectual Efficiency	38.84	4.45	38.68	3.97
Psychological Mindedness	10.91	2.24	10.69	2.10
Flexibility	9.36	3.22	9.22	2.82
Femininity	21.10	4.53	20.99	4.50
Factor I	73.65	11.99	71.75	11.19
Factor II	30.24	6.90	30.25	6.51
Rigidity	13.34	3.01	13.32	2.75
Managerial	142.25	16.24	142.36	14.36
Acquiescence	15.11	2.86	15.26	2.54
Social Desirability	19.58	3.64	19.06	3.62

CHAPTER 3

Explaining Twin Differences

One assumption of the heritability formulas previously described is that the environmental similarity of identical twins is not different from that of fraternal twins on within family variables relevant to the dependent variables under study. Errors in heritability estimates due to the violation of this assumption can be adjusted by the proposed K1 constant.

The hypothesis of differential within family treatment by zygosity can be tested in part by examining selected items from the parent questionnaire. The parent was asked to respond to a number of items concerning the past and present family environments of the twins. Those items which were judged as reflecting different parental treatment of the twins were selected, and are listed in Appendix 4.*

Each of these items was scored dichotomously. A score of zero indicated that the twins were treated alike on the item, that is the parent indicated that the item was true of both twins or neither twin. The item was scored 1 if the parent indicated that it was true of one twin but not of the other. The scores were summed across 69 items which

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* These items were selected from the Parent Questionnaire by John Loehlin in consultation with Robert Nichols in 1968.

included reports about infant, preshcool, childhood and adolescent treatment differences. The total score for each twin set indicated the degree of differential treatment the twin set reportedly received. A low score indicated that the set was reported to be treated alike on these dimensions; a high score indicated that the twins were reported to be treated differently.

A one-way analysis of variance by zygosity was performed on the within family treatment difference score for each twin set. The means and standard deviations for the groups are reported in Table 4. A test of the zygosity difference yielded an F of 143.79, evaluated with 1 and 823 degrees of freedom, which is significant at the .01 level. However, the corresponding eta was .148, indicating that only about 2% of the variance in the within family treatment difference score could be explained by zygosity. A comparison of the means showed that DZ twins are only .79 standard deviations above the mean for MZ twins on this score.

Existence of a difference on the within family treatment score by zygosity allows for further analysis in two directions. First, this different treatment scale can be used as a predictor for twin differences on measured abilities and personality. Secondly, possible causes of the zygosity difference can be investigated.

The relatively small difference between zygosity groups

Table 4

Means and Standard Deviations by Zygosity

on the Within Family Treatment Difference Score

	MZ	DZ	Total
Mean	11.66	14.63	12.82
Standard Deviation	3.26	3.79	3.77
Number of Sets	501	323	824

on this differential treatment score may be due to several factors. The questionnaire asked the parent, usually the mother, to report about the early development of the twins, who were high school juniors at the time of the study. It is quite likely that the parent could not accurately recall all of the early treatment differences requested by these items. Secondly, this item set includes only a limited number of dimensions upon which twin treatment differences might have occurred. The items include questions concerning only gross treatment differences by the parents, and may not sample all of the subtle treatment differences which could yield a larger discrepancy between zygosity groups. Likewize, differential treatment by the twins' teachers, friends or other relatives would not be reflected by the different treatment score. This observed zygosity difference on the within family treatment score, then, might be considered as a very conservative estimate of the actual treatment differences experienced by the twins.

It is hypothesized that differential treatment within families is one of the factors causing the twins of a set to have different scores on measured achievement and personality. An absolute difference between each of the twins' scores on all ability and personality scales was computed spearately for MZ and DZ twins. A one-way analysis of variance by zygosity was computed on these difference scores,

and the results are reported in Table 5. As was expected, dizygotic twins were significantly more different than monozygotic twins on all NMSQT scales. All CPI scales showed greater average score differences between DZ sets than between MZ sets, though 5 of the comparisons did not reach significance at the .01 level.

Differential within family treatment as measured by the previously selected parent questionnaire items should explain some of the variance of the twin differences on these criterion variables. The differential treatment scores were therefore correlated with the twin difference scores separately for MZ and DZ sets, and are reported in Table 6.

The correlations of treatment difference scores and the within set difference scores on measured ability and personality proved to be quite low. The different treatment score did not predict a statistically significant proportion of the variance of twin differences on any of the NMSQT scales. While some of the correlations between the treatment difference score and twin differences on the CPI scales reached statistical significance, the strength of prediction was very weak. The highest correlation observed was .192 between reported treatment differences and Self Control Difference for DZ twins. This indicated that less than 4% of the variance in Self Control difference between DZ sets could be explained by the parents' report of different treatment

TABLE 5

Means and Standard Deviations of

Twin Difference Scores (Absolute Values)

on The NMSQT and CPI Scales

	MZ (N=509)		DZ (N=330)		
	M	SD	M	SD	F
NMSQT Scales					
English Usage	2.57	2.09	3.43	2.43	30.25**
Mathematics Usage	3.42	2.88	4.95	4.09	40.69**
Social Studies Reading	2.60	2.06	3.77	2.90	46.48**
Natural Science Reading	3.43	3.04	4.15	3.37	10.05**
Word Usage	1.98	1.70	3.00	2.48	49.39**
Selection Score	8.58	6.97	14.65	11.07	95.12**
CPI Scales					
Dominance	4.24	3.71	5.45	4.41	18.49**
Capacity for Status	2.69	2.21	3.23	2.64	10.00**
Sociability	3.58	3.08	4.61	3.94	18.09**
Social Presence	3.89	3.24	5.47	4.25	36.99**
Self Acceptance	2.86	2.34	3.42	2.74	10.09**
Sense of Well Being	3.33	3.11	4.16	3.53	12.79**
Responsibility	2.99	2.66	3.31	2.93	2.63
Socialization	3.36	3.12	4.22	3.68	13.49**
Self Control	5.48	4.65	6.50	5.40	8.43**
Tolerance	3.34	3.07	4.29	3.22	18.31**
Good Impression	4.61	3.76	5.13	4.49	3.33
Communality	1.32	1.66	1.48	1.45	2.10
Achievement via Conform.	3.36	2.95	4.39	3.63	20.37**
Achievement via Indep.	3.05	2.60	3.35	2.74	2.64
Intellectual Efficiency	3.72	3.21	4.33	3.22	7.11**
Psychological Minded.	2.10	1.87	2.54	2.02	10.03**
Flexibility	2.92	2.37	3.48	2.78	9.66**
Femininity	2.88	2.44	3.38	2.66	7.73**
Factc I	9.45	8.28	12.12	10.18	17.31**
Factor II	5.40	4.48	7.41	5.81	23.71**
Rigidity	2.68	2.35	3.37	2.85	14.81**
Managerial	12.21	10.87	15.29	12.38	14.45**
Aquiescence	2.77	2.28	3.17	2.62	5.52*
Social Desirability	3.32	2.67	3.99	3.11	14.49**

** Significant at the .01 level
* Significant at the .05 level

TABLE 6

Correlations of Treatment Difference Score and Twin Difference Scores (Absolute Values)

NMSQT scales	MZ (N=501)	DZ (N=323)
English Usage	.031	.013
Mathematics Usage	.079	.066
Social Studies Reading	.062	.038
Natural Science Reading	-.041	.071
Word Usage	-.010	.095
Selection Score	.078	.080
CPI Scales		
Dominance	.054	.050
Capacity for Status	.109*	.040
Sociability	.035	.087
Social Presence	.049	.074
Self Acceptance	.038	.042
Sense of Well Being	.097*	.074
Responsibility	.016	.122*
Socialization	.101*	.098
Self Control	.040	.192**
Tolerance	.063	.142*
Good Impression	.042	.135*
Communality	.025	.027
Achievement via Conformance	.033	.162**
Achievement via Independence	.018	.058
Intellectual Efficiency	-.038	.033
Psychological Mindedness	.078	.013
Flexibility	.013	.068
Femininity	.020	.069
Factor I	.090*	.179**
Factor II	.131**	.062
Rigidity	.056	.066
Managerial	.091*	.139*
Acquiescnece	.007	.111
Social Desirability	.048	.037

** Significant at the .01 level
* Significant at the .05 level

of their twins.

While few of the individual correlations between the treatment difference score and the criterion scores reached statistical significance, the consistency of the results warrant further interpretation. All but two of the 12 correlations computed between NMSQT difference scores and the treatment difference score were positive. This consistency indicates that, while the relationship is very weak, in general the greater the reported treatment differences, the greater the difference between the twins on measured ability. The very small correlations may be explained in part by the low reliability of the treatment difference score and twin differences on the NMSQT scales. While the average reliability of the five NMSQT scales reported in the test manual is about .88, the reliability of the differences between twins within a set on any NMSQT scale is much lower, perhaps in the .4 range. The reliability of the treatment difference score is not known, but might be estimated at .5. If the average correlation of .046 between measured ability differences and the treatment difference score is corrected for this estimated unreliability, a theoretical correlation of about .10 is obtained, which still indicates a weak relationship. However, the items which were summed to create the different treatment score most likely represent only a small proportion of the actual

dimensions upon which the twins may have been treated differently. Subtle treatment differences not sampled by these items may be a major determinant of twin differences in achievement. In addition, parents are being asked to recall some treatment differences to which they subjected their twins in infancy and childhood, and the accuracy of their report 16 years later is somewhat questionable. Furthermore, twin differences in measured achievement may be related to treatment by individuals other than the parent, such as teachers, friends, or other siblings, or to the interaction between a twin and his co-twin. All of these factors would tend to supress the true relationship between differential treatment of the twins within a set and their difference in actual achievement. The corrected correlation between the two measured variables of .10, then, must be considered as the lower limit of the true correlation. If all relevant dimensions could be observed and measured, this correlation might be considerably greater.

The correlations between CPI score differences and the parental treatment score may be corrected in a similar manner. All but one of the 48 correlations were positive, again indicating a consistent positive relationship between reported treatment differences and measured personality differences. The average reliability of the CPI scales reported in the test manual is about .65. The average

reliability of twin differences on any CPI scale would be much lower, and might be estimated as about .3. Assuming that the reliability of the parental report of differential treatment is about .5, the average correlation of the CPI differences and the different treatment score can be corrected. The correlation of .067 corrected by these two reliability eatimates yields a theoretical correlation of about .17.

The true relationship between differential treatment and twin differences in personality is obscured as well by the validity of the parents' report of their differential treatment of their twins. Furthermore, the CPI scales most likely measure only part of all relevant dimensions of adolescent personality. The theoretical correlation of twin differences in personality and the total differential treatment they received throughout their development is most likely greater than .17.

While the observed correlations between reported treatment differences of twins and twin differences on achievement and personality measures is very low, a positive relationship persists on almost all individual subscales despite low reliability and questionable validity. This suggests that differential treatment by zygosity may introduce an appreciable bias in heritability estimates of achievement and personality. While the environmental bias appears to be small for the achievement measures, these results indicate that it may be considerably larger in the personality domain.

Factors Determining Differential Treatment

While it has been shown that, within the present sample, MZ twins are reported to be treated more alike by their parents than are DZ twins, further analysis is needed to discover the origin of the difference. Scarr (1969) noted that this fact alone is not sufficient to conclude that an environmental bias artificially inflates heritability estimates derived from twin comparisons. She suggested two alternative hypotheses which could explain the reported treatment differences by zygosity. If parents of twins encourage the development of differences between DZ twins and discourage the development of differences between MZ twins because they believe DZ twins ought to be different and MZ twins ought to be alike, then an environmental bias would exist. If this is the case, intra-pair differences for MZ twins will be artificially reduced and differences within DZ sets will be artificially inflated. Since the excess of DZ twin differences is proposed to be purely genetic in origin, the existence of parental pressures would introduce an environmental bias.

However, another explanation of differential parental treatment by zygosity can be proposed which would not indicate the existence of an environmental bias. More similar treatment of MZ twins may be due to their greater genotypic, and therefore greater phenotypic similarity. If parental treatment is simply a response to the similarity of the

twins' behavior which arises from their degree of genetic similarity, then an environmental bias does not exist.

Scarr (1969) proposed a clever design by which these two opposing hypotheses can be tested. She noted that parents are not always correct in diagnosing their twins' zygosity. If MZ twins believed to be DZ by their parents are treated more differently than MZ twins correctly diagnosed by their parents, it can be concluded that parental beliefs determine their behavior toward their twins. The same comparison can be made between correctly and incorrectly classified DZ twins. However, if parents who are mistaken about their twins' zygosity treat them more like their actual zygosity group, then it can be concluded that differential treatment by zygosity is induced by the degree of genetic relatedness of the twins. Unfortunately, Scarr's sample of twins was too small to yield statistically significant results. Her findings indicated, however, that differential treatment by zygosity was due to the degree of genetic similarity of the twins, and that the alleged environmental bias did not exist.

Scarr's design can be applied to the present data. Item 24 of the Parent Questionnaire asked:

> "As you know, there are two kinds of twins: identical twins which have the same heredity, and fraternal twins which have different heredity. Which kind are your twins?

I am certain they are identical twins
I think they are identical twins, but I am not certain
I don't know which kind they are
I think they are fraternal twins, but I am not certain
I am certain they are fraternal twins."

The parents' belief about the zygosity of their twins was compared with the diagnosis of twin zygosity based on the zygosity questionnaire. Eighty-eight sets of twins who were diagnosed as MZ by the zygosity questionnaire were thought to be DZ by their parents. Fifty-three sets of twins diagnosed DZ by the zygosity questionnaire were thought to be MZ by their parents. The 23 sets whose parents responded "I don't know which kind they are" were omitted from this analysis.

The total different treatment score was used to indicate the degree of similarity of parental treatment of the twins. Recall that, according to the parents' report, DZ twins are treated significantly more differently than MZ sets when the zygosity questionaire diagnosis was used. (See Table 4.) The different treatment scores of the twins correctly diagnosed by their parents were compared to the scores of those twins incorrectly diagnosed within each actual zygosity group. The means and standard deviations for these two comparisons are shown in Table 7.

The comparison of the treatment difference score of MZ twins thought to be DZ by their parents to the score of

TABLE 7

Means and Standard Deviations of Different Treatment Score by Parental Diagnosis Within Actual Diagnosis

	Actual MZ		
	Parents Diagnose MZ (N=406)	Parents Diagnose DZ (N=88)	
Mean	11.70	11.53	
S.D.	3.37	2.84	F=.18
	Actual DZ		
	Parents Diagnose DZ (N=257)	Parents Diagnose MZ (N=53)	
Mean	14.91	13.45	
S.D.	3.73	3.84	F= 6.71*

* Significant at the .05 level

MZ twins correctly diagnosed yielded no significant difference. Within the actual DZ group, however, a significant difference was found between the treatment difference score of the twins correctly diagnosed by their parents and those incorrectly diagnosed. While DZ twins thought to be MZ by their parents are treated more alike than DZ twins correctly diagnosed, the mean difference is quite small. However, the ordering of the four groups along the dimension of reported parental treatment difference is that which would be predicted by the hypothesis that parental beliefs determine differential treatment. The twins whose treatment difference scores are the lowest are the MZ twins correctly diagnosed by their parents, followed by the actual MZ twins thought to be DZ by their parents. DZ twins whose parents believe them to be MZ have lower treatment difference scores than the DZ twins correctly diagnosed by their parents. Again, low reliability and questionable validity of the treatment difference score would tend to supress actual differences among these four group means. If all relevant dimensions of treatment difference could be measured accuratly, the spread among the four group means might be considerably greater.

These results indicate that the major determinant of the degree of treatment difference reported by the parents is the actual genetic similarity of the twins. While parental belief about the zygosity of their twins does not produce large differences within actual zygosity groups,

the ordering of the group means lends support to the hypothesis that parental belief about zygosity also determines to some extent their reported treatment of their twins. It seems reasonable to conclude, therefore, that heritability estimates based on twin comparisons are contaminated to some small degree by this environmental bias, and that some correction factor is justified.

Parental belief about their twins' zygosity has been shown to have a small but convincing relationship to the amount of differential treatment the twins reportedly received. In addition, the reported differential treatment has a small but consistent relationship to twin differences on measured achievement and personality. The relationship between parental belief about zygosity and twin differences in measured achievement and personality might indicate the extent to which the environmental bias affects heritability estimates of these measures.

The twins' belief about their own zygosity most likely coincides with the zygosity diagnosis provided by their parents. It is not unreasonable to assume that significant others such as friends, teachers, or other relatives also share the parents' belief about the twins' zygosity. Perhaps MZ twins' behavior is more similar than that of DZ twins because they believe that they ought to be alike, or because others in their life space believe they should

be alike. If this is the case, it would be expected that MZ twins whose parents, and presumably the twins themselves, think they are DZ ought to show greater behavioral differences as measured by achievement and personality scales. Likewize, under this hypothesis, DZ twins who are misdiagnosed as MZ ought to show smaller behavioral differences than DZ twins correctly diagnosed. If these relationships hold, evidence for an environmental bias in heritability estimates of achievement and personality scales would gain further support. However, if twin differences on measured achievement and personality are identical regardless of the parental disgnosis of zygosity, existence of an environmental bias for these measures would be questionable.

The twin set difference scores on the NMSQT and CPI scales were analyzed separately for actual MZ and DZ sets as determined by the zygosity questionnaire. Within each actual zygosity group, the difference scores of the twins whose parents, and presumably the twins themselves, were correct about their zygosity were compared to those whose parents were incorrect about their zygosity. The means and standard deviations of these difference score comparisons are shown in Table 8 and Table 9.

On the NMSQT scales within the actual MZ group, one comparison reached significance at the .05 level. MZ twins classified correctly by their parents were actually more different on English Useage than MZ twins misclassified.

TABLE 8

Means and Standard Deviations of MZ Twin Differences on NMSQT and CPI Scales by Parental Zygosity Diagnosis

	Parents Diagnose MZ (N=412)		Parent Diagnose DZ (N=90)		
	M	SD	M	SD	F
NMSQT Scales					
English Usage	2.66	2.18	2.16	1.67	4.29*
Mathematics Usage	3.44	2.92	3.44	2.79	.00
Social Studies Reading	2.63	2.09	2.44	1.95	.58
Natural Science Reading	3.40	3.03	3.64	3.17	.46
Word Usage	2.00	1.65	1.83	1.81	.75
Selection Score	8.64	6.93	8.59	6.95	.00
CPI Scales					
Dominance	4.33	3.18	3.71	3.24	2.09
Capacity for Status	2.67	2.22	2.77	2.22	.13
Sociability	3.59	3.11	3.27	2.82	.84
Social Presence	3.85	3.17	4.11	3.54	.47
Self Acceptance	2.87	2.35	2.87	2.29	.00
Sense of Well Being	3.23	2.92	3.83	3.89	2.76
Responsibility	2.93	2.65	3.24	2.79	1.01
Socialization	3.24	3.16	3.18	2.99	.43
Self Control	5.35	4.54	6.04	5.20	1.66
Tolerance	3.26	3.10	3.72	2.99	1.63
Good Impression	4.43	3.72	5.50	3.90	6.04*
Communality	1.24	1.41	1.76	2.52	7.27**
Achievement via Conform.	3.43	3.03	3.02	2.56	1.42
Achievement via Indepen.	3.02	2.57	3.14	2.77	.16
Intellectual Efficiency	3.66	3.26	4.06	3.03	1.15
Psychological Mindedness	2.10	1.85	2.13	2.01	.02
Flexibility	2.84	2.31	3.20	2.65	1.68
Femininity	2.86	2.50	3.01	2.23	.27
Factor I	9.27	8.30	10.33	8.42	1.21
Factor II	5.39	4.52	5.29	4.31	.03
Rigidity	2.62	2.29	2.88	2.67	.86
Managerial	12.17	10.64	12.53	12.21	.08
Aquiescence	2.75	2.25	2.81	2.47	.06
Social Desirability	3.21	2.65	3.31	2.85	.11

** Significant at the .01 level
* Significant at the .05 level

TABLE 9

Means and Standard Deviations of DZ Twin Differences on NMSQT and CPI Scales by Parental Zygosity Diagnosis

	Parents Diagnose DZ (N=261)		Parents Diagnose MZ (N=53)		
NMSQT Scales	M	SD	M	SD	F
English Usage	3.50	2.48	3.34	2.66	.19
Mathematics Usage	5.07	4.13	4.45	4.19	.99
Social Studies Reading	3.90	3.01	3.34	2.15	1.65
Natural Science Reading	4.19	3.44	4.11	3.21	.02
Word Usage	3.03	2.49	2.91	2.64	.12
Selection Score	15.13	11.39	13.32	10.31	1.15
CPI Scales					
Dominance	5.58	4.45	5.06	4.40	.61
Capacity for Status	3.37	2.72	2.53	2.25	4.45*
Sociability	4.84	4.02	3.96	3.76	2.16
Social Presence	5.70	3.49	4.92	3.71	1.47
Self Acceptance	3.48	2.81	3.25	2.53	.32
Sense of Well Being	4.33	3.62	3.83	3.31	.85
Responsibility	3.39	2.97	2.98	3.03	.84
Socialization	4.38	3.75	3.58	3.33	2.05
Self Control	6.81	5.42	5.94	5.51	1.13
Tolerance	4.46	3.27	3.51	2.89	3.85
Good Impression	5.29	4.53	4.89	4.73	.35
Communality	1.52	1.46	1.40	1.43	.31
Achievement via Conform.	4.58	3.81	3.57	2.82	3.39
Achievement via Indepen.	3.44	2.87	2.79	1.92	2.49
Intellectual Efficnency	4.48	3.21	3.45	3.33	4.48*
Psychological Mindedness	2.64	2.04	2.15	2.00	2.53
Flexibility	3.57	2.81	3.13	2.84	1.08
Femininity	3.54	2.71	2.62	2.16	5.40*
Factor I	12.81	10.47	10.28	9.40	2.67
Factor II	7.37	5.80	6.51	6.20	.95
Rigidity	3.41	2.77	3.26	3.40	.11
Managerial	16.09	12.68	11.89	11.51	5.01*
Acquiescence	3.21	2.61	3.34	2.93	.11
Social Desirability	4.15	3.23	3.64	2.61	1.18

* Significant at the .05 level

The mean difference between the difference scores was very small, but not in the hypothesized direction. Within the actual DZ group, none of the comparisons of difference scores on the NMSQT reached statistical significance. However, all of the differences were in the hypothesized direction, that is, DZ twins correctly classified have larger difference scores than those incorrectly classified. The evidence from both sets of analyses suggest that parental belief about zygosity does not appreciably affect twin differences on measured achievement. Support for the hypothesis that environmental pressures artificially inflate differences between MZ and DZ twins on measured achievement is weak. The conclusion that differences between actual zygosity groups on measured achievement are due almost entirely to the difference in genetic similarity within the groups seems to be more reasonable.

Comparison of MZ twin differences on the CPI scales yielded two statistically significant differences. On the Good Impression and Communality scales, MZ twins thought to be MZ had smaller difference scores than MZ twins incorrectly diagnosed. However, of the 24 comparisons between groups on the CPI scales, 18 yielded mean differences in the hypothesized direction. Of the CPI scale difference comparisons within the actual DZ group, four reached statistical significance: Capacity for Status, Intellectual

Efficiency, Femininity and Managerial. Twenty-two of the 24 comparisons within the actual DZ group showed differences in the hypothesized direction, that is, DZ twins thought to be MZ were less different in measured personality than DZ twins correctly classified. The sampling error of the difference between two difference scores on scales with only moderate reliability is very large, and the observation that few of these comparisons reached statistical significance is not surprising. The overwhelming consistency of the direction of these comparisons lends considerable support to the hypothesis that the greater similarity of MZ twins on measured personality is contaminated by an environmental bias.

The hypothesis that actual zygosity group differences on measured personality is due entirely to the difference in the genetic similarity within the two groups is questionable. Again, it seems justifiable to make some correction in the heritability estimates of the CPI scales for this environmental bias.

Differences in Between Family Environment by Zygosity

A seldom discussed assumption of the previously described heritability formulae is that of equivalent between family environments for the two kinds of twins. One of the major components of between family environment is socioeconomic status, and Scarr-Salapatek (1971) has noted that heritability within differing SES groups may be quite different. If large SES differences between the two zygosity groups could be found, heritability estimates derived from the comparison of these two groups would be somewhat difficult to interpret. In a sample of 243 sets of twins drawn from school populations, Smith (1965) found that DZ twins had significantly lower composite scores on his SES indicators than did MZ twins, and he concluded that an additional environmental bias existed in his sample.

The assumption of equal between family environments by zygosity could be tested in part by comparing the SES of the two kinds of twins. From the parent questionnaire, three items relating to SES were selected: mothers' education, fathers' education, and family income.The education scales for both parents ranged from a score of 1 (8th grade or less) to 6 (beyond bachelor's degree), and scores on the income item ranged from 1 (less than $5,000/year) to 7 (more than $25,000/year.) In addition, a set of items were drawn from the twin questionnaire asking which of 41

TABLE 10

Means and Standard Deviations on SES Variables by Zygosity

		M	SD	N	F
Mothers' Education	MZ	3.33	1.17	478	5.20*
	DZ	3.53	1.25	309	
Fathers' Education	MZ	3.53	1.51	473	1.63
	DZ	3.67	1.52	309	
Family Income	MZ	3.16	1.57	459	2.34
	DZ	3.33	1.52	290	
Sum of Items in Home	MZ	20.02	5.43	509	1.97
	DZ	20.55	5.44	330	

* Significant at the .05 level

items they had in their home. Each of these items were scored dichotomously, and the total score was obtained by summing the items.

A one-way analysis of variance for each of these variables was computed to test the difference between zygosity groups. Those cases with missing data were excluded from individual analyses. The group means and standard deviations for each of the variables are presented in Table 10. None of these comparisons reached significance at the .01 level. Only mothers' education reached significance at the .05 level, though the means differed only slightly. Unlike the results of Smith's (1965) sample, the DZ twins had higher scores on each variable. The small but consistant advantage of the DZ twins may be due to the fact that their parents were about a year older than the parents of MZ twins.

While SES is only one of the components of between family environment, the lack of large group differences on these SES variables would indicate that the assumption of equivalent between family environments does not appear to be seriously violated in this sample.

CHAPTER 4

Estimated Heritability of Achievement and Personality

Heritability estimates based on the present twin sample were calculated by the method described in Chapter 1. First, the raw intra-class correlations were calculated separately for MZ and DZ twins using the formula:

$$r_i = \frac{MSB - MSW}{MSB + MSW}$$

where MSB is the mean square between, or the mean squared deviation of the family means about the grand mean.

MSW is the mean square within, or the mean squared deviation of individual twin scores about their family mean.

MSB + MSW is the total variance of the scores for the zygosity group.

The F statistic suggested by Clark (1956) was computed for each variable by the formula:

$$F = \frac{MSW_{DZ}}{MSW_{MZ}}$$

This statistic provides a test of the existence of heritable variation, and is evaluated with degrees of freedom equal to the number of DZ sets in the numerator and the number of MZ sets in the denominator. While the original h^2 statistic suggested by Holzinger (1929) has often been misinterpreted,

these values are presented here so that the results might be compared to previous twin studies. These h^2 values were calculated by the formula:

$$h^2 = \frac{rMZ - rDZ}{1 - rDZ}$$

The F and Holzinger's h^2 statistics are reported in Table 11.

Within the NMSQT scales, the Ftest was significant at the .01 level for all measures. Within the CPI scales, only Communality failed to reach significance. While this indicates that the existence of heritable trait variation for Communality is questionable, this scale has been included in further analyses for comparison. Responsibility, Achievement via Independence and Intellectual Efficiency yielded F statistics significant at the .05 level; the remainder of the CPI scales yielded F statistics significant at the .01 level.

The raw intra-class correlations were then corrected for attenuation due to unreliability. While some researchers may object to this procedure, these corrections are necessary here since the conclusions of heritability studies are made within a theoretical framework. Omitting the correction for attenuation due to unreliability is equivalent to making the assumption that these traits have been measured perfectly. Such an assumption is clearly erroneous.

Estimates of the reliability of these measures for this twin sample were not available. Reliability estimates

Table 11

F Statistics and Holzinger's h^2 Statistics

for NMSQT and CPI Scales

(NMZ = 497, NDZ = 319)

	F	h^2
NMSQT Scales		
English Usage	1.65**	.46
Mathematics Usage	2.10**	.52
Social Studies Reading	1.99**	.50
Natural Science Reading	1.36**	.31
Word Usage	2.22**	.60
Selection Score	2.76**	.66
CPI Scales		
Dominance	1.57**	.37
Capacity for Status	1.43**	.21
Sociability	1.64**	.34
Social Presence	1.87**	.39
Self Acceptance	1.42**	.29
Sense of Well Being	1.43**	.27
Responsibility	1.20*	.25
Socialization	1.49**	.30
Self Control	1.37**	.31
Tolerance	1.40**	.28
Good Impression	1.29**	.24
Communality	.94	.21
Achievement via Conformance	1.61**	.36
Achievement via Independence	1.21*	.27
Intellectual Efficiency	1.21*	.27
Psychological Mindedness	1.31**	.24
Flexibility	1.40**	.34
Femininity	1.30**	.21
Factor I	1.57**	.35
Factor II	1.73**	.38
Rigidity	1.55**	.34
Managerial	1.45**	.36
Aquiescence	1.33**	.31
Social Desirability	1.41**	.23

** Significant at the .01 level
* Significant at the .05 level

used in the present calculations were taken from the NMSQT and CPI manuals, and from the original articles in which the additional CPI scales were reported. The reliability estimates from the NMSQT manual are most likely reasonable approximations to the reliabilities for the present sample, because the NMSQT was given under controlled conditions, and the reliability information was gathered from a sample of Merit program participants. The assumption that the reliabilities reported in the CPI manual are applicable to the present sample is somewhat questionable for several reasons. The CPI was not administered to the twins under controlled conditions, but was included in the questionnaire material sent to them. While the subjects were told not to discuss their responses with their twin, some co-twin communication may have occurred. The sample used to obtain reliability estimates for the original CPI scales were high school students, but the sample size was small. Reliabilities for the additional CPI scales were not based on equivalent populations. For lack of better data, however, these reliability estimates were used to correct the raw twin correlations.

Reliability estimates for two of the CPI scales posed special problems. No reliability estimate was available for the Managerial scale. The large number of items in this scale would contribute to its reliability, and the value of .75 was therefore assigned. The reliability estimate of

the Femininity scale reported in the CPI manual was .62, but the observed MZ correlation exceeded this value. This indicates that the reliability of the Femininity scale for this sample is higher than that reported in the manual. The reliability estimate for this scale was therefore adjusted to the rMZ for want of a better estimate. Reliabilities used in further calculations are presented in Table 12.

The twin correlations corrected for attenuation due to unreliability were then adjusted for probable zygosity misdiagnosis. In the present sample, the zygosity questionnaire has been shown to be accurate in about 93% of the cases (Nichols and Bilbro, 1965.) The errors of diagnosis, however, are systematic. The questionnaire method errors in diagnosing identical twins as fraternal if the twins do not look exactly alike, or if they are not frequently mistaken for one another. Thus, the DZ correlation is artificially inflated due to the 7% of the MZ twins included in this sample. The MZ correlation is not appreciably affected by these probable errors of diagnosis. The DZ correlation was therefore adjusted by the method described in Chapter 1.

Table 13 lists the raw twin correlations, the correlations corrected for attenuation due to unreliability, and the rDZ further adjusted for probable errors of diagnosis (noted as RDZ(A)). The remainder of this table con-

Table 12

Reliability Estimates for NMSQT and CPI Scales

NMSQT Scales [a]				
English Usage	.89	Natural Science Reading	.84	
Mathematics Usage	.85	Word Usage	.94	
Social Studies Reading	.87	Selection Score	.97	
CPI Scales [b]				
Dominance	.68	Achievement Via Conform.	.67	
Capacity for Status	.65	Achievement via Indepen.	.60	
Sociability	.70	Intellectual Efficiency	.76	
Social Presence	.62	Psychological Mindedness	.49	
Self Acceptance	.69	Flexibility	.64	
Sense of Well Being	.72	Femininity	.62	c
Responsibility	.69	Factor I	.88	d
Socialization	.67	Factor II	.81	d
Self Control	.72	Rigidity	.72	e
Tolerance	.66	Managerial	.75	f
Good Impression	.68	Aquiescence	.59	g
Communality	.41	Social Desirability	.53	g

a. KR20 reliabilities reported in the Interpretive Manual, p.7. Based on data from 1960-1964.

b. From CPI manual, averate test-retest reliabilities based on 125 high school females and 101 high school males. (Gough, 1957, p.19)

c. The raw MZ correlation exceeded this value, and the rMZ of .70 was used for further calculations.

d. KR21 based on cross-validation sample of 250 male college freshmen. (Nichols and Schnell, 1963, p.231)

e. Split-half reliability based on 60 subjects. (Rehfisch, 1968, p.14)

f. The reliability of this scale was not reported in the article introducing this scale (Goodstien and Schrader, 1963). Reliability was estimated at .75.

g. Split-half reliabilities based on a sample of 100 females. (Dicken, 1963, p.704)

Table 13

	RAW	ADJUSTED			READ	REL −.10	REL +.10	K1 −.1	K1 −.05	K1 +.05	K1 +.1	K3 −.1	K3 −.05	K3 +.05	K3 +.1
NMSQT ENGLISH USAGE	RMZ= .76	RMZ= .85	K1=1.10	M	.53	.62	.45	.56	.54	.51	.49	.50	.51	.54	.55
	RDZ= .55	RDZ= .62	K3=1.20	WE	.16	.04	.26	.15	.15	.17	.18	.16	.16	.16	.16
		RDZ(A)= .60	REL=.89	BE	.31	.34	.29	.30	.30	.32	.33	.34	.33	.30	.29
NMSQT MATH USAGE	RMZ= .75	RMZ= .88	K1=1.10	M	.73	.85	.63	.75	.74	.71	.70	.69	.71	.74	.76
	RDZ= .49	RDZ= .56	K3=1.20	WE	.13	0.00	.23	.12	.12	.14	.14	.13	.13	.13	.13
		RDZ(A)= .54	REL=.85	BE	.15	.15	.14	.13	.14	.15	.16	.18	.16	.13	.11
NMSQT SOCIAL STUDIES	RMZ= .77	RMZ= .89	K1=1.10	M	.60	.71	.52	.63	.61	.59	.57	.57	.59	.61	.63
	RDZ= .54	RDZ= .62	K3=1.20	WE	.13	0.00	.23	.11	.12	.13	.14	.13	.13	.13	.13
		RDZ(A)= .60	REL=.87	BE	.27	.29	.26	.26	.27	.28	.29	.30	.29	.26	.25
NMSQT NATURAL SCIENCE	RMZ= .69	RMZ= .82	K1=1.10	M	.35	.43	.29	.39	.37	.34	.32	.34	.35	.36	.37
	RDZ= .55	RDZ= .65	K3=1.20	WE	.20	.07	.29	.18	.19	.21	.21	.20	.20	.20	.20
		RDZ(A)= .64	REL=.84	BE	.45	.49	.41	.43	.44	.46	.47	.46	.46	.44	.43
NMSQT WORD USAGE	RMZ= .80	RMZ= .91	K1=1.10	M	.53	.62	.46	.55	.54	.53	.52	.51	.52	.55	.56
	RDZ= .64	RDZ= .68	K3=1.20	WE	.09	-.03	.19	.09	.09	.10	.10	.09	.09	.09	.09
		RDZ(A)= .66	REL=.94	BE	.37	.40	.35	.36	.37	.38	.38	.40	.38	.36	.35
NMSQT SELECTION SCORE	RMZ= .88	RMZ= .91	K1=1.10	M	.56	.66	.49	.59	.58	.55	.54	.54	.55	.58	.59
	RDZ= .64	RDZ= .66	K3=1.20	WE	.10	-.01	.20	.09	.10	.11	.11	.10	.10	.10	.10
		RDZ(A)= .64	REL=.97	BE	.33	.36	.31	.32	.33	.34	.34	.36	.35	.32	.31
DOMINANCE	RMZ= .54	RMZ= .79	K1=1.30	M	.75	.98	.57	.79	.77	.73	.71	.71	.73	.77	.79
	RDZ= .27	RDZ= .40	K3=1.05	WE	.27	.09	.40	.25	.26	.28	.29	.27	.27	.27	.27
		RDZ(A)= .37	REL=.68	BE	-.02	-.07	.03	-.04	-.03	-.01	.01	.02	.00	-.03	-.05
CAPACITY FOR STATUS	RMZ= .58	RMZ= .89	K1=1.30	M	.31	.47	.16	.33	.32	.30	.28	.29	.30	.31	.32
	RDZ= .47	RDZ= .72	K3=1.05	WE	.14	-.07	.29	.13	.13	.15	.15	.14	.14	.14	.14
		RDZ(A)= .71	REL=.65	BE	.55	.60	.52	.54	.55	.56	.56	.57	.56	.55	.54
SOCIABILITY	RMZ= .53	RMZ= .76	K1=1.30	M	.57	.77	.43	.62	.60	.55	.53	.55	.56	.59	.60
	RDZ= .30	RDZ= .43	K3=1.05	WE	.32	.15	.44	.29	.30	.33	.34	.32	.32	.32	.32
		RDZ(A)= .40	REL=.70	BE	.11	.08	.14	.08	.10	.12	.13	.14	.12	.10	.08
SOCIAL PRESENCE	RMZ= .55	RMZ= .89	K1=1.30	M	.98	1.26	.74	.98	.97	.95	.94	.91	.94	.99	1.01
	RDZ= .26	RDZ= .42	K3=1.05	WE	.10	-.07	.31	.14	.14	.15	.16	.15	.15	.15	.15
		RDZ(A)= .38	REL=.62	BE	-.11	-.19	-.05	-.12	-.11	-.10	-.10	-.06	-.06	-.13	-.16
SELF ACCEPTANCE	RMZ= .50	RMZ= .72	K1=1.30	M	.47	.65	.33	.53	.50	.44	.41	.45	.46	.48	.49
	RDZ= .30	RDZ= .43	K3=1.05	WE	.36	.20	.48	.33	.34	.37	.39	.36	.36	.36	.36
		RDZ(A)= .41	REL=.69	BE	.17	.15	.19	.14	.16	.19	.20	.20	.18	.16	.15
SENSE OF WELL BEING	RMZ= .49	RMZ= .68	K1=1.30	M	.39	.55	.26	.45	.42	.35	.32	.37	.38	.39	.40
	RDZ= .30	RDZ= .42	K3=1.05	WE	.42	.27	.52	.38	.40	.43	.45	.42	.42	.42	.42
		RDZ(A)= .40	REL=.72	BE	.20	.18	.21	.17	.18	.22	.23	.22	.21	.19	.18
RESPONSIBILITY	RMZ= .53	RMZ= .77	K1=1.30	M	.37	.54	.24	.42	.39	.34	.32	.35	.36	.38	.39
	RDZ= .37	RDZ= .54	K3=1.05	WE	.30	.13	.43	.28	.29	.31	.32	.33	.33	.33	.33
		RDZ(A)= .52	REL=.69	BE	.33	.33	.33	.31	.32	.34	.35	.35	.34	.32	.31

Table 13 (continued)

	RAW	ADJUSTED			READ	REL -.10	REL +.10	K1 -.1	K1 -.05	K1 +.05	K1 +.1	K3 -.1	K3 -.05	K3 +.05	K3 +.1
SOCIALIZATION	RMZ= .56	RMZ= .84	K1=1.30	M	.52	.72	.38	.56	.54	.51	.49	.50	.51	.54	.55
	ROZ= .37	ROZ= .55	K3=1.05	WE	.21	.02	.35	.20	.21	.22	.23	.21	.21	.21	.21
		ROZ(A)= .53	REL=.67	BE	.26	.25	.27	.25	.25	.27	.28	.29	.28	.25	.24
SELF CONTROL	RMZ= .57	RMZ= .79	K1=1.30	M	.61	.80	.46	.65	.63	.59	.56	.58	.59	.62	.64
	ROZ= .33	ROZ= .46	K3=1.05	WE	.27	.10	.40	.25	.26	.28	.29	.27	.27	.27	.27
		ROZ(A)= .43	REL=.72	BE	.12	.09	.15	.10	.11	.13	.14	.15	.14	.11	.09
TOLERANCE	RMZ= .53	RMZ= .80	K1=1.30	M	.48	.68	.34	.52	.50	.46	.44	.46	.47	.49	.50
	ROZ= .35	ROZ= .53	K3=1.05	WE	.26	.07	.39	.24	.25	.27	.28	.26	.26	.26	.26
		ROZ(A)= .51	REL=.66	BE	.26	.25	.27	.24	.25	.27	.28	.29	.28	.25	.24
GOOD IMPRESSION	RMZ= .47	RMZ= .69	K1=1.30	M	.36	.53	.24	.42	.39	.33	.30	.34	.35	.37	.36
	ROZ= .30	ROZ= .44	K3=1.05	WE	.40	.25	.52	.37	.39	.42	.43	.40	.40	.40	.40
		ROZ(A)= .42	REL=.68	BE	.24	.22	.25	.20	.22	.25	.27	.25	.25	.23	.22
COMMUNALITY	RMZ= .36	RMZ= .88	K1=1.30	M	.69	1.38	.60	.92	.91	.88	.87	.85	.87	.91	.94
	ROZ= .18	ROZ= .44	K3=1.05	WE	.16	-.21	.38	.15	.15	.16	.17	.16	.16	.16	.16
		ROZ(A)= .41	REL=.41	BE	-.05	-.17	.02	-.06	-.06	-.04	-.04	-.01	-.03	-.07	-.09
ACHIEVEMENT VIA CONFORMANCE	RMZ= .46	RMZ= .69	K1=1.30	M	.76	1.00	.58	.83	.79	.73	.70	.72	.74	.78	.80
	ROZ= .17	ROZ= .25	K3=1.05	WE	.41	.25	.52	.38	.39	.42	.44	.41	.41	.41	.41
		ROZ(A)= .22	REL=.67	BE	-.17	-.25	-.11	-.20	-.19	-.15	-.14	-.13	-.15	-.19	-.21
ACH VIA INDEPENDENCE	RMZ= .55	RMZ= .92	K1=1.30	M	.54	.77	.37	.55	.55	.53	.52	.51	.52	.55	.56
	ROZ= .39	ROZ= .65	K3=1.05	WE	.11	-.13	.28	.10	.10	.11	.12	.11	.11	.11	.11
		ROZ(A)= .63	REL=.60	BE	.36	.36	.35	.35	.35	.36	.36	.36	.37	.34	.33
INTELLECTUAL EFFICIENCE	RMZ= .52	RMZ= .83	K1=1.30	M	.33	.47	.22	.39	.36	.30	.26	.31	.32	.34	.34
	ROZ= .34	ROZ= .45	K3=1.05	WE	.41	.28	.51	.38	.39	.43	.44	.41	.41	.41	.41
		ROZ(A)= .43	REL=.76	BE	.26	.25	.27	.23	.25	.28	.29	.28	.27	.25	.25
PSYCHOLOGICAL MINDEDNESS	RMZ= .41	RMZ= .84	K1=1.30	M	.71	1.35	.48	.74	.73	.69	.68	.67	.69	.73	.74
	ROZ= .23	ROZ= .47	K3=1.05	WE	.21	-.67	.40	.20	.20	.22	.23	.21	.21	.21	.21
		ROZ(A)= .44	REL=.49	BE	.05	.02	.12	.06	.07	.09	.10	.11	.10	.06	.04
FLEXIBILITY	RMZ= .48	RMZ= .75	K1=1.30	M	.74	.99	.56	.79	.77	.72	.69	.71	.72	.76	.78
	ROZ= .22	ROZ= .34	K3=1.05	WE	.32	.14	.46	.30	.31	.34	.35	.32	.32	.32	.32
		ROZ(A)= .31	REL=.64	BE	-.07	-.14	-.02	-.09	-.08	-.05	-.04	-.03	-.05	-.08	-.10
FEMININITY	RMZ= .70	RMZ=1.00	K1=1.30	M	.25	.40	.14	.25	.25	.25	.25	.24	.25	.26	.26
	ROZ= .62	ROZ= .89	K3=1.05	WE	0.00	-.22	.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		ROZ(A)= .88	REL=.70	BE	.75	.62	.69	.75	.75	.75	.75	.76	.75	.74	.74
FACTOR 1	RMZ= .56	RMZ= .84	K1=1.30	M	.43	.53	.30	.48	.44	.37	.33	.38	.39	.41	.42
	ROZ= .31	ROZ= .35	K3=1.05	WE	.47	.37	.56	.44	.45	.49	.51	.47	.47	.47	.47
		ROZ(A)= .33	REL=.68	BE	.12	.10	.14	.09	.11	.14	.16	.14	.13	.11	.11
FACTOR 2	RMZ= .58	RMZ= .72	K1=1.30	M	.53	.69	.41	.59	.56	.50	.47	.51	.52	.55	.56
	ROZ= .32	ROZ= .40	K3=1.05	WE	.37	.24	.47	.34	.35	.36	.40	.37	.37	.37	.37
		ROZ(A)= .37	REL=.61	BE	.10	.07	.12	.07	.08	.11	.13	.12	.11	.08	.07
RIGIDITY	RMZ= .47	RMZ= .65	K1=1.30	M	.61	.81	.46	.63	.65	.58	.54	.58	.60	.63	.64
	ROZ= .20	ROZ= .28	K3=1.05	WE	.45	.31	.55	.42	.43	.47	.49	.45	.45	.45	.45
		ROZ(A)= .25	REL=.72	BE	-.06	-.13	-.02	-.10	-.08	-.05	-.03	-.03	-.05	-.08	-.09

	Raw	Adjusted				REL		K1				K3			
						READ	-.10	+.10	-.1	-.05	+.05	+.1	-.1	-.05	+.05	+.1
MANAGERIAL	RMZ= .59	RMZ= .79	K1=1.30	H		.54	.72	.41	.59	.57	.52	.50	.52	.53	.56	.57
	RDZ= .36	RDZ= .48	K3=1.05	WE		.28	.12	.40	.26	.27	.29	.30	.28	.28	.28	.28
		RDZ(A)= .46	REL=.75	BE		.18	.16	.19	.16	.17	.19	.20	.20	.19	.16	.15
ACQUIESCENCE	RMZ= .43	RMZ= .73	K1=1.30	H		.77	1.05	.57	.82	.80	.74	.71	.73	.75	.79	.80
	RDZ= .18	RDZ= .31	K3=1.05	WE		.35	.16	.49	.33	.34	.37	.38	.35	.35	.35	.35
		RDZ(A)= .27	REL=.59	BE		-.12	-.21	-.06	-.15	-.13	-.11	-.09	-.08	-.10	-.14	-.16
SOCIAL DESIRABILITY	RMZ= .48	RMZ= .91	K1=1.30	H		.57	.84	.38	.59	.58	.56	.55	.54	.55	.58	.59
	RDZ= .33	RDZ= .62	K3=1.05	WE		.12	-.15	.31	.11	.12	.13	.13	.12	.12	.12	.12
		RDZ(A)= .68	REL=.53	BE		.31	.31	.31	.30	.31	.32	.32	.34	.33	.30	.28

tains a series of estimates of the three variance components calculated under a variety of assumptions.

The estimates of heritability, within family environment, and between family environment are varied around the estimates of K1, K3 and reliability listed in the third column of Table 13. While the K1 and K3 constants are not directly calculable, the values used in this analysis were not selected arbitrarily. Recall that K1 reflects the extent to which identical twins are treated more alike than fraternal twins on environmental dimensions relating to the measured trait. While few of the specific investigations of this environmental bias yielded statistically significant results, the consistency of results across scales and across research designs led to the conclusion that an environmental bias probably exists for the NMSQT and CPI measures. It was further concluded that this environmental bias was probably greater for the CPI than for the NMSQT. Therefore, the value of K1 was set to 1.1 for the NMSQT scales and to 1.3 for the CPI scales.

The value of K3 reflects the biasing effect introduced by assortative mating and non-additive genetic effects. No information is available about the bias due to non-additive genetic effects, and the information about the extent of assortative mating for these traits is minimal. Inspection of the correlations between parents on intelligence and personality ratings reported by Spuhler (1967) shown

in Table 1 indicated that positive assortative mating takes place in the populations sampled. The correlations between mates for the personality measures were all positive, but quite low. Therefore, the value of K3 for the CPI scales was set at 1.05. The correlations between mates on the various intelligence measures indicated that assortative mating is somewhat greater, and therefore the value of K3 for the NMSQT scales was set at 1.20.

The next column in Table 13 gives the estimated theoretical proportions of variance due to heredity, within family environment and between family environment based on the values selected for K1, K3, and reliability. This column is the one to which further results will be compared. The remainder of the columns in Table 13 show the effects of varying each assumption on these three theoretical proportions of vaiance.

Uncertainty about the reliability of each measure for this twin sample, combined with imprecise estimates of K1 and K3 prevent excat point estimation of the three variance components. An alternative approach is the estimation of the probable range in which the exact estimates most probably lie. Varying the estimates of the reliability, K1 and K3 will define the probable ranges for these three values. This procedure will also indicate the effects of "wrong guesses" about the values selected for reliability, K1 and K3.

The two columns in Table 13 under the heading REL show the effect of decreasing by .10 and increasing by .10 the value of the reliability coefficient obtained from the sources previously described. Reducing the reliability from the original estimate increases heritability at the expense of within family environment. The correction for attenuation due to unreliability increases both raw correlations, but increases the larger correlations more than the smaller one. Since heritability is based on the difference between the two twin correlations, reducing the reliability estimate increases the difference between rMZ and rDZ, and increases heritability. The estimate of the within family environmental component is based upon the difference between rMZ and 1.0, and further increase in rMZ reduces the estimate of this variance component.

In some cases, reduction of the estimated reliability by .10 causes the rMZ to be greater than the reliability, which is theoretically unacceptable. The unreasonably low reliability estimate yields negative proportions of variance for Word Usage, Selection Score, Dominance, Capacity for Status, and Social Presence. This indicates that the true reliability of these scales for this sample is greater than the manual-derived estimate less .10, since negative proportions of variance are uninterpretable.

The effects of increasing the reliability by .10 are shown in the next column of Table 13. In all cases, in-

creasing the reliability reduces the heritability and increases the within family environmental variance. The effect of increasing the reliability by .10 is particularly pronounced in some of the CPI scales. Note that the original estimated proportion of variance due to between family environment for some scales yields negative values, which are uninterpretable. For Social Presence, Communality, Achievement via conformance, Flexibility, Rigidity and Aquiescence scales, the raw rDZ is very low, and correction for unreliability has a relatively small effect on these correlations relative to the rMZ. The correction greatly magnifies the difference between the two twin correlations, and unreasonably high heritabilities result. The difference between the corrected rMZ and 1.0 is substantial for these measures, and the value of WE is positive. Since the three estimates must sum to 1.0, the estimate of BE is negative. In the case of these 6 scales, increasing the estimate of reliability by .10 reduces the artificially large difference between the twin correlations, reduces heritability, and increases WE and BE. In one case this upwards adjustment of reliability removed the negative variance component, and in all 6 scales the largest BE obtained was produced by this adjustment. Clearly in the case of these 6 scales, and probably for all of the CPI scales, the reliabilities reported in the manual underestimate the reliabilities which would have been obtained from this sample. If this is the

case, heritability estimates for all of the CPI scales are artificially inflated, and the two environmental components are underestimated.

The next 4 columns of Table 13 show the effect of varying the value of K1 with reliability and K3 set at the original value. Reducing the value of K1 to 1.0 for the NMSQT scales and to 1.2 for the CPI scales increases the heritability by reducing WE and BE. Increasing K1 reduces the heritability and increases WE and BE. The scales with the smallest rMZ statistics are most sensitive to variations in K1, since the difference between rMZ and 1.0 is adjusted by multiplying it by K1. In the case of the 6 CPI scales with originally negative BE estimates, increasing K1 increases BE by a small amount, but in no case did adjustment of K1 yield non-negative BE estimates.

The final 4 columns of Table 13 show the results of variation of the value of K3, holding constant K1 and reliability at the values to which they were originally set. In all cases, reducing the K3 constant reduced heritability and increased BE. Increasing K3 increases heritability at the expense of BE. The estimate of WE is not affected by variations in K3. Those measures with the largest differences between rMZ and rDZ are affected most by variations in K3. For the 6 CPI scales with original negative BE estimates, reduction of K3 had the greatest effect in increasing BE, but in no case did variation in K3 yield positive values

for BE. Note, however, that reducing K3 to .95 for the personality scales, is in effect making the assumption that negative assortative mating takes place in the population. This assumption is questionable given the findings of Spuhler (1967) reported in Table 1.

Some general conclusions can be made concerning the calculated range of theoretical variance components within the NMSQT and CPI scales. The heritabilities within the NMSQTscales are relatively consistent with the exception of Natural Science Reading. For the other NMSQT scales, the majority of the trait variation can be attributed to heredity. The within family environmental component of the NMSQT scales is smaller than the between family environmental component. This is reasonable, since the effect of different schools and differential SES is included in the BE estimate.

Within the CPI scales, the results are not as clear. The heritability estimates vary greatly from measure to measure. This may be a function of erronious reliabilities, but even extreme adjustment of reliability does not account for all of the unreasonable values obtained. The calculations of the proportions of variance due to these three sources is further complicated by the very low rDZ statistics. It is clear, however, that the majority of the environmental variance in the CPI scales is due to within family influences

as opposed to between family influences. The variation of heritabilities is so extreme that the only conclusion which can be drawn is that heredity plays some role in determining individual differences in personality as measured by the CPI.

CHAPTER 5

Multivariate Analysis of Twin Data

Description of Method

The previously described method for analyzing twin data provides useful information about theoretical sources of population variance for any one measure. But a series of univariate analyses alone cannot be used to draw inferences about hereditary and environmental sources of variation within a **set** of measures. In the univariate analyses of the NMSQT, for example, each of the subtest scores was found to have a substantial hereditary component. Given only this information, it is impossible to tell if each score was influenced by different hereditary mechanisms, or if the hereditary variance was due to a common factor reflected by each of the five measures. Sets of ability measures have been shown to reflect a general factor, and a series of specific factors. Univariate techniques cannot identify which of these factors are genetic in origin and which are environmental. Given just two measures, a method is needed which would enable a partition of the covariation between the two traits into hereditary and environmental components.

Multivariate procedures of varying complexity have been suggested by Husén (1959), Vandenberg (1965), Bock and Vandenberg (1968) and Humphreys (1970). Husén (1959)

proposed a method by which the correlation between two traits could be found to reflect common hereditary influences. The method described by Vandenberg (1965) and Bock and Vandenberg (1968) is the most complex, yet it provides only a multivariate analogue for the F test usually employed by Vandenberg. The method of Loehlin and Vandenberg (1968) is most similar to the one presently proposed, and it involves the factoring of assumed genetic and environmental covariance matrices.

The present multivariate method is a simple extension of the previously described univariate technique. When working with only one trait, twin correlations were computed and manipulated in such a manner to isolate the hereditary and environmental proportions of total trait variation. In the multivariate case, analogous matrices of twin correlations are manipulated and used to isolate hereditary and environmental sources of covariation among traits. These matrices are then factored to provide dimensions of hereditary and environmental covariation. The factors obtained from the original matrix of simple correlations among traits are then compared to the factors from the hereditary and environmental matrices, and an attempt is made to identify each original factor as being hereditary or environmental in origin. It must be emphasized that these procedures can only be employed when the set of variables do not contain overlapping items. The method cannot be applied to

analyze sources of covariation among CPI scales, for example, since different scales contain identical items.

In the univariate case, the value to be partitioned into hereditary and environmental sources is the population variance, expressed as unity. In the multivariate case, the matrix to be partitioned is the matrix of covariation, expressed in terms of correlations between traits. This criterion matrix is calculated by treating all twins as single individuals and correlating each score with each other score across all individuals. Husén (1959) has called this matrix a matrix of within twin correlations, but the fact that the subjects occur in pairs is not relevant for these calculations.

In the univariate case, the two essential statistics are the intra-class correlations calculated separately for MZ and DZ twins. Recall that, with a large enough sample, the value of the intra-class correlation is the same as the product-moment correlation obtained from comparing twin 1's score with twin 2's score, given random assignment of twin 1 and twin 2 to the x and y variable. In the multivariate case, a cross-twin correlation is computed separately for MZ and DZ twins. These matrices are obtained by correlating, for example, twin 1's score on scale 1 with twin 2's score on scale 2. The diagonals of these matrices, the correlation of twin 1's score on scale 1 with twin 2's score on scale 1, are numerically equivalent to the intra-

class correlations used in the univariate calculations.

The cross-twin matrix for MZ twins reflects the same theoretical sources of variation as the rMZ in the univariate case. Each element in the MZ cross-twin correlation matrix (Matrix 1) reflects the hereditary sources and the between family environmental sources common to both traits. Given two measures governed by independent hereditary mechanisms and unrelated environmental influences, the MZ cross-twin correlation would approach zero.

The elements in the matrix of cross-twin correlations for DZ twins, Matrix 2, reflect the extent to which between family environmental sources and between family hereditary sources are common to both traits. As was the case with the MZ cross-twin correlation matrix, Matrix 2 also has values equivalent to the rDZ intra-class correlations on the diagonal. Assuming that the set of between family environmental influences are the same for MZ and DZ twins, the difference between the MZ cross-twin correlation matrix (Matrix 1) and the DZ cross-twin correlation matrix (Matrix 2) will provide Matrix 3, whose elements show the extent to which within family hereditary factors are common to the set of traits. This matrix subtraction is analogous to the calculation of rMZ - rDZ in the univariate case.

In the univariate case, it was assumed that WG = BG,

and therefore the difference between the twin correlations, multiplied by 2.0, would yield an estimate of heritability. A constant could be introduced into this calculation to correct for the effect of assortative mating on the trait. In the multivariate case, the H matrix (Matrix 4) is obtained by multiplying each element in Matrix 3 by 2.0. While this constnat may be changed, the pattern of correlations will not be altered, and the value of the constant will not affect the factor pattern of the H matrix.

Matrix 5, the between family environment matrix, is obtained by subtracting the H matrix (4) from the MZ cross-twin matrix (1). The matrix representing estimates of within family environmental variance common to the set of measures is calculated by subtracting the MZ cross twin correlation matrix (1) from the criterion matrix of correlations among traits. The diagonal elements of this matrix (Matrix 6), representing the set of univariate calculations, are produced by subtracting rMZ from 1.0. In the off diagonal elements, the MZ cross-twin correlations are subtracted from the corresponding simple correlations between the two measures.

From these calculations, only three matrices are of interest for further analysis: the H matrix (4), the BE matrix (5), and the WE matrix (6), all of which sum numerically to the criterion correlation matrix. The values in the diagonal of each of these matrices can be directly in-

terpreted as proportions of trait variance due to the three sources, since the values are all proportional to the total variance, 1.0. The off diagonal elements of these three matrices reflect the proportions of covariation between the two traits, and are proportional to the simple correlation between the two measures. To interpret the H, WE and BE matrices in terms of percents of covariation, each element must be divided by the corresponding element in the criterion correlation matrix.

Of greater interest than the proportions of covariance between two traits attributable to common H, WE and BE is the factor structure of the H, WE and BE matrices. By comparing the factor pattern obtained from each of these matrices to that from the original criterion matrix, the original factors may be identified as being hereditary or environmental in origin.

An alternative method can be used to create an H and a WE matrix which should be factorilly equivalent to the H and WE matrices obtained from the manipulation of the two cross-twin correlation matrices. These alternative WE and H matrices are obtained from the simple correlations of twin differences on a set of measures.

Identical twin differences on any one measurement are due only to different environmental experiences and error of measurement. Any correlation between identical twin differences on two measures, then, would indicate common

within family environmental influences operating on the two traits. While error of measurement will produce twin differences on one score, the errors of measurement are assumed to be uncorrelated, and therefore would not affect the pattern of correlations in the MZ twin difference correlation matrix (Matrix 7). The factor structure of the WE matrix obtained from correlating MZ twin differences ought to be the same as that derived from the cross-twin correlation method, Matrix 6.

Correlations between DZ twin differences are attributable to both common environmental influences causing twin differences and to common hereditary factors which produce twin differences on the two traits. If the within family environmental influences are assumed to be the same for MZ as for DZ twins, then subtracting the MZ twin difference matrix (7) from the DZ twin difference matrix (8) will yield an alternative WG matrix (9), and multiplying this matrix by 2 will provide an alternative H matrix (10). The structure of the H matrix (10) obtained from the twin difference correlation matrices should be identical to that of the H matrix (4) obtained from manipulating cross-twin correlation matrices.

Multivariate Analysis of NMSQT

The multivariate procedures previously described were applied to the five scales of the NMSQT. Since the sex of the twins may influence the pattern of correlations among the NMSQT scales, all correlations were transformed by partailing out the influence of sex. The simple correlation matrix obtained by treating each twin as an individual subject is shown in Table 14. The correlations of the scales with sex show that females are at a disadvantage on all NMSQT scales but English Usage, and that the disadvantage is greatest on the Mathematics Usage and Natural Science Reading scales. The criterion correlation matrix with the effect of sex partailed out is also presented in Table 14. All of the scales correlate highly with one another, indicating that a strong general factor exists in this matrix. The homogeneity is not surprising, since all NMSQT items require the application of some verbal ability.

Table 15 shows the MZ cross-twin correlations before and after removing the sex effect, and Table 16 presents the same information for DZ twins. These two cross-twin matrices were used to compute the H, WE, and BE matrices shown in Table 17. The elements in these three matrices sum to the elements in the criterion matrix.

The three matrices shown in Table 17 are more easily interpreted as percentages of covariation due to H, WE, and BE. Therefore, each element in these matrices was

Table 14

Correlations Among NMSQT Scales

(Criterion Correlation Matrix

Raw Correlations

	E	M	S	N	W	Sex
English Usage	1.00	.54	.63	.57	.66	.10
Mathematics Usage		1.00	.60	.65	.55	-.29
Social Studies Reading			1.00	.67	.77	-.13
Natural Science Reading				1.00	.60	-.23
Word Usage					1.00	-.01
Sex (1 = male, 2 = female)						1.00

Correlations with Sex Removed

	E	M	S	N	W
English Usage	1.00	.60	.65	.61	.67
Mathematics Usage		1.00	.59	.63	.57
Social Studies Reading			1.00	.66	.77
Natural Science Reading				1.00	.61
Word Usage					1.00

Table 15

MZ Cross-twin Correlations on NMSQT

(Matrix 1)

Raw Correlations

	E	M	S	N	W	Sex
English Usage	.76	.49	.59	.54	.60	.13
Mathematics Usage		.75	.57	.61	.51	-.28
Social Studies Reading			.77	.62	.71	-.09
Natural Science Reading				.69	.52	-.21
Word Usage					.86	.01
Sex (1 = male, 2 = female)						1.00

Correlations with Sex Removed

	E	M	S	N	W
English Usage	.76	.55	.61	.59	.60
Mathematics Usage		.73	.57	.59	.53
Social Studies Reading			.77	.62	.71
Natural Science Reading				.68	.53
Word Usage					.86

Table 16

DZ Cross-twin Correlations on NMSQT

(Matrix 2)

Raw Correlations

	E	M	S	N	W	Sex
English Usage	.55	.33	.40	.39	.46	.04
Mathematics Usage		.48	.39	.42	.38	-.31
Social Studies Reading			.54	.51	.53	-.18
Natural Science Reading				.55	.47	-.25
Word Usage					.64	-.09
Sex (1 = male, 2 = female)						1.00

Correlations with Sex Removed

	E	M	S	N	W
English Usage	.55	.36	.41	.41	.47
Mathematics Usage		.42	.36	.37	.37
Social Studies Reading			.52	.49	.52
Natural Science Reading				.52	.46
Word Usage					1.00

Table 17

H, WE, and BE Matrices Calculated from Cross-twin Correlations

Hereditary Matrix (Matrix 4)

	E	M	S	N	W
English Usage	.40	.38	.40	.36	.26
Mathematics Usage		.62	.42	.44	.32
Social Studies Reading			.50	.26	.38
Natural Science Reading				.32	.14
Word Usage					.44

Within Family Environment Matrix (Matrix 6)

	E	M	S	N	W
English Usage	.24	.05	.04	.02	.07
Mathematics Usage		.27	.02	.04	.04
Social Studies Reading			.23	.04	.06
Natural Science Reading				.32	.08
Word Usage					.14

Between Family Environment Matrix (Matrix 5)

	E	M	S	M	W
English Usage	.36	.17	.21	.23	.34
Mathematics Usage		.11	.15	.15	.21
Social Studies Reading			.27	.36	.33
Natural Science Reading				.36	.39
Word Usage					.42

divided by the corresponding element in the criterion matrix. The correlations transformed to percents of covariation are shwon in Table 18.

These three matrices must be interpreted cautiously, since no adjustment has been made for violations of the assumptions inherent in the twin method. In the univariate case, it was shown that the existence of positive assortative mating for one trait affects the relative proportion of between to within family hereditary variance. However, there is no information about the effect of this bias on the proportion of covariation between two traits. Likewize, the effect of differential within family environments by zygosity on the covariation between two traits is also unknown. Lack of information about these possible sources of bias prevent precise estimates of the percent of covariation between two traits due to common hereditary or environmental factors.

A comparison of the matrices shown in Table 18 indicates that the primary source of covariation among the NMSQT scales is common hereditary mechanisms. Between family environmental sources common to the set of NMSQT scales accounts for most of the remaining covariation among the scores, and common within family environmental sources explain the smallest percentage of covariation. One noticable exception to this pattern is the partition of the covariation between Natural Science and Word Usage, which appears

Table 18

H, WE, and BE Matrices Transformed to Percents of Covariance

Hereditary Matrix

	E	M	S	N	W
English Usage	.40	.63	.62	.59	.39
Mathematics Usage		.62	.71	.70	.56
Social Studies Reading			.50	.40	.49
Natural Science Reading				.32	.23
Word Usage					.44

Within Family Environmental Matrix

	E	M	S	N	W
English Usage	.24	.08	.06	.03	.11
Mathematics Usage		.27	.03	.06	.07
Social Studies Reading			.23	.06	.08
Natural Science Reading				.32	.13
Word Usage					.14

Between Family Environmental Matrix

	E	M	S	N	W
English Usage	.36	.28	.32	.38	.51
Mathematics Usage		.11	.25	.24	.37
Social Studies Reading			.27	.55	.43
Natural Science Reading				.36	.64
Word Usage					.42

to be due primarily to common between family environmental sources. This may be due in part to the low heritability of the Natural Science Reading scale. Also, the DZ cross-twin correlation between these two scales is large compared to the other off diagonal elements in Table 16, while the MZ cross-twin correlation is one of the highest in Table 15. Since the hereditary matrix is obtained by subtracting the DZ cross-twin correlation matrix from the MZ cross-twin matrix, the value in the H matrix representing the proportion of covariation between Natural Science Reading and Word Usage is quite small. The standard error of these two correlations, however, is about .025, and the low H value observed may be due to sampling fluctuations of the MZ and DZ cross-twin correlations. Indeed, increasing the MZ correlation by one standard error and decreasing the DZ correlation by the same amount yields an H estimate of 39%, which is low but more comparable to the other values in the transformed H matrix.

While the partition of the correlation between two traits is informative, the comparison of the pattern of correlations in the H, WE, and BE matrices to the pattern in the criterion NMSQT matrix provides even more useful information.

A comparison of the factor structures of the criterion correlation matrix to that of the H, WE and BE matrices will allow for classification of the original factors as hereditary or environmental in origin. The structure of the criterion correlation matrix with sex removed was obtained from a principal components factor analysis with communalities estimated as unity. As was expected, a strong general factor emerged, which accounted for 70.9% of the variance in the original matrix. A second factor, accounting for an additional 10% was also retained. Unfortunately, the small number of scales and the weak factor structure of the NMSQT makes this variable set a poor one for testing the power of the multivariate twin method. A larger set of ability measures with a variety of group factors would be more appropriate for this kind of analysis. However, the two factor structure of the NMSQT can be plotted in two dimensional space and allows for a simple graphic comparison of the factors of this matrix to those extracted from the three components matrices.

The H, WE and BE matrices with the sex effect removed were also factored by the principal components method. Since the diagonal elements in each of these matrices can be directly interpreted as variance components, the diagonal elements were used as the communality estimates. Two factors were retained from the analysis of the hereditary matrix, the first accounting for 80% of the variance, the

second accounting for an additional 14.3%. The first unrotated factor extracted from the within family environmental matrix was not as large as the first from the hereditary or criterion matrix; it accounted for only 36.3% of the variance in the WE matrix. A second and third factor were also retained, accounting respectively for 22.4% and 19.7% of the variance. The first two unrotated factors obtained from the between family environmental matrix summed to 101.5% of the variance, but it was decided to retain both of these factors. The first factor accounted for 90.4% of the variance in the BE matrix; the second accounted for an additional 11.1%.

The factor structure of each of the component matrices was compared to the factor structure of the criterion NMSQT matrix by plotting the location of each scale in the two dimensional factor space defined by the first two unrotated factors. Such a graphic comparison required that each vector be normalized to unit length. The vectors of the criterion matrix as well as those of the H, WE and BE matrices were normalized by the following procedure. For the criterion, H, and BE matrices, the set of squared loadings of each variable on the first two unrotated factors were summed to obtain the communality. For the WE matrix, the squared loadings on the first three unrotated factors were summed. Each squared loading was then divided by its communality.

The normalized loadings were restored by taking the square root of each resulting quotient. The factor structure of the criterion matrix could then be compared to that of each component matrix by plotting the location of each scale in the two dimensional factor space.

The original axes were rotated 50 clockwize to obtain a maximum separation of the two factors within the criterion matrix. The first factor is identified by the high loadings of Word Usage and Social Studies Reading, though the other three scales loaded positively on this factor. The second factor is characterized by the high loadings of Mathematics Usage and Natural Science Reading, though again all scales had positive loadings on the second rotated factor. The English Usage scale was split between the two factors, and had an equally large loading on both rotated factors. While the separation of scales is not great, it appears that the first rotated factor is primarily a verbal one; the second is a math-science factor. The correlations of each scale from the three criterion matrices with the rotated factors were read with reference to the rotated axes. Tables 19, 20, 21, and 22 list the loadings of each variable on the unrotated and rotated factors for the criterion, H, WE and BE matrices.

Figure 2 provides a graphic comparison of the factor structures of the criterion and hereditary matrix. As was the case for the criterion matrix, the first factor of

Table 19

Loadings of the 5 NMSQT Scales from the Criterion Matrix on Unrotated and Rotated Factors

	A		B		C	
	I	II	I	II	I	II
English Usage	.84	-.07	.99	-.10	.71	.72
Mathematics Usage	.80	.50	.85	.53	.12	.99
Social Studies	.88	-.26	.95	-.30	.85	.57
Natural Science	.83	.24	.96	.28	.42	.92
Word Usage	.86	-.35	.93	-.37	.90	.52

A Loadings on unrotated factors

B Normalized loadings on unrotated factors

C Loadings on rotated factors

Table 20

Loadings of the 5 NMSQT Scales from the Hereditary Matrix on Unrotated and Rotated Factors

	A		B		C	
	I	II	I*	II*	I	II
English Usage	.60	-.07	.98	.17	.50	.88
Mathematics Usage	.73	-.19	.96	.26	.50	.85
Social Studies	.65	.20	.95	-.30	.85	.57
Natural Science	.51	-.29	.87	.49	.18	.98
Word Usage	.51	.40	.79	-.62	.99	.22

A Loadings on unrotated factors

B Normalized loadings on unrotated factors

C Loadings on rotated factors

* Factor reflected

Table 21

Loadings of the 5 NMSQT Scales from the Within Family Environmental Matrix on Unrotated and Rotated Factors

	A			B			C	
	I	II	III	I*	II	III	I	II
English Usage	-.27	.26	-.14	.66	.66	-.35	.71	.30
Mathematics Usage	-.28	.22	.36	.56	.44	.71	-.20	.89
Social Studies	-.25	.06	-.28	.66	.00	-.75	1.00	.05
Natural Science	-.39	-.38	.07	.71	-.69	.17	.35	.78
Word Usage	-.26	.00	-.07	.94	.00	-.35	.88	.52

A Loadings on unrotated factors

B Normalized loadings on unrotated factors

C Loadings on rotated factors

* Factor reflected

Table 22

Loadings of the 5 NMSQT Scales from the Between Family Environmental Matrix on Unrotated and Rotated Factors

	A		B		C	
	I	II	I	II	I	II
English Usage	.50	-.30	.74	-.26	.70	.44
Mathematics Usage	.31	-.10	.91	-.09	.65	.68
Social Studies	.52	.16	.90	.10	.50	.88
Natural Science	.59	.21	.90	.10	.50	.88
Word Usage	.65	-.04	1.00	.00	.63	.80

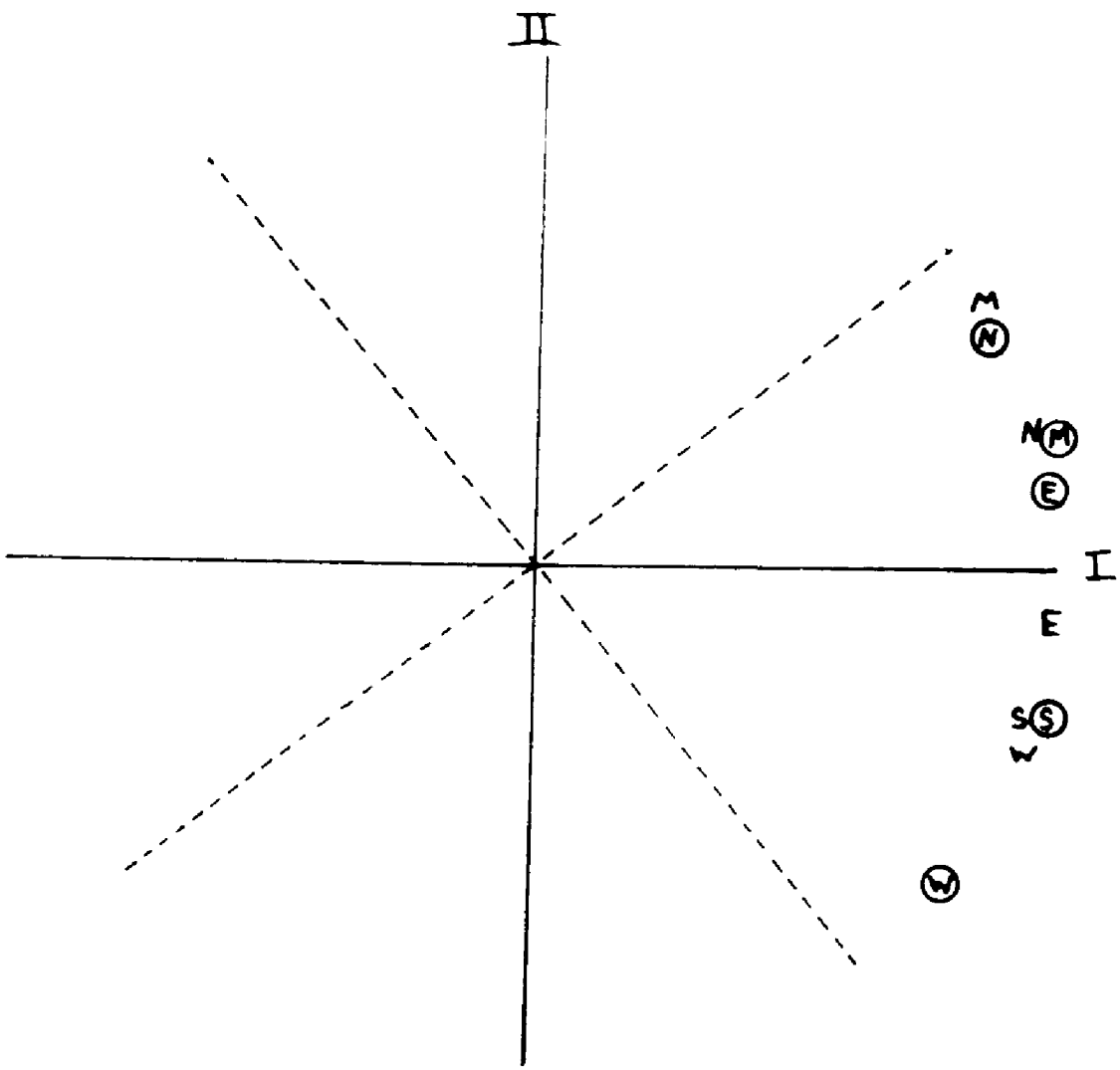
A Loadings on unrotated factors

B Normalized Loadings on unrotated factors

C Loadings on rotated factors

Figure 2

A Comparison of the Factor Pattern of the Criterion NMSQT Matrix and the Hereditary Matrix Calculated from Cross-twin Correlations



Simple letters represent criterion matrix
Circled letters represent hereditary matrix

E = English Usage
M = Mathematics Usage
S = Social Studies Reading
N = Natural Science Reading
W = Word Usage

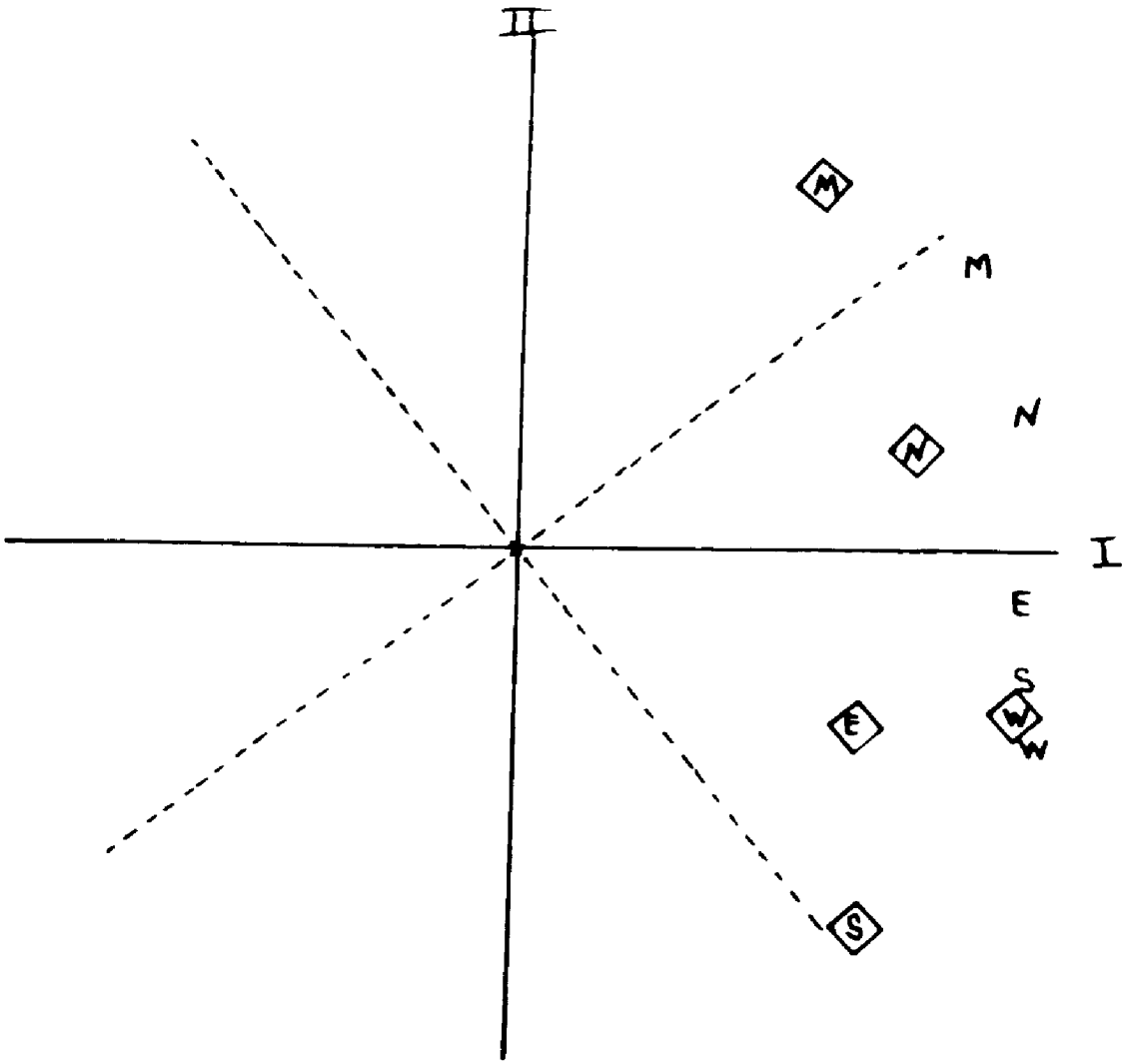
the H matrix has high loadings on Word Usage and Social Studies Reading. A rank-order correlation between the two sets of loadings is .83. The second rotated factor from the H matrix had high loadings on Mathematics Usage, Natural Science Reading and English Usage, and correlated .70 with the second factor of the criterion matrix. The similarity in structure of these two matrices indicates that both factors in the criterion matrix have hereditary components.

A comparison of the criterion and within family environmental matrix is shown in Figure 3. Three original factors were retained from the WE matrix, and the first and third are compared to the two criterion factors. The location of the variables from the WE matrix are closer to the origin since three factors were used to compute the normalized loadings. Again, a fairly close correspondence is apparent, though the English Usage scale loads higher on the verbal factor in the WE matrix. The correlation between the loadings on Factor I of the criterion matrix with Factor I on the WE matrix is .90, indicating very close agreement. A correlation of .70 was obtained between the second criterion factor and the third WE factor. This similarity indicates that the verbal and math-science factors in the original matrix also exist in the WE matrix

The criterion and BE matrices are compared graphically in Figure 4. The variables in the BE matrix are clustered

Figure 3

A Comparison of the Factor Pattern of the Criterion NMSQT Matrix and the Within Family Environmental Matrix Calculated from Cross-twin Correlations

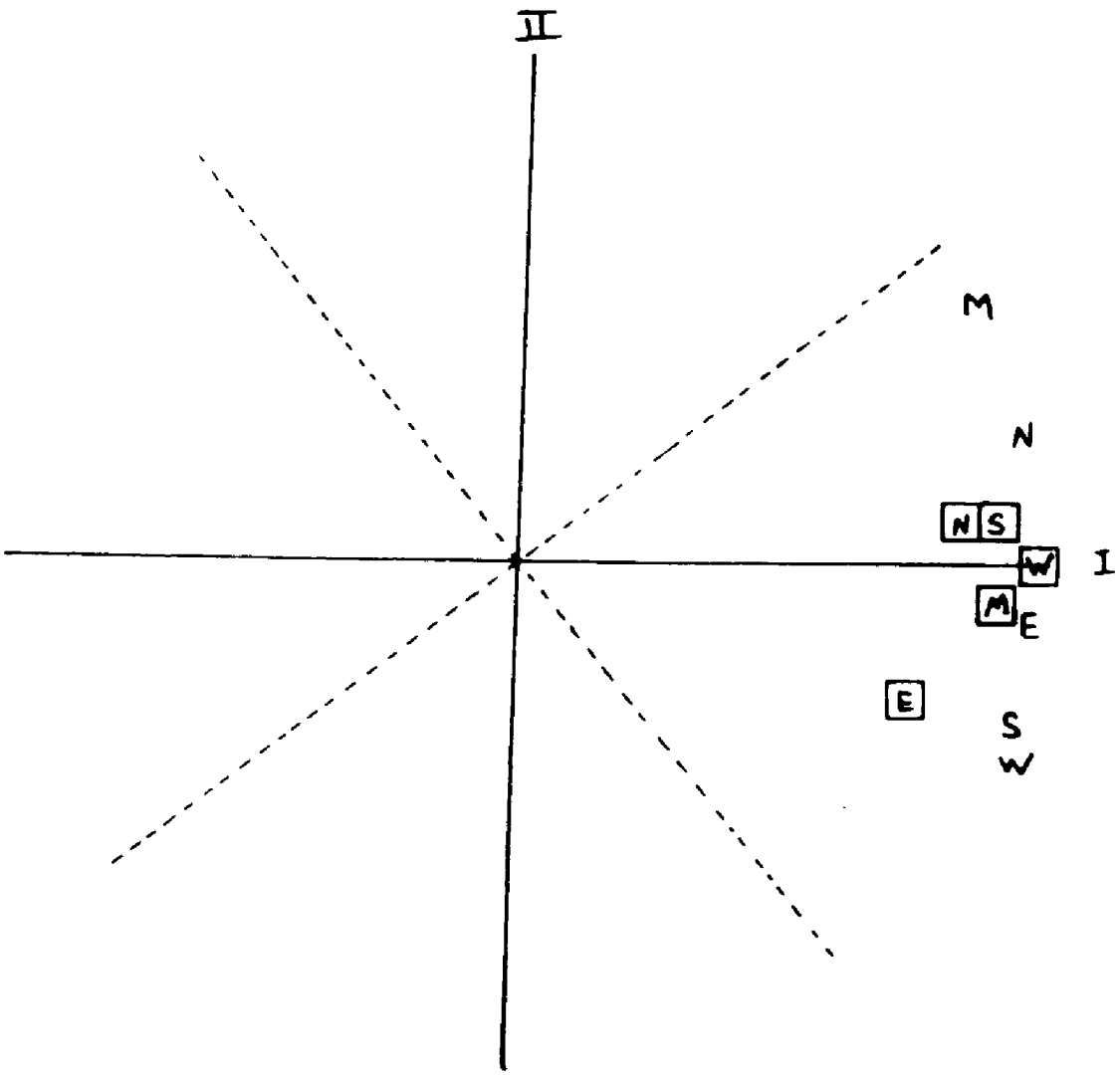


Simple letters represent criterion matrix
Letters in a diamond represent the within family environmental matrix

E = English Usage
M = Mathematics Usage
S = Social Studies Reading
N = Natural Science Reading
W = Word Usage

Figure 4

A Comparison of the Factor Pattern of the Criterion NMSQT Matrix and the Between Family Environmental Matrix Calculated from Cross-twin Correlations



Simple letters represent criterion matrix
Letters in a square represent between family environment matrix

E = English Usage
M = Mathematics Usage
S = Social Science Reading
N = Natural Science Reading
W = Word Usage

quite close together in the two factor space, indicating that only one general factor exists in this matrix. A comparison of the loadings of the criterion and BE variables on the two rotated factors therefore showed little agreement, yielding correlations of -.17 and .03. This indicates that verbal and math-science factors do not exist in the BE matrix.

Alternative hereditary and within family environmental matrices can be calculated from correlations among twin differences. Existence of a similar factor structure in these alternative matrices would cross validate the results of the previous analyses. The alternative within family environmental matrix is obtained from correlating twin set differences on the NMSQT. Correlations of MZ twin differences with sex were all less than .08, so that partailing out the sex effect did not alter the correlations calculated to two decimal places. Matrix 7, the alternative WE matrix, is presented in Table 23.

Table 23 also shows the correlations among DZ twin differences, Matrix 8. Again, the correlation of the difference scores with sex were very small, and partailing out the sex effect yielded no change in the correlations calculated to two decimal places. An alternative hereditary matrix was obtained from taking twice the difference between Matrix 7 and Matrix 8, and this matrix is also shown in Table 23.

Table 23

Alternative Matrices Calculated from Twin Difference Correlations

Correlations Among MZ Twin Differences
Alternative WE Matrix (Matrix 7)

	E	M	S	N	W
English Usage	1.00	.17	.19	.07	.32
Mathematics Usage		1.00	.19	.16	.18
Social Studies Reading			1.00	.12	.30
Natural Science Reading				1.00	.19
Word Usage					1.00

Correlations Among DZ Twin Differences
(Matrix 8)

	E	M	S	N	W
English Usage	1.00	.42	.46	.41	.47
Mathematics Usage		1.00	.37	.46	.41
Social Studies Reading			1.00	.38	.59
Natural Science Reading				1.00	.44
Word Usage					1.00

Alternative Hereditary Matrix
(Matrix 10)

	E	M	S	N	W
English Usage	.00	.50	.54	.68	.30
Mathematics Usage		.00	.36	.60	.66
Social Studies Reading			.00	.52	.58
Natural Science Reading				.00	.50
Word Usage					.00

The alternative H and WE matrices were then factored by the principal components method. The values in the diagonal of the WE matrix were all unity, but these were judged to be inappropriate for communality estimates. Communalities were therefore estimated as the highest correlation of the variable with any other variable. Likewize, the diagonal elements in the alternative H matrix could not be used as communality estimates, and the highest correlation of each variable with any other variable was subetituted.

The first unrotated factor extracted from the alternative WE matrix accounted for 80.5% of the common variance in the matrix. A second factor was also retained which accounted for an additional 14.1% of the variance. From the alternative H matrix, two factors were retained, the first accounting for 85.1% of the variance, the second explaining an additional 12.1%. So that a graphic comparison could be made, the loadings of each variable on the first two factors of the alternative H and alternative WE matrix were normalized. The location of each variable was then plotted in the two dimensional space defined by the first two unrotated factors. The location of the variables with regard to the previously described rotated axes was also read. Table 24 lists the loadings on the unrotated and rotated factors from the alternative H matrix, and Table 25 lists the loadings of the variables on the factors from the alternative WE matrix.

Table 24

Loadings of the 5 NMSQT Scales from the Alternative Hereditary Matrix on Unrotated and Rotated Factors

	A		B		C	
	I	II	I*	II*	I	II
English Usage	-.75	.33	.92	.40	.30	.98
Mathematics Usage	-.69	.10	.99	.14	.52	.87
Social Studies	-.71	-.23	.95	-.30	.85	.57
Natural Science	-.82	.15	.98	.17	.49	.88
Word Usage	-.66	-.42	.84	-.54	.97	.32

A Loadings on unrotated factors

B Normalized loadings on unrotated factors

C Loadings on rotated factors

* Factor reflected

Table 25

Loadings of the 5 NMSQT Scales from the Alternative Within Family Environmental Matrix on Unrotated and Rotated Factors

	A		B		C	
	I	II	I*	II*	I	II
English Usage	-.49	.27	.87	-.50	.95	.37
Mathematics Usage	-.38	-.14	.94	.35	.35	.96
Social Studies	-.49	-.04	1.00	.00	.63	.80
Natural Science	-.30	-.30	.71	.71	-.11	1.00
Word Usage	-.58	.05	1.00	.00	.63	.80

A Loadings on unrotated factors

B Normalized loadings on unrotated factors

C Loadings on rotated factors

* Factor reflected

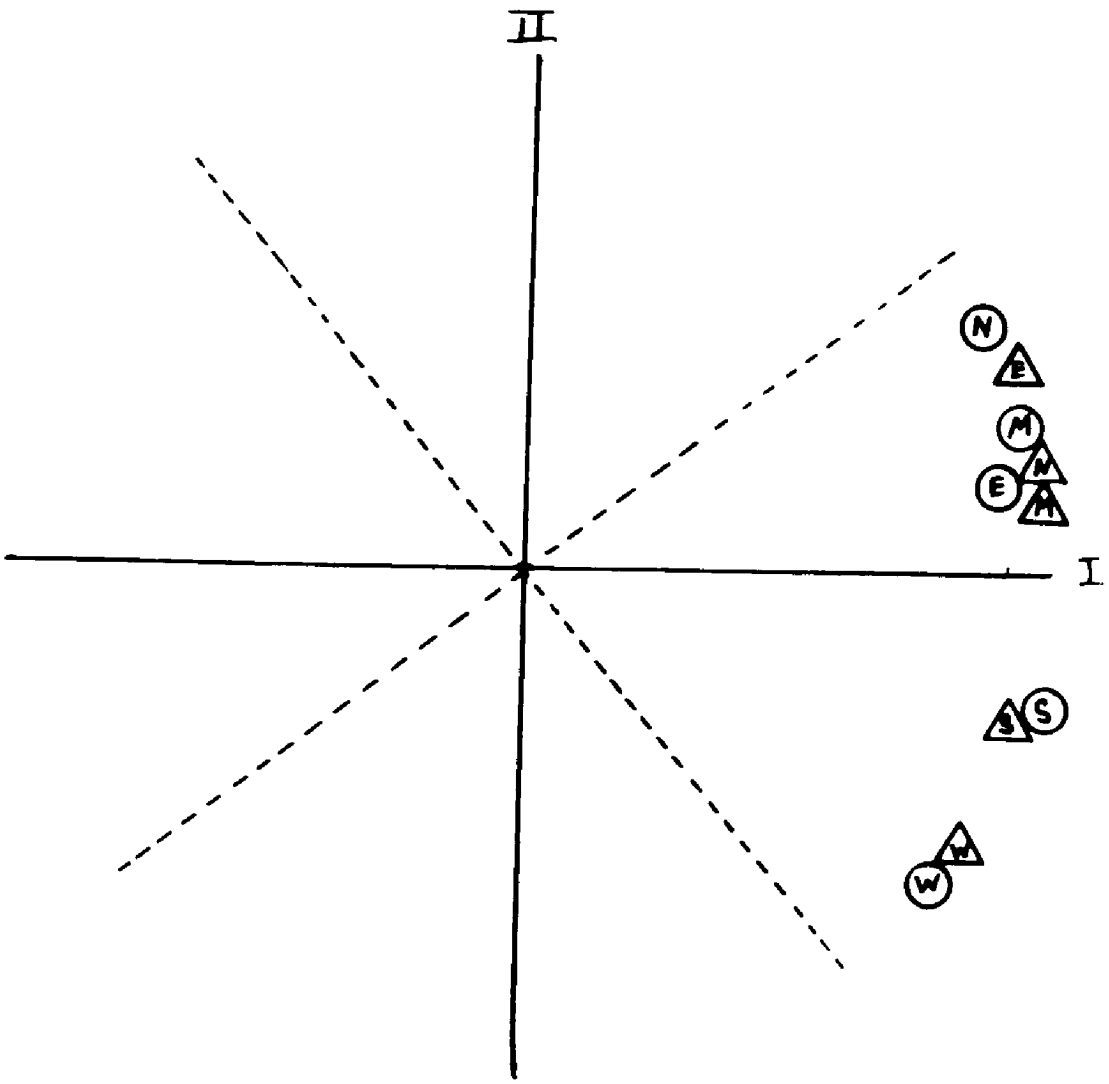
A graphic comparison of the structure of the H matrix calculated from cross-twin correlations and the alternative H matrix calculated from twin difference correlations is presented in Figure 5. The locations of the variables obtained from the two methods are quite similar. A rank-order correlation of the loadings on the first rotated factor from each method was .73. The correlation between the two sets of loadings on the second rotated factor was .90. Clearly the two alternative methods of calculating a matrix representing common hereditary components yield matrices with very similar structures.

The correspondence between the two methods of calculating the WE matrix is not so striking, as can be seen in Figure 6. Again, the locations of the variables obtained from the WE matrix calculated from cross-twin correlations are all closer to the origin because three factors were used in the normalization calculations. The correlation between the two sets of loadings on the first rotated factor was only .63. The correlation of the two sets of loadings on the second factor was .73. The slightly lower degree of correspondence between the two sets of loadings may be due in part to the sampling fluctuation of the MZ difference correlations, which ranges from .03 to .04.

From this series of factor structure comparisons, it can be concluded that the verbal and math-science factors found in the criterion correlation matrix have both heredi-

Figure 5

A Comparison of the Factor Pattern of the Hereditary Matrix Calculated from Cross-twin Correlations and the Hereditary Matrix Calculated from Twin Difference Correlations

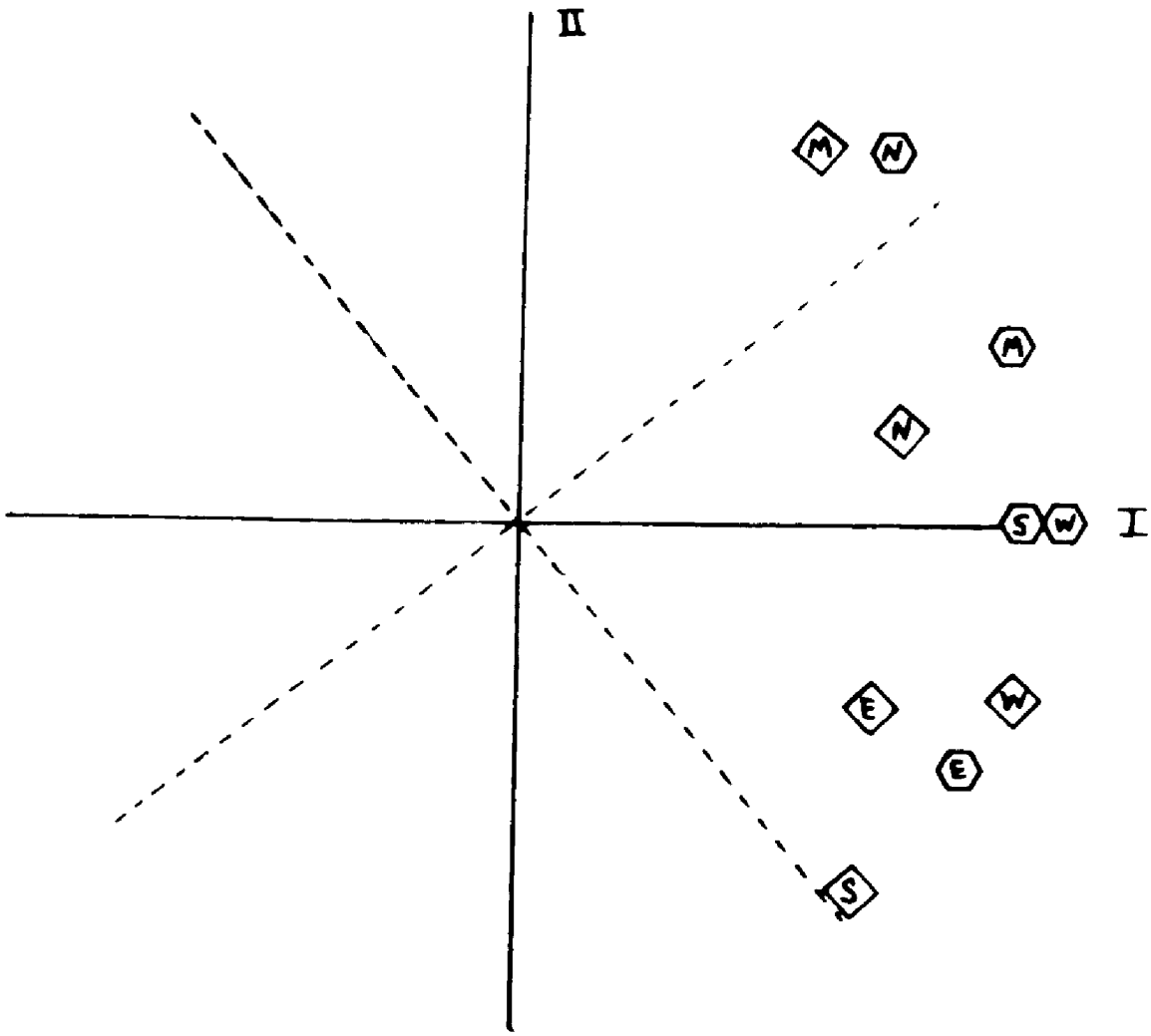


Letters in a circle represent the hereditary matrix calculated from cross twin correlations
Letters in a triangle represent the hereditary matrix calculated from twin difference correlations

E = English Usage
M = Mathematics Usage
S = Social Studies Reading
N = Natural Science Reading
W = Word Usage

Figure 6

A Comparison of the Factor Pattern of the Within Family Environmental Matrix Calculated from Cross-twin Correlations and the Within Family Environmental Matrix Calculated from Twin Difference Correlations



Letters in a diamond represent the within family environmental matrix calculated from cross-twin correlations
Letters in a hexagon represent the within family environmental matrix calculated from twin difference correlations.

E = English Usage
M = Mathematics Usage
S = Social Studies Reading
N = Natural Science Reading
W = Word Usage

tary and within family environmental origins, but the two factor structure is not related to any opposing dimensions in between family environment, which reflect only one genreal factor. In no case were the verbal and math-science factors clearly separated in two-factor space. However, these results indicate that the verbal and math-science factors may be under somewhat different genetic controls. Likewize, it appears that within family environmental effects also fall into two fairly distinct categories. The factor structures of the H and WE matrices obtained from the correlations among twin differences are very similar to those obtained from matrices derived from cross-twin correlations. While the matrices obtained from twin difference correlations may be somewhat less accurate, the similarity of factor structure further validates the results of the initial analyses.

CHAPTER 6

Conclusions and Implications for Education

Within the last 100 years, many investigators have studied twin populations for the purpose of resolving nature-nurture issues. Several of these investigators have proposed ways of manipulating twin data to make meaningful statements about the relative proportions of hereditary and environmental influences on trait variance. This paper has presented a new method, based on the insights of these previous investigators, for manipulating twin correlations and drawing conclusions about sources of individual differences in measures of achievement and personality. Some of the assumptions upon which the twin method is based have been tested, and the results used to increase the precision of estimates of hereditary and environmental variance components. Given this information alone, however, point estimates of these components cannot yet be justified. Further narrowing of the estimated ranges for these variance components will require several pieces of additional information. More research needs to be done to establish the precise degree of assortative mating in the population for each characteristic under investigation. Likewize, careful direct observation of subtle differences in the environments of identical and fraternal twins is needed. Knowledge about test reliability for the specific twin sample would also

reduce the uncertainty about the values of heritability and the within and between family environmental components.

The multivariate technique proposed in this paper provides a method by which patterns of correlations among measures can be further explored. While ranking of traits within the same general domain according to their heritability is of some interest, definition of the specific dimensions of heredity and environment common to the set of measures contributes much to our understanding of individual differences. A larger set of reliable tests administered to a substantial twin sample would provide more adequate data for analysis by this method. Only the ability domain has been explored by multivariate twin methods, and other domains of individual differences need to be investigated by this technique.

Implications for Education

The implications of heritability studies for education and social policy have been widely misunderstood, and this indeed may explain why Jensen's paper "How Much Can We Boost IQ and Scholastic Achievement?" has caused so much continuing consternation.

Specifically, a heritability estimate can be interpreted as the proportion of trait variance in the population which cannot be reduced given present environmental conditions. The value of $1 - h^2$ indicates the amount population variance could be reduced if environment were held constant.

This value also indicates the proportion of population variance which is presently influenced by educational,social-psychological or other environmental manipulations including prenatal and nutritional factors.

A heritability estimate only reflects the present balance between hereditary and environmental influences, and it will change if this balance changes. The relatively high heritability of the NMSQT scales, for instance, indicates that biological inheritance plays a major role in determining individual differences on these measures. Jensen noted, "This is not to say, however, that as yet undiscovered biological, chemical, or psychological forms of intervention in the genetic or developmental process could not diminish the relative importance of heredity as a determinant of intellectual differences." (Jensen, 1967, p.153). It should also be noted that if some method could be derived by which all individuals could be given the same "good" (or bad) environment, heritability would approach 1.00, since all observed individual differences could only be due to heredity.

Cooley and Lohnes (1968) feel that educators ought to be aware of results of heritability studies "to temper our enthusiasm for programs that try to shape human personality. It is easy for us to overestimate the potency of our educational arrangements." (Cooley and Lohnes, 1968, p.345). Educators should realize that the task of education cannot be to reduce individual differences on highly heritable

traits. Successful educational interventions may aim at increasing the average intellectual performance of school children, but the existance of genetic variation will result in substantial variation about the population mean.

Jensen aptly sums up the positive implications of heritability studies for educational and social policy. "We (should) take individual differences more seriously than regarding them as superficial, easily changed manifestations of environmental differences... We (should) look more critically and carefully at environmental variables that contribute most to differences in mental development, as I suggested that prenatal and nutritional factors had not been given due consideration. Also, we (should) expend more research effort on exploring and mapping a wider range of abilities than those measured by IQ tests, on discovering the particular learning strengths of each child, and on devising methods that will more fully utilize these strengths to help all children to benefit more from their schooling." (Jensen, 1969b, p.479).

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APPENDIX I

Zygosity Questionnaire

TWIN QUESTIONNAIRE

Dear Student:

When you took the National Merit Scholarship Qualifying Test last year, you indicated that you were a twin. We are doing a special analysis of the test scores of twins, and it will be very helpful if you will tell us how similar you and your twin are in physical appearance. Your answers will be used only for research, and will be kept confidential. Thank you very much for your help.

Check your name and address. If there are any errors, please correct.

a) Do you have a twin? Yes ____ No ____
b) Are you and your twin members of the same sex? Yes ____ No ____

If your answer to both of the above questions is YES, please complete the following items. Your responses will assist us in determining how similar you and your twin are in physical appearance.

If you do not have a twin or if your twin is of the opposite sex, please return this questionnaire in the envelope provided.

1. What is the natural color of your hair?_____

2. If your hair is different in any of the following ways from that of your twin, please describe these differences.

   Color:_____

   Rate of growth:_____

   Hairline or pattern of growth:_____

   Thickness or texture:_____

   Curliness:_____

   Other (Please specify):_____

3. What is the color of your eyes?_____

4. If your eye color is different from that of your twin, please describe the difference.

5. How tall are you?_____ft._____in.

6. What is the difference in your height and that of your twin?

   I am _____inches (taller, shorter).
   circle one

7. How much do you weigh?_____pounds.

8. What is the difference in your weight and that of your twin? I am _____pounds (lighter, heavier).
   circle one

9. If you know your blood type and Rh factor, write them here.

10. As a young child did your parents ever mistake you for your twin? (check one)
    ____ Yes, frequently
    ____ Occasionally
    ____ Rarely or never

11. Have your parents mistaken you for your twin recently? (check one)
    ____ Yes, frequently
    ____ Occasionally
    ____ Rarely or never

12. Have your teachers ever mistaken you for your twin? (check one)
    ____ Yes, frequently
    ____ Occasionally
    ____ Rarely or never

13. Have close friends ever mistaken you for your twin? (circle one)
    ____ Yes, frequently
    ____ Occasionally
    ____ Rarely or never

14. Have casual friends ever mistaken you for your twin? (check one)
    ____ Yes, frequently
    ____ Occasionally
    ____ Rarely or never

15. Do you and your twin look alike? Please explain.

16. Describe those physical features which most closely resemble those of your twin. (Give details)

17. Describe those physical features most unlike those of your twin. (Give details)

18. Do you know whether you are a fraternal or an identical twin?
____ I don't know whether I am an identical or a fraternal twin.
____ I think I am a fraternal twin.
____ I know for sure that I am a fraternal twin.
____ I think I am an identical twin.
____ I know for sure that I am an identical twin.

19. If you know whether you are fraternal or identical, indicate how and by whom it was determined.

20. If you had any major illnesses or accidents that your twin did not have, please indicate the nature of the illness or accident and your age when it occurred.

21. If you were ever separated from your twin for more than a month at a time before age 13 years, please indicate where each of you were living, what you were doing, and your age at the time.

22. Have you had any important experiences or training that your twin has not had? Please explain.

23. What is your grade average for your highest level of work so far? Circle one.

1. A (93-100)
2. A- or B+ (89-92)
3. B (84-88)
4. B- or C+ (78-83)
5. C (73-77)
6. C- or D+ (68-72)
7. D or lower (67 or below)

For Questions 24-41 you are to indicate the degree of interest you have in each of the occupations listed. Consider only how well you think you would like the work connected with the occupation. Do not consider salary, job prestige, required training, etc. (Your answer does not necessarily mean that you would enter the occupation). Mark your answer as follows:

1. Like very much
2. Like somewhat
3. Neither like nor dislike
4. Dislike a little
5. Dislike very much

24. Engineer . . . . . ___
25. Physician . . . . . ___
26. Accountant . . . . . ___
27. Artist . . . . . ___
28. Electrician . . . . . ___
29. Lawyer . . . . . ___
30. Shop Foreman . . . . . ___
31. Farmer . . . . . ___
32. Bookkeeper . . . . . ___
33. Research Scientist . . . . . ___
34. Business Manager . . . . . ___
35. Sales Representative . . . . . ___
36. High School Teacher . . . . . ___
37. Writer or Journalist . . . . . ___
38. Social Worker . . . . . ___
39. Life Insurance Salesman . . . . . ___
40. Building Contractor . . . . . ___
41. Nurse or Hospital Attendant . . . . . ___

APPENDIX II

Twin Questionnaire

CA _____ (1-6)

1. What is your sex? (Circle one.)

Male 1 (7)
Female 2

2. When did (will) you graduate from high school? (Circle one.)

Mid-term 1962-63. . . . . 3 (8)
Spring 1963 4
Summer 1963 5
Mid-term 1963-64. 6
Other (Circle and specify.) _____ 7

3. What will you be doing this fall? If you expect to be doing two things simultaneously, circle both. If you are considering two alternatives, circle only the more probable.

Student in college, high school or training course. 1 (9)
Working at a type of job which I expect to be my long-run career field. 2
Working at a job which will probably not be my long-run career field. 3
Military service. 4
Housewife 5
Other (Circle and specify.) _____ 6

4. What college or school are you planning to attend next year? (If you will not be a student next fall, write in "None".)

_____ (10-13)
Name of College City and State

5. What will be your future career or life work? (Be as specific as possible.)

_____ (14-15)

6. What alternative career plans are you considering? _____ (16-17)

_____

7. What is the highest level of education you expect to complete? (Circle one.)

High school diploma. 1 (18)
Non-college training course (business school, nurse's training, etc.). . . . 2
College, but less than a bachelor's degree 3
Bachelor's degree or equivalent. 4
One or two years of graduate or professional study (M.A., M.B.A., etc.). . . 5
Doctor of Philosophy (Ph.D.) 6
Doctor of Medicine (M.D.). 7
Doctor of Dental Surgery (D.D.S.). 8
Bachelor of Laws (L.L.B.). 9
Bachelor of Divinity (B.D.). 0
Other (Circle and specify.) _____ x

8. Which hand do you favor? (Circle one.)

I have always been right handed. 1 (19)
I favored my left hand as a child, but am now right handed 2
I am left handed and tried, unsuccessfully, to write. 3
I am left handed and have not seriously tried to write. 4
I am ambidextrous 5

9. What is your academic rank in your high school class? (0001 is the highest rank, 0002 the next highest, etc.)

I ranked number [ ][ ][ ][ ] in a class of [ ][ ][ ][ ] (76-83)

How accurate is your report of high school rank? (Circle one.)

It is correct as reported to me by the school 1
It is an estimate calculated from grade average, percentile rank or some other measure of performance 2
It is a guess based on my general impression 3
I have no idea of my high school rank and have left the item blank 4 (84)

Is your rank in class as reported above a fair indication of your ability? (Circle one.)

It grossly under-represents my ability 1
It slightly under-represents my ability 2
It is a fair representation of my ability 3
It slightly over-represents my ability 4
It grossly over-represents my ability 5 (85)

10. Which of the following best describe the community which you think of as your home town during high school days? (Circle one.)

Farm or open country 1
Suburb in a metropolitan area of--
more than 2 million population 2
500,000 to 2 million 3
100,000 to 499,999 4
less than 100,000 5
Central city in a metropolitan area or city of--
more than 2 million population 6
500,000 to 2 million 7
100,000 to 499,999 8
50,000 to 99,999 9
10,000 to 49,999 0
less than 10,000 . . . . . A (86)

11. How much do you smoke? (Circle all that apply.)

I have never smoked 1
I used to smoke but quit 2
I smoke only occasionally or under special circumstances 3
I smoke from 1 to 19 cigarettes a day 4
I smoke from 20 to 39 cigarettes a day 5
I smoke 40 or more cigarettes a day 6
I smoke from 1 to 3 cigars a day 7
I smoke from 4 to 6 cigars a day 8
I smoke 7 or more cigars a day 9
I smoke from 1 to 3 pipefuls of tobacco a day 0
I smoke from 4 to 6 pipefuls of tobacco a day . . . . . A
I smoke 7 or more pipefuls of tobacco a day . . . . . B (87)

12. If you smoke do you inhale the smoke into your lungs? (Circle one.)

I don't smoke . . . . . 1 ( )
I rarely or never inhale 2
I sometimes inhale 3
I usually inhale 4

13. In an average week during the past school year, how much time did you spend in each of the following activities? Indicate time when you were attending school--do not include vacation time. Fill in the boxes with two digits indicating the average number of hours spent in each activity during a typical seven-day period. Indicate time to the nearest hour. Do not write in fractional hours. (69-76)

FOR EXAMPLE:
If you spend about 8 hours a night sleeping, you sleep 7 x 8 hours a week, which you would indicate: 5 6

	No. of Hrs.		No. of Hrs.
Studying for school assignments . . .		Daydreaming.	
Attending class		Personal care (bathing, fixing hair, putting on make-up, etc.)	
Reading for pleasure.		Attending club or organizational activities (meetings, pledge-duties, etc.)	
Talking informally with others. . . .		Participating in musical, dramatic or artistic activities	
Watching TV		Working on other projects or hobbies not directly related to course work or a job	
Attending movies and plays.		Hanging around, waiting time	
Watching sports events.		Playing games (cards, chess, etc.)	
Sleeping.		Participating in sports and practice sessions. . . .	
Working for a salary, hourly wage or commission			
Working on your own private business enterprise			

14. What is your racial background? (Circle one.) (77)

White. 1
Negro. 2
Oriental 3
Other (Circle and specify.)_____ 4

In which religion were you reared? (Circle one.)

Protestant (Circle and specify.)_____ 1 (78)
Roman Catholic 2
Jewish 3
Other (Circle and specify.)_____ 4
None 5

What is your present religious preference? (Circle one.)

Protestant (Circle and specify.)_____ 1 (79)
Roman Catholic 2
Jewish 3
Other (Circle and specify.)_____ 4
None 5

ID _____ (1-6)

15. Below is a list of things that students sometimes do. Indicate which of these things you have done during the past year (since this time last year.) If you have engaged in an activity regularly with a frequency appropriate for the activity, circle the number under "Frequently." If you have engaged in an activity one or more times, but not frequently, circle the number under "Occasionally." If you have not engaged in the activity during the past year, circle the number under "Not at all." (Circle one for each item.)

(7-62)

	Frequently	Occasionally	Not at all
Played checkers	1	2	3
Played chess	1	2	3
Went horseback riding	1	2	3
Went ice skating	1	2	3
Went roller skating	1	2	3
Picked-up a date in a bar, restaurant or similar place	1	2	3
Made minor repairs around the house	1	2	3
Took cough syrup	1	2	3
Cared for tropical fish or goldfish	1	2	3
Cared for other pet animals	1	2	3
Prayed (not including prayer before meals)	1	2	3
Said grace before meals	1	2	3
Discussed how to make money with friends	1	2	3
Listened to modern (progressive) jazz	1	2	3
Listened to New Orleans (Dixieland) jazz	1	2	3
Listened to folk music	1	2	3
Rode a motorcycle	1	2	3
Went to a party	1	2	3
Gambled with cards	1	2	3
Gambled with dice	1	2	3
Discussed school subjects with friends	1	2	3
Drove a car over 70 M.P.H.	1	2	3
Sold used textbooks	1	2	3
Went to sleep in class	1	2	3
Shot pool	1	2	3
Borrowed money	1	2	3
Used "Man-Tan," "Tan-O-Rama," "Q.T." or similar products	1	2	3

	Frequently	Occasionally	Not at all
Played a practical joke on someone	1	2	3
Played golf	1	2	3
Ran track (hurdles, hurdles, distance, etc.)	1	2	3
Went water skiing or surf board riding	1	2	3
Went skiing	1	2	3
Participated in crew events (sculls, pairs, fours, etc.)	1	2	3
Stayed up all night	1	2	3
Attended a public lecture (not for a course)	1	2	3
Drank wine	1	2	3
Gave a public recital (vocal, instrumental, etc.)	1	2	3
Gave a prepared talk to fifteen or more people	1	2	3
Listened to the radio	1	2	3
Performed magic or card tricks	1	2	3
Made wisecracks in class	1	2	3
Played a piano or other instrument while others were singing	1	2	3
Lent money to a friend	1	2	3
Bought a folk music record	1	2	3
Drank sherry, gin or other hard liquor	1	2	3
Made contact in a library or [illegible]	1	2	3
Had [illegible]	1	2	3
Worked on a scrap book	1	2	3
Knitted	1	2	3
Made an article of clothing	1	2	3
Went to social (ballroom) dancing	1	2	3
Lived at your home	1	2	3
Polished your shoes	1	2	3
Played Tic-Tac-Toe, Hangman's Noose, or similar games in class	1	2	3

x

x

B _____ (1-6)

(7-63)

	Frequently	Occasionally	Not at all
Studied with another person	4	5	6
Took dancing lessons	4	5	6
Took No-Doz or other stay-awake pills	4	5	6
Repaired or worked on a car	4	5	6
Changed clothes during the day (exclude gym or athletics)	4	5	6
Baby sat	4	5	6
Performed pledge duties	4	5	6
Took a sleeping pill	4	5	6
Sang in a church choir	4	5	6
Sang in a school choir	4	5	6
Sang in a small ensemble (trio, quartet, etc.)	4	5	6
Took golf lessons	4	5	6
Bought a popular or jazz record	4	5	6
Took horseback riding lessons	4	5	6
Cooked a complete meal	4	5	6
Cleaned and dusted your room	4	5	6
Daydreamed in class	4	5	6
Worked backstage on a play	4	5	6
Did voluntary work for a hospital or service organization (Red Cross, Heart Fund, etc.)	4	5	6
Arranged a date for a friend	4	5	6
Attended athletic events	4	5	6
Worked on a number painting	4	5	6
Made bets on a game or other event (not cards or dice)	4	5	6
Played charades	4	5	6
Attended a burlesque show	4	5	6
Went to a party with a date	4	5	6
Went to an overnight or week-end party	4	5	6

x

	Frequently	Occasionally	Not at all
Went square dancing	4	5	6
Cared for a potted plant	4	5	6
Argued with a teacher in class	4	5	6
Bought a paper-back book	4	5	6
Bought a classical or semi-classical record	4	5	6
Chewed gum	4	5	6
Bit your fingernails	4	5	6
Rode in a sports car	4	5	6
Went sightseeing	4	5	6
Practiced on a musical instrument	4	5	6
Took a nap or rest during the day	4	5	6
Talked in a language other than English	4	5	6
Conducted a choir, band or orchestra	4	5	6
Took voice lessons	4	5	6
Crocheted	4	5	6
Picked-up a hitch-hiker	4	5	6
Tutored someone for money	4	5	6
Tutored someone for free	4	5	6
Wrote articles for a school paper, year-book or similar publication	4	5	6
Went to a night club with a floor show	4	5	6
Took photographs	4	5	6
Built or flew a model airplane	4	5	6
Took Metrecal or similar dietary formula	4	5	6
Participated in a student demonstration (strike, water-fight, etc.)	4	5	6
Attended an orchestra concert	4	5	6
Attended a formal dance	4	5	6
Read magazines at a newsstand without buying any	4	5	6
Worked for a club or organization	4	5	6

x

(1-6)

(7-12)

	Frequently	Occasionally	Never
Played football (touch or tackle)	7	8	9
Bowled	7	8	9
Went to the movies	7	8	9
Developed pictures (darkroom work)	7	8	9
Attended a professional stage play	7	8	9
Solicited advertising for a school paper, yearbook or similar publication	7	8	9
Went swimming	7	8	9
Participated in field events (shot put, javelin, high jump, etc.)	7	8	9
Saw a foreign movie	7	8	9
Rode a bicycle	7	8	9
Attended a horse race	7	8	9
Played tennis	7	8	9
Took tranquilizing pills	7	8	9
Attended a student stage play	7	8	9
Drove a car	7	8	9
Went boating	7	8	9
Washed dishes	7	8	9
Worked crossword puzzles	7	8	9
Ate lunch or dinner alone	7	8	9
Watched TV	7	8	9
Put up decorations for a party	7	8	9
Attended a ballet performance	7	8	9
Overslept and missed a class or appointment	7	8	9
Visited a person in a hospital	7	8	9
Obtained a book or journal from the library	7	8	9
Read The Bible	7	8	9
Danced the twist	7	8	9

	Frequently	Occasionally	Never
Took vitamins	7	8	9
Participated in a track meet	7	8	9
Attended a professional prize fight or wrestling match	7	8	9
Flew in an airplane	7	8	9
Attended a football game	7	8	9
Visited a museum	7	8	9
Played football or frisbee	7	8	9
Went on a camping trip	7	8	9
Voted in a student council election	7	8	9
Went hunting	7	8	9
Discussed religion with friends	7	8	9
Took a laxative	7	8	9
Talked for over thirty minutes at a time on the telephone	7	8	9
Called a teacher by his first name	7	8	9
Participated in a wedding (usher, bridesmaid, etc.)	7	8	9
Bought stamps for a stamp collection	7	8	9
Cut classes	7	8	9
Twirled a baton	7	8	9
Wrote letters to friends your own age	7	8	9
Went window shopping	7	8	9
Drank in a bar	7	8	9
Took aspirin	7	8	9
Painted a picture (oil, watercolor, pastel, etc.)	7	8	9
Played cards (bridge, pinochle, etc.)	7	8	9
Told jokes	7	8	9
Listened to records in a store without buying	7	8	9
Played in a band or jazz band	7	8	9

(1-6) _____

(7-57)

	Frequently	Occasionally	Not at all
Ate Chinese food.	1	2	3
Swore in the presence of your parents	1	2	3
Swore in the presence of girls your own age	1	2	3
Swore in the presence of boys your own age	1	2	3
Was consulted for help or advice by someone with a personal problem	1	2	3
Took anti-acids (Bromo-Seltzer, Roll-Aids, etc.)	1	2	3
Lay awake for an hour or more trying to go to sleep.	1	2	3
Had a nightmare	1	2	3
Went without breakfast.	1	2	3
Went without lunch.	1	2	3
Went without dinner	1	2	3
Wrote a letter to a "pen-pal" whom you have never met in person.	1	2	3
Did an imitation or impersonation of another person.	1	2	3
Complained about service in a restaurant.	1	2	3
Cribbed a paper or had someone ghost-write one for you	1	2	3
Drank black coffee (no cream or sugar).	1	2	3
Attended a church or service of a religion other than your own	1	2	3
Placed a long distance call of over 500 miles	1	2	3
Went on a double date	1	2	3
Wrote a "love-letter"	1	2	3
Purposely ditched a date.	1	2	3
Wrote a "Letter-to-the-Editor".	1	2	3
Had a hangover.	1	2	3
Played a slot machine	1	2	3

x

	Frequently	Occasionally	Not at all
Let work for a class pile up until just before a test.	1	2	3
Read poetry that was not required reading.	1	2	3
Wrote poetry on your own initiative.	1	2	3
Discussed sexual matters with your mother.	1	2	3
Discussed sexual matters with your father.	1	2	3
Discussed sexual matters with a male friend	1	2	3
Discussed sexual matters with a female friend	1	2	3
Borrowed clothing from a friend.	1	2	3
Wore glasses	1	2	3
Used a thermometer to take your temperature.	1	2	3
Attended a religious revival meeting	1	2	3
Looked something up in an encyclopedia	1	2	3
Bought or sold corporate stocks.	1	2	3
Baked a cake or pie from scratch (no mixes)	1	2	3
Wore sun glasses after dark.	1	2	3
Awakened in the middle of the night and was unable to go back to sleep	1	2	3
Ate a steak cooked rare.	1	2	3
Was "stood-up" by a date	1	2	3
Reported someone to the authorities for some form of misbehavior	1	2	3
Entered a speech or debate contest	1	2	3
Had your back rubbed	1	2	3
"Bird-dogged" (stole another person's date).	1	2	3
Had your date "bird-dogged" by someone else	1	2	3
Had a drink before breakfast or instead of breakfast	1	2	3
Produced a work of art (not for a course).	1	2	3

x

(7-70)

	Frequently	Occasionally	Not at all
Had a quarrel with your mother.	4	5	6
Had a quarrel with your father.	4	5	6
Had a quarrel with your brother or sister.	4	5	6
Had a quarrel with a male friend.	4	5	6
Had a quarrel with a female friend.	4	5	6
Visited a friend's home overnight	4	5	6
Visited a relative's home overnight	4	5	6
Had a friend visit your home overnight	4	5	6
Started a conversation with strangers	4	5	6
Went to the movies alone.	4	5	6
Tried on clothes in a store without buying anything	4	5	6
Pushed a stalled car (other than your own)	4	5	6
Listened to classical or semi-classical music	4	5	6
Smoked a cigarette or cigar before breakfast	4	5	6
Played a pinball machine.	4	5	6
Went skin diving.	4	5	6
Attended an art exhibition.	4	5	6
Played pool (indoor or outdoor)	4	5	6
Went skeet or trapshooting.	4	5	6
Hitch-hiked	4	5	6
Acted in a play	4	5	6
Tried to hypnotize someone.	4	5	6
Taught Sunday school.	4	5	6
Attended Sunday school.	4	5	6
Attended church	4	5	6
Cried	4	5	6
Played basketball	4	5	6
Memorized things	4	5	6
Discussed sports with friends	4	5	6
Blushed	4	5	6
Had a blind date.	4	5	6

x

(1-4) c _____

	Frequently	Occasionally	Not at all
Kissed your mother	4	5	6
Kissed your father	4	5	6
Wore formal clothing (evening gown, tuxedo, dinner jacket, etc.)	4	5	6
Told a "dirty joke" to male friends.	4	5	6
Told a "dirty joke" to female friends.	4	5	6
Hit or slapped a boy of your own age	4	5	6
Hit or slapped a girl of your own age.	4	5	6
Was hit or slapped by a boy of your own age.	4	5	6
Was hit or slapped by a girl of your own age.	4	5	6
Lent something to a friend.	4	5	6
Played Monopoly, Scrabble, or similar games.	4	5	6
Drew pictures or doodles in a notebook during class	4	5	6
Participated in a science contest or talent search.	4	5	6
Played sick to avoid taking an examination or other unpleasant duty	4	5	6
Played in a concert orchestra.	4	5	6
Lifted weights	4	5	6
Played table tennis or ping-pong	4	5	6
Worked on Hi-Fi or radio equipment	4	5	6
Dined by candle light.	4	5	6
Participated in a debate or speech contest	4	5	6
Played soccer.	4	5	6
Played in a marching band.	4	5	6
Lost your temper	4	5	6
Went fishing	4	5	6
Asked questions in class	4	5	6
Led a cheering section	4	5	6
Became intoxicated	4	5	6
Played solitaire	4	5	6
Collected insect specimens	4	5	6
Ate candy	4	5	6
Drank beer	4	5	6

x

(7-58)

-C_____ (-)

Frequency Occasionally Not

Rode on a roller coaster, ferris wheel, merry go round, or similar ride. . . . . / S -

As a check on accuracy of recording make no response at all to this item. . . . . - - -

Studied with the radio, record player or TV on . . . . . - - -

Had a porter or red cap carry a suitcase for you. . . . . - - -

Paid someone to paint your house. . . . . - - -

Cut your own hair. . . . . - - -

Started a false rumor. . . . . - - -

Voted for someone you knew a thing or two about . . . . . - - -

Spent an hour or a time daydreaming. . . . - - -

Smashed a vase or other object in an expression of anger or frustration . . . - - -

Gave a tip of more than 15% of the check to a waiter, taxi driver, etc. . . . . - - -

Gave a tip to a washroom attendant . . . - - -

Read an entire book in a single sitting. . . . - - -

Painted . . . . . - - -

Ran a race. . . . . - - -

Obtained the autograph of a famous person - - -

Mixed a cocktail, milkshake, highball or more ingredients (e.g. lemonade, tea). . - - -

Carried a tray of food (like a waitress, steward, soda jerk). . . . - - -

Dove from a diving board or into a swimming pool at least waist deep. . . . - - -

Jumped in a swimming pool . . . . . - - -

Drank [illegible] - - -

Drank four or more cups of coffee or tea in one day. . . . . - - -

[illegible] - - -

Had a party with a theme . . . . . - - -

Slept more than 12 hours at a time . . . - - -

Bought a gift to make them feel . . . . - - -

Left a party or dance in order to finish some work. . . . . / S -

Tried to convince someone to change his (her) religious beliefs. . . . . / S -

Tried to convince someone to change his (her) political or social beliefs. . . . / S -

Practiced decorative or unusual handwriting. . . . . - - -

Took a bubble bath . . . . . - - -

Read the editorial page of a newspaper . / S -

Made a new friend. . . . . / S -

Made your own bed. . . . . - - -

Washed dishes . . . . . / S -

Took a day off work to . . . . . / S -

Wrote a letter to a congressman. . . . . - - -

Bought a [illegible] . . . . . - - -

Took a [illegible] . . . . . - - -

Turned down an invitation from [illegible] - - -

Bought or took out a life insurance policy . . . . . - - -

Visited a doctor for a physical exam [illegible] . . . . . - - -

Put a [illegible] - - -

Was [illegible] - - -

Ate breakfast in bed (e.g. on a special occasion). . . . . - - -

[illegible] - - -

[illegible] - - -

[illegible] - - -

Was late for work or school . . . . . / S -

16. People have many different goals in life, some of the more common of which are listed below. Indicate the importance which you place on the following kinds of accomplishments, aspirations, and goals. (Circle one in each row.)

CD_____(1-6)	Essential (something I must achieve)	Very Important to achieve (but not essential)	Somewhat Important to achieve	Of little or no importance
Becoming happy and content.	1	2	3	4
Being well-off financially.	1	2	3	4
Inventing or developing a useful product or device.	1	2	3	4
Helping others who are in difficulty.	1	2	3	4
Becoming accomplished in one of the performing arts (acting, dancing, etc.).	1	2	3	4
Developing a meaningful philosophy of life.	1	2	3	4
Becoming an authority on a special subject in my field.	1	2	3	4
Doing something which will make my parents proud of me	1	2	3	4
Becoming an outstanding athlete	1	2	3	4
Making sacrifices for the sake of the happiness of others	1	2	3	4
Becoming a community leader	1	2	3	4
Becoming influential in public affairs.	1	2	3	4
Becoming a mature and well-adjusted person.	1	2	3	4
Following a formal religious code	1	2	3	4
Having the time and means to relax and enjoy life.	1	2	3	4
Making a theoretical contribution to science.	1	2	3	4
Making a technical contribution to science.	1	2	3	4
Writing good fiction (poems, novels, short stories, etc.).	1	2	3	4
Being well read	1	2	3	4
Obtaining awards or recognition	1	2	3	4
Never being obligated to people	1	2	3	4
Keeping in good physical condition.	1	2	3	4
Producing good artistic work (painting, sculpture, decorating, etc.)	1	2	3	4
Becoming an accomplished musician (performer or composer).	1	2	3	4
Becoming an expert in finance and commerce.	1	2	3	4
Keeping up to date with political affairs	1	2	3	4
Being well-liked.	1	2	3	4
Being a good husband or wife.	1	2	3	4
Being a good parent	1	2	3	4
Finding a real purpose in life.	1	2	3	4
Being active in religious affairs	1	2	3	4
Having executive responsibility for the work of others	1	2	3	4
Avoiding hard work.	1	2	3	4
Engaging in exciting and stimulating activities	1	2	3	4
Being successful in a business of my own.	1	2	3	4

17. Which of the following statements best describes your religious belief? (Circle one.)

I believe in a personal God, a supreme being, who knows my thoughts and hears my prayers. 1 (45)

I believe in a supreme being who created and controls the universe, but I am not sure that individual people can communicate with Him 2

I am not sure whether or not there is a God, but I tend to think that there is. 3

I am not sure whether or not there is a God, but I tend to think that there is not. 4

I believe that there is no God. 5

I don't know what I believe 6

Other (Circle and specify.)_____ 7

---

18. An issue which has been the subject of public debate recently is the speed with which integration of the races, particularly Negroes and Whites, should take place in this country. Which of the statements below comes closest to your personal opinion? (Circle one.)

All discrimination among people on the basis of race is unfair and should be stopped immediately, even though this probably would change many current social institutions 1 (46)

The elimination of all discrimination among people on the basis of race should be our goal, but we should proceed slowly enough to allow people to make adjustments to the changes that will occur 2

Basic legal rights should be provided for all races, but beyond this, people should be able to limit their associations to members of their own race if they want to 3

There are great differences between the races and there is no reason why these differences should not be used as the basis for certain civil rights such as voting privileges, education, jobs, etc. 4

I have no particular feeling one way or the other 5

Other (Circle and specify.)_____

_____ 6

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19. Another issue which has been the subject of public debate recently is the role of the federal government in providing for the needs of the people. Which of the statements below comes closest to your personal opinion? (Circle one.)

The federal government should provide for the people only what they cannot possibly do for themselves. This includes such matters as international relations, national defense and the like. All other functions are better left to local governments or private enterprise 1 (47)

The federal government can bring benefits to the people in many ways and should enter fields such as [illegible] welfare, stimulation of the economy and the like, only if [illegible] governments and private enterprise have failed to [illegible] . . . 2

The federal government is responsible for the welfare of the people and should expand its activities in such areas as education, health, generation of power, etc., even though there are already local or private programs in existence 3

I have no particular feeling one way or the other 4

Other (Circle and specify.)_____ 5

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20. What is your current marital or dating status? (Circle one.)

Married (children or expecting)	1	(46)
Married (no children)	2	
Engaged	3	
Pinned or going steady	4	
Usually date the same person	5	
Usually date different persons	6	
Do not date at all	7	

21. What is the frequency of your dates? Indicate the average number of dates of each type that you have per month. Round to the nearest whole number. If less than one every two months, write in "00." (If married, indicate the number of times you and your spouse go out together to these events.)

(47-52)

Casual coke, coffee or study dates (No. per month)		Informal dates to movies, student gatherings, etc. (No. per month)		Formal dates to dances and big parties (No. per month)	

22. Have you done any of the following things during the past year (since this time last year)? If you have done a thing one or more times during the year, circle the number under "Yes;" if not, circle the number under "No." (Circle one for each item.)

ID_____(1-6)

(7-42)

	YES	NO		YES	NO
Gained more than ten pounds in weight	1	2	Wore a wig	1	2
Lost more than ten pounds in weight	1	2	Had a change in your glasses prescription	1	2
Flunked a course	1	2	Dropped a course	1	2
Took a course over and above requirements	1	2	Changed your long-term career plans	1	2
Went on a diet	1	2	Fell in love	1	2
Became pinned or engaged	1	2	Fell out of love	1	2
Broke-up with a girlfriend	1	2	Visited a private agency	1	2
Broke-up with a boyfriend	1	2	Was in an auto accident, but was not driving	1	2
Donated money to a charity	1	2	Had an auto accident while driving	1	2
Worked for the election of a political party or candidate	1	2	Read one or more novels that were not required	1	2
Contributed money to a political party or candidate	1	2	Went on a marital trip with friends your own age	1	2
Proposed marriage to someone	1	2	Was fired from a job	1	2
Received a marriage proposal	1	2	Donated blood	1	2
Got a ticket for a traffic violation	1	2	Repeated a year in school (flunking)	1	2
Was arrested or got a ticket for something other than a traffic violation	1	2	Wrote a paper or report of ten or more pages	1	2
Went on the wagon (swore off drinking)	1	2	Wrote a paper or report of thirty or more pages	1	2
Signed a petition	1	2	Visited the dentist	1	2
Cust mized an auto, bike	1	2	Read the biography of a famous person	1	2
Read one or more non-fiction books that were not required reading	1	2	Went to the basement or put under a table to protect possible damage from a storm	1	2
Painted a room or house	1	2	Changed your hair style	1	2
Got a tattoo	1	2	Seriously considered changing your first name	1	2
Had a check bounce	1	2	Seriously considered changing your last name	1	2
Set-up a schedule with specific times for various activities	1	2	Contemplated suicide	1	2
Went to a carnival, amusement park or circus	1	2	Had a deep spiritual experience	1	2
Had psychotherapy	1	2			
Made your own Christmas cards	1	2			
Grew a beard	1	2			
Bleached or dyed your hair	1	2			

(1-4)

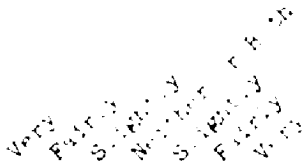
4. Below are a number of dimensions along which people vary. Please rate yourself on each dimension as honestly as you can. The words or phrases describe each end of the scale. If one of a pair of words is descriptive of you, circle the number near that end. If neither is descriptive of you or if it is equally applicable, circle one of the numbers near the center. Many of the traits depend on the situation, of course, but try to rate yourself as you usually are. (Circle one in each row.)

	Very	Fairly	Slightly	Neither	Slightly	Fairly	Very	
Religious	1	2	3	4	5	6	7	Non-religious (7-5)
Good-looking	1	2	3	4	5	6	7	Unattractive
Happy	1	2	3	4	5	6	7	Unhappy
Satisfied with self	1	2	3	4	5	6	7	Dissatisfied with self
Considerate	1	2	3	4	5	6	7	Inconsiderate
Well-adjusted	1	2	3	4	5	6	7	Maladjusted
Dependable	1	2	3	4	5	6	7	Undependable
Ambitious	1	2	3	4	5	6	7	Unambitious
Optimistic	1	2	3	4	5	6	7	Pessimistic
High-strung	1	2	3	4	5	6	7	Calm
Responsible	1	2	3	4	5	6	7	Irresponsible
Lazy	1	2	3	4	5	6	7	Energetic
Stable	1	2	3	4	5	6	7	Give to worry
Extravert	1	2	3	4	5	6	7	Introvert
Critical of others	1	2	3	4	5	6	7	Uncritical of others
Talkative	1	2	3	4	5	6	7	Quiet
Like responsibility	1	2	3	4	5	6	7	Try to avoid responsibility
Messy	1	2	3	4	5	6	7	Neat
Easily upset	1	2	3	4	5	6	7	Calm most of the
Worried	1	2	3	4	5	6	7	Carefree
Have many friends	1	2	3	4	5	6	7	Have few friends
Cheerful	1	2	3	4	5	6	7	Not cheerful
Timid	1	2	3	4	5	6	7	Bold
Predictable	1	2	3	4	5	6	7	Predictably conservative
Jealous	1	2	3	4	5	6	7	Trusting
Self-confident	1	2	3	4	5	6	7	Lacking in self-confidence
Patient	1	2	3	4	5	6	7	Impatient
Successful	1	2	3	4	5	6	7	Unsuccessful
Persistent	1	2	3	4	5	6	7	Gives up easily
Friendly	1	2	3	4	5	6	7	Unfriendly
Original	1	2	3	4	5	6	7	Uninventive
Strong	1	2	3	4	5	6	7	Weak
Prompt	1	2	3	4	5	6	7	Unprompt
Kind	1	2	3	4	5	6	7	Cruel
Hard worker	1	2	3	4	5	6	7	Poke fun easily
Reserved	1	2	3	4	5	6	7	Outgoing
Prefer to work alone	1	2	3	4	5	6	7	Prefer to work with others
Leader	1	2	3	4	5	6	7	Follower
Quarrelsome	1	2	3	4	5	6	7	Peaceful
Often tired	1	2	3	4	5	6	7	Rarely tired
Great difficulty getting up in the morning	1	2	3	4	5	6	7	Little difficulty getting up in the morning
Masculine	1	2	3	4	5	6	7	Feminine
Confident	1	2	3	4	5	6	7	Unsure
Practical	1	2	3	4	5	6	7	Impractical
Shy	1	2	3	4	5	6	7	Outgoing
Sophisticated	1	2	3	4	5	6	7	Unsophisticated
Work best at night	1	2	3	4	5	6	7	Work best in the morning

x (54)

(1-6)

24. Below are the same traits on which you rated yourself before. This time indicate how you **would like to be** on each trait. Remember, this time it does not matter how you are, just indicate how you would like to be. (Circle one in each row.)



Religious	1	2	3	4	5	6	7	Non-religious
Good-looking	1	2	3	4	5	6	7	Unattractive
Happy	1	2	3	4	5	6	7	Unhappy
Satisfied with self	1	2	3	4	5	6	7	Dissatisfied with self
Considerate	1	2	3	4	5	6	7	Inconsiderate
Well-adjusted	1	2	3	4	5	6	7	Maladjusted
Dependable	1	2	3	4	5	6	7	Undependable
Ambitious	1	2	3	4	5	6	7	Unambitious
Optimistic	1	2	3	4	5	6	7	Pessimistic
High-strung	1	2	3	4	5	6	7	Calm
Responsible	1	2	3	4	5	6	7	Irresponsible
Lazy	1	2	3	4	5	6	7	Energetic
Stubborn	1	2	3	4	5	6	7	Give in easily
Extrovert	1	2	3	4	5	6	7	Introvert
Critical of others	1	2	3	4	5	6	7	Uncritical of others
Talkative	1	2	3	4	5	6	7	Quiet
Like responsibility	1	2	3	4	5	6	7	Try to avoid responsibility
Messy	1	2	3	4	5	6	7	Neat
Easily angered	1	2	3	4	5	6	7	Good-tempered
Worried	1	2	3	4	5	6	7	Carefree
Have many friends	1	2	3	4	5	6	7	Have few friends
Conforming	1	2	3	4	5	6	7	Nonconforming
Timid	1	2	3	4	5	6	7	Bold
Politically liberal	1	2	3	4	5	6	7	Politically conservative
Careless	1	2	3	4	5	6	7	Careful
Self-confident	1	2	3	4	5	6	7	Lacking in self-confidence
Patient	1	2	3	4	5	6	7	Impatient
Successful	1	2	3	4	5	6	7	Unsuccessful
Persistent	1	2	3	4	5	6	7	Give up easily
Friendly	1	2	3	4	5	6	7	Unfriendly
Original	1	2	3	4	5	6	7	Unoriginal
Strong	1	2	3	4	5	6	7	Weak
Popular	1	2	3	4	5	6	7	Unpopular
Kind	1	2	3	4	5	6	7	Cruel
Hard worker	1	2	3	4	5	6	7	Take it easy
Rugged	1	2	3	4	5	6	7	Delicate
Prefer to work alone	1	2	3	4	5	6	7	Prefer to work with others
Leader	1	2	3	4	5	6	7	Follower
Good sense of humor	1	2	3	4	5	6	7	Poor sense of humor
Often tired	1	2	3	4	5	6	7	Rarely tired
Great difficulty getting up in the morning	1	2	3	4	5	6	7	Little difficulty getting up in the morning
Masculine	1	2	3	4	5	6	7	Feminine
Confident	1	2	3	4	5	6	7	Unsure
Practical	1	2	3	4	5	6	7	Impractical
Shy	1	2	3	4	5	6	7	Outgoing
Sophisticated	1	2	3	4	5	6	7	Unsophisticated
Work best at night	1	2	3	4	5	6	7	Work best in the morning

(7-53)

x (54)

75. There is a lot of talk these days about the problems facing people in the world. What, do you see it, are the major problems facing people in this school today? (Circle one for each item.)

4B_____ (1-6) (64-75)

	A major problem	Somewhat of a problem	Not much of a problem
Choosing a career	1	2	3
Getting along with their parents	1	2	3
Obtaining money to get started in a business or profession	1	2	3
Finding a meaning or purpose in life in these days of mass culture	1	2	3
Worry over international tensions and uncertainty in the world	1	2	3
Keeping up with events in this time of rapidly expanding knowledge	1	2	3
Personal conflicts and tensions reflecting our "Age of Anxiety"	1	2	3
Adjusting to the personal and responsibilities of adult status	1	2	3
Conflict at school or college	1	2	3
Disruption of plans by military service	1	2	3
Financing a college education	1	2	3

F_____ (-0) (76-)

	A major problem	Somewhat of a problem	Not much of a problem
Finding a suitable husband or wife	1	2	3
Having their ideas accepted by older people	1	2	3
Finding a suitable job in these days of unemployment	1	2	3
Accepting the possibility of military service	1	2	3
Making an adequate adjustment to relationships with the opposite sex	1	2	3
Finding something to interest them and keep them occupied	1	2	3
Lack of a feeling of being a part of society. The feeling of being a "lost generation"	1	2	3
Accepting more responsibility for the behavior expected by the culture	1	2	3
Having enough money to live on	1	2	3

76. Which of the following things do you have in your home? If an item is now in your home, circle the number under "Yes" if not, circle the number under "No." (Circle one for each item.)

5G_____ (-0) (7-)

	YES	NO
Carpentry tools (hand)	1	2
Power tools	1	2
Library of more than 50 books	1	2
One or more musical instruments	1	2
Some art supplies or equipment	1	2
Sports equipment	1	2
A sewing machine	1	2
Photographic equipment	1	2
A photographic darkroom	1	2
Fishing or hunting equipment	1	2
A collection of encyclopedias or reference books	1	2
A Hi-Fi or Stereo set	1	2
Reproductions of famous paintings	1	2
Examples of original art work (painting, sculpture, ceramics, etc.)	1	2
A foreign made car	1	2
A motor boat or sail boat	1	2
A motorcycle or motorbike	1	2
A flower or vegetable garden	1	2
A pet dog or cat	1	2
Other animal pets	1	2

	YES	NO
A typewriter	1	2
Farm equipment	1	2
Chemical laboratory equipment	1	2
Electrical laboratory equipment	1	2
Botany or zoology laboratory equipment	1	2
A tape recorder	1	2
A movie or slide projector	1	2
Leather working tools	1	2
A typewriter	1	2
An encyclopedia	1	2
An unabridged dictionary	1	2
Piano or musical instrument	1	2
A violin	1	2
Books in a foreign language	1	2
A sailing boat	1	2
A bar meter	1	2
An FM radio	1	2
Two or more cars	1	2
A television set	1	2

CH _____ (1-6)

27. Which of the following adjectives do you consider to be descriptive of yourself? Circle the number beside any adjective that you might use in describing yourself to someone else. Your behavior will vary with the situation, of course, so circle the numbers beside adjectives which might apply to you frequently, even though they are not appropriate all the time. Work rapidly, putting down your first thoughts.

Absent-minded	1	(7)	Frank	1	(13)	Quarrelsome	1	(19)
Adaptable	2		Friendly	2		Quiet	2	
Aggressive	3		Generous	3		Realistic	3	
Alert	4		Good-looking	4		Reasonable	4	
Aloof	5		Good-natured	5		Rebellious	5	
Ambitious	6		Helpful	6		Reckless	6	
Anxious	7		High-strung	7		Relaxed	7	
Apathetic	8		Honest	8		Reliable	8	
Argumentative	9		Hostile	9		Resentful	9	
Artistic	1	(8)	Humorous	1	(14)	Reserved	1	(20)
Assertive	2		Idealistic	2		Resourceful	2	
Attractive	3		Imaginative	3		Responsible	3	
Boastful	4		Immature	4		Restless	4	
Businesslike	5		Impatient	5		Rude	5	
Calm	6		Impulsive	6		Sarcastic	6	
Capable	7		Independent	7		Self-centered	7	
Carefree	8		Industrious	8		Self-confident	8	
Careless	9		Ingenious	9		Sensitive	9	
Cautious	1	(9)	Inhibited	1	(15)	Serious	1	(21)
Cheerful	2		Insightful	2		Shrewd	2	
Clear-thinking	3		Intelligent	3		Shy	3	
Clever	4		Irresponsible	4		Sincere	4	
Complaining	5		Irritable	5		Slow	5	
Confident	6		Jolly	6		Snobbish	6	
Conforming	7		Kind	7		Sociable	7	
Confused	8		Lazy	8		Sophisticated	8	
Conscientious	9		Leisurely	9		Stable	9	
Conventional	1	(10)	Logical	1	(16)	Stubborn	1	(22)
Cooperative	2		Loyal	2		Submissive		
Critical of others	3		Maladjusted	3		Suggestible	3	
Curious	4		Mannerly	4		Suspicious	4	
Cynical	5		Masculine	5		Tactful	5	
Defensive	6		Mature	6		Talkative	6	
Deliberate	7		Meek	7		Temperamental	7	
Dependable	8		Messy	8		Tense	8	
Dependent	9		Methodical	9		Thorough	9	
Determined	1	(11)	Mild	1	(17)	Thoughtful	1	(23)
Disorderly	2		Mischievous	2		Timid	2	
Dissatisfied	3		Modest	3		Unambitious	3	
Distractible	4		Moody	4		Unassuming	4	
Dominant	5		Naive	5		Unconventional	5	
Dull	6		Nervous	6		Undependable	6	
Easy-going	7		Obliging	7		Unemotional	7	
Efficient	8		Opinionated	8		Uninhibited	8	
Egotistical	9		Original	9		Versatile	9	
Emotional	1	(12)	Outgoing	1	(18)	Warm	1	(24)
Energetic	2		Outspoken	2		Well-adjusted	2	
Enthusiastic	3		Patient	3		Well-thought of	3	
Excitable	4		Persistent	4		Whiny	4	
Fearful	5		Pleasant	5		Wholesome	5	
Feminine	6		Polished	6		Withdrawn	6	
Forceful	7		Practical	7		Witty	7	
Forgetful	8		Preoccupied	8		Worrying	8	

x (25)

28. How many times have you visited your physician during the past year? (Circle one.)

None	0
1	1
2	2
3	3
4	4
5	5
6	6
7 or more	7

If this was mostly for some routine treatment, such as allergy shots, explain here: _____

_____

29. How much time have you spent as a patient in the hospital during the past year? (Circle one.)

None	0
Between 1 and 7 days	1
Between 1 week and 1 month	2
More than 1 month	3

30. Compared with most people your age, would you say your health is: (Circle one.)

Much better	1
A little better	2
About the same	3
A little worse	4
Much worse	5

31. Have you had any of the following during the past year? (Circle one number in each line.)

	Problem	Not a problem	Don't know
Cancer	1	2	3
Nausea	1	2	3
Allergy	1	2	3
Automobile sickness	1	2	3
Other motion sickness	1	2	3
Epilepsy	1	2	3
Hemorrhoids	1	2	3
Excessive tension	1	2	3
Headaches	1	2	3
Insomnia	1	2	3
Asthma	1	2	3
Stomach ulcer	1	2	3
Loneliness	1	2	3
Shortness of breath	1	2	3
Sweating palms or hands wet or clammy	1	2	3
Hay fever	1	2	3
Nervous stomach	1	2	3
Heart trouble	1	2	3
Hernia	1	2	3
Loss of appetite	1	2	3
Diarrhea	1	2	3
Chest pain	1	2	3
Muscle weakness or paralysis	1	2	3
Back pain	1	2	3
Menstrual problems	1	2	3
Urinary difficulty	1	2	3
Anemia	1	2	3
Heart palpitations or irregular heartbeat	1	2	3
Hiccups	1	2	3

32. Have you ever had a problem with your [illegible] at any time in your life?

Yes	1
No	2

If Yes --

What was it? _____

Over how many years did it occur? _____

What was the problem like at the worst time it occurred? _____

What was the nature of the problem? _____

_____

Do you think you were helped? _____ In what way? _____

33. Which of the following do you have displayed in your room? (Circle all that apply.)

The walls are blank (parental or apartment rules)	1	(63)	Calendars or schedules	1	(63)
The walls are blank (by choice)	2		Abstract paintings	2	
Pennants	3		Other paintings or drawings	3	
Pin-ups	4		Photographs of friends	4	
Maps	5		Sculpture	5	
A mobile	6		Jokes	6	
Quotations and mottoes	7		Medals	7	
Scientific models	8		Blueprints/charts	8	
Religious articles	9		Posters	9	
Diplomas	0		Sports trophies	0	
Scholarship trophies	x		Sports equipment	x	
			Other (Circle and specify.) _____	y	

34. During the past year how well did you get along with the following people? (Circle one in each row.)

	Very Well	Fairly Well	Just [illegible]	Fairly [illegible]	Very Poorly	
Boys your own age	1	2	3	4	5	(64-69)
Girls your own age	1	2	3	4	5	
Your mother	1	2	3	4	5	
Your father	1	2	3	4	5	
Your teachers	1	2	3	4	5	
Other adults	1	2	3	4	5	

35. This is an inventory of your feelings and attitudes about many kinds of work. Show the occupations which interest or appeal to you by circling the number in the "Yes" column opposite that occupation. Circle the number in the "No" column for the occupations you dislike or find uninteresting. (Circle one for each item.)

ID_____ (1-5) (7-12)

	YES	NO		YES	NO
Aviator	1	2	Buyer	1	2
Private investigator	1	2	Olympic athlete	1	2
YMCA secretary	1	2	Wrecker (building)	1	2
Detective	1	2	Narcotics inspector	1	2
Post office clerk	1	2	Elementary school teacher	1	2
Route salesman	1	2	School principal	1	2
Electronic technician	1	2	Power plant operator	1	2
Humorist	1	2	Actress/actor	1	2
Photographer	1	2	Juvenile delinquency expert	1	2
Interplanetary scientist	1	2	Police reviewer	1	2
Airplance mechanic	1	2	Stock and bond salesman	1	2
Meteorologist	1	2	Musician	1	2
Foreign missionary	1	2	Prize fighter	1	2
Bookkeeper	1	2	Diplomat	1	2
Speculator	1	2	Experimental laboratory engineer	1	2
Poet	1	2	Crane operator	1	2
Deep sea diver	1	2	Master plumber	1	2
Newspaper editor	1	2	Aeronautical design engineer	1	2
Nursery school teacher	1	2	Speech therapist	1	2
Lawyer	1	2	Traffic manager	1	2
Fish and wildlife specialist	1	2	Manufacturer's representative	1	2
Biologist	1	2	Author	1	2
High school teacher	1	2	Fireman	1	2
Quality control expert	1	2	Army officer	1	2

4G _____ (1-6) (7-63)	Yes	No
Interior Decorator	7	8
Novelist	7	8
Power Shovel Operator	7	8
Anthropologist	7	8
Marriage Counselor	7	8
Statistician	7	8
Television Producer	7	8
Commercial Artist	7	8
Wild Animal Trainer	7	8
U.N. Official	7	8
Sculptor	7	8
Automobile Mechanic	7	8
Surveyor	7	8
Zoologist	7	8
Physical Education Teacher	7	8
Court Stenographer	7	8
Hotel Manager	7	8
Free Lance Writer	7	8
Stunt Man (Motion Picture)	7	8
Criminal Lawyer	7	8
Professional Athlete	7	8
Carpenter	7	8
Construction Inspector	7	8
Chemist	7	8
Playground Director	7	8
Bank Teller	7	8
Business Executive	7	8
Musical Arranger	7	8
Jockey	7	8
Ventriloquist	7	8
Army Officer	7	8
Banker	7	8
Radio Operator	7	8
Independent Research Scientist	7	8
Clinical Psychologist	7	8
Tax Expert	7	8
Restaurant Worker	7	8
Art Dealer	7	8
Motorcycle Driver	7	8
Police Judge	7	8
Referee (Sporting Events)	7	8
Truck Gardener	7	8
Filling Station Attendant	7	8
Writer of Scientific or Technical Articles	7	8
Social Science Teacher	7	8
Inventory Controller	7	8
Master of Ceremonies	7	8
Dramatic Coach	7	8
Blaster (Dynamiter)	7	8
Mind Reader	7	8
English Teacher	7	8
Sales Manager	7	8
Tree Surgeon	7	8
Editor of a Scientific Journal	7	8
Director of Welfare Agency	7	8
IBM Equipment Operator	7	8

x

5G _____ (1-6) (7-63)	Yes	No
Traveling Salesman	7	8
Concert Singer	7	8
F.B.I. Agent	7	8
Prosecuting Attorney	7	8
Factory Foreman	7	8
College Professor	7	8
Tool Designer	7	8
Geologist	7	8
Asst. City School Superintendent	7	8
Financial Analyst	7	8
Real Estate Salesman	7	8
Composer	7	8
Mountain Climber	7	8
Congressional Investigator	7	8
Portrait Artist	7	8
Machinist	7	8
Locomotive Engineer	7	8
Botanist	7	8
Personal Counselor	7	8
Cost Estimator	7	8
Industrial Relations Consultant	7	8
Stage Director	7	8
Explorer	7	8
Supreme Court Judge	7	8
Draftsman	7	8
Judge	7	8
Photoengraver	7	8
Scientific Research Worker	7	8
Psychiatric Case Worker	7	8
Pay Roll Clerk	7	8
Sports Promoter	7	8
Playwright	7	8
Test Pilot	7	8
Criminologist	7	8
Children's Clothing Designer	7	8
Truck Driver	7	8
Electrician	7	8
Physicist	7	8
Vocational Counselor	7	8
Bank Examiner	7	8
Political Campaign Manager	7	8
Cartoonist	7	8
Racing Car Driver	7	8
Book Censor	7	8
Social Worker	7	8
Locksmith	7	8
Funeral Director	7	8
Counter-Intelligence Man	7	8
Architect	7	8
Shipping and Receiving Clerk	7	8
Criminal Psychologist	7	8
Insurance Clerk	7	8
Barber	7	8
Bill Collector	7	8
Ward Attendant	7	8
Mailman	7	8

x

CI_____ (.-4)

36. Below are a number of honors which high school students might achieve. Circle the number beside those accomplishments which you have achieved during high school.

Wrote an independent paper on a scientific topic which received the highest possible mark in my school. 1 (7)

Did an independent, scientific experiment (not a course assignement) 2

Was a member of a student honorary scientific society. 3

Invented a patentable device. 4

Had a paper published in a scientific journal. 5

Built a piece of equipment or laboratory apparatus on my own (not course work). 6

Participated in a scientific contest or talent search. 7

Participated in a National Science Foundation summer program for high school students at: 1 (8)

_____
Name of College

Placed first, second or third in a:
- National science contest 2
- Regional or state science contest. . . 3
- City or county science contest 4
- School Science contest 5

Won a prize for any other scientific work or study. 6

Placed first, second or third in a:
- National speech or debate contest. . . 7
- Regional or state speech or debate contest 1 (9)
- City or county speech or debate contest 2
- School speech or debate contest. . . . 3

Had a leading role in one or more plays . 4

Had minor roles in one or more plays. . . 5

Wrote a play. 6

Directed a play 7

Appeared on radio or TV as a performer. . 1 (10)

Read for a part in a high school or church play. 2

Read for a part in a play which was not sponsored by my school or church . . . 3

Organized a school political group or campaign. 4

Organized my own business or service. . . 5

Received a Junior Achievement award . . . 6

Composed music which has been given at least one public performance 7

Performed with a professional orchestra 1 (11)

Played in a school musical organization 2

Played a musical instrument. 3

Played in a dance or jazz band for wages 4

Organized your own dance or jazz band. 5

Received a rating of "Good" or "Excellent" in a:
- National music contest. 6
- Regional or state music contest . . 7
- City or county music contest. . . . 1 (12)
- School music contest. 2

Organized a singing group. 3

Directed (publicly) a band or orchestra 4

Exhibited a work of art (painting, sculpture, etc.) at:
- A national art show 5
- A regional or state art show. . . . 6
- A city or county art show 7
- A school art show 1 (13)

Won a prize or award for an artistic creation (painting, sculpture, etc.) at:
- A national art show 2
- A regional or state art show. . . . 3
- A city or county art show 4
- A school art show 5

Won a prize or award for a work published in a public newspaper or magazine 6

Edited a school paper or literary magazine. 7

Won a literary award for creative writing 1 (14)

Had poems, stories, essays or articles published in a school publication 2

Wrote an original, but unpublished piece of creative writing on my own (not as part of a course). 3

Published one or more issues of my own newspaper 4

Had poems, stories or articles published in a public newspaper or magazine (not school) 5

37. In the items listed below please compare yourself with your twin and indicate whether each statement is more true of you or more true of your twin. (Circle one for each item.)

	I am (or do)	Both the same	My twin is (or does)	
Which twin:				
Has more friends	1	2	3	(15-39)
Makes better grades in school	1	2	3	
Does more talking when the two of you meet a new person	1	2	3	
Usually wins in athletic contests between you (tennis, bowling, etc.)	1	2	3	
Reads faster	1	2	3	
Has more dates	1	2	3	
Usually gets up first in the morning	1	2	3	
Usually goes to sleep first at night	1	2	3	
Is the better artist (painting, drawing, etc.)	1	2	3	
Is the better musician (singing, playing an instrument, etc.)	1	2	3	
Is the better writer (stories, essays, etc.)	1	2	3	
Knows more about science	1	2	3	
Is better at public speaking	1	2	3	
Is more likely to be elected the leader of a group to which both belong	1	2	3	
Is more religious	1	2	3	
Studies harder	1	2	3	
Is more liked by your mother	1	2	3	
Is more liked by your father	1	2	3	
Usually decides what you are going to do when you are together	1	2	3	
Used to decide what you were going to play, etc. when you were children	1	2	3	
Usually wins arguments between you	1	2	3	
Knows more people	1	2	3	
Gets married more readily	1	2	3	
Saves more money	1	2	3	
Gets sick more frequently	1	2	3	

38. Which of the following would you and your twin usually do together? (Circle one for each item.)

	Usually do together	Usual pattern	Usually do separately	
Eat lunch	1	2	3	(45-46)
Study	1	2	3	
Go to the movies	1	2	3	
Go out on dates	1	2	3	
Work on hobbies	1	2	3	
Read books	1	2	3	(47)

39. How frequently do you and your twin quarrel or fight? (Circle one.)

We are usually fighting	1 (47)
We sometimes fight	2
We rarely or never fight	3

40. Do you and your twin dress alike? (Circle one.)

We always dress alike.	1	(48)
We usually dress alike	2	
We sometimes dress alike	3	
We rarely or never dress alike	4	

41. Do you and your twin have the same or different friends? (Circle one.)

All my friends are also my twin's friends.	1	(49)
Most of my friends are also my twin's friends.	2	
Some of my friends are also my twin's friends.	3	
Few or none of my friends are also my twin's friends	4	

42. Which twin was born first? (Circle one.)

I was.	1	(50)
My twin was.	2	
I don't know	3	

43. What was the longest period of time that you have been separated from your twin? (Circle one.)

One day or less.	1	(51)
Two or three days.	2	
Four to six days	3	
One or two weeks	4	
Two weeks to one month	5	
More than one month.	6	

44. How often are you and your twin together? (Circle one.)

Almost always (more than 90% of the time)	1	(52)
Usually (75% to 90% of the time).	2	
Often (50% to 75% of the time).	3	
Sometimes (25% to 50% of the time).	4	
Rarely (less than 25% of the time).	5	

45. If you could start life over, would you like to be a twin again? (Circle one.)

I would definitely choose to be a twin.	1	(53)
I would probably choose to be a twin.	2	
I wouldn't care one way or the other.	3	
I would probably choose not to be a twin.	4	
I would definitely choose not to be a twin.	5	

46. Do you and your twin share many things or do you each have your own possessions? (Circle one.)

We share almost all our possessions	1	(54)
We share many things but each have some individual possessions. . .	2	
We generally have our own possessions, but share some things. . . .	3	
We have our own possessions and share very little	4	

How long did it take you to answer the questions in this booklet? (55-57)

☐ Hours, ☐☐ minutes

APPENDIX III

Parent Questionnaire

Your Name _____ Date _____

CJ _____ (1-6)

1. What is your relationship to the twins for whom you are completing this questionnaire? (Circle one.)

Mother	1
Father	2
Stepmother	3
Stepfather	4
Guardian (Circle and explain.) _____	5
Other (Circle and specify.) _____	6

(7)

2. How well did you know the twins as children? (Circle one.)

If you knew the twins only casually or not at all, do not complete the questionnaire. If there is no one available who knew them well, check here _____ and return the questionnaire blank.

Very well	7
Fairly well	8
Casually	9
Not at all	0

(8)

3. What is the current status of the family? (Circle all that apply.)

If the twins are not living with the true parents, answer the following five questions in regard to those now acting as the parents.

True mother deceased	1
True father deceased	2
Parents together	3
Parents separated, but not divorced	4
Parents divorced	5
Mother remarried	6
Father remarried	7

(9)

4. What is the father's occupation? (If duties are not clear from the job title, please give details.) (10-11)

5. What is the mother's occupation? (If duties are not clear from the job title, please give details.) (12-13)

6. What are the parents' ages? (Write in age at the last birthday.) If deceased, write in the age which would have been attained if still living.

Mother. . . [ ][ ] (14-15)

Father. . . [ ][ ] (16-17)

7. What is each parent's highest educational attainment? (Circle one in each column.)

	Mother	Father
8th grade or less	1	1
Part high school	2	2
High school graduate	3	3
Part college or junior college	4	4
College graduate	5	5
Graduate or professional degree beyond the bachelor's degree	6	6

(18-19)

8. What is the family's income? Indicate total family income before taxes. (Circle one.)

Less than $5,000 per year	1
$5,000 to $7,499	2
$7,500 to $9,999	3
$10,000 to $14,999	4
$15,000 to $19,999	5
$20,000 to $24,999	6
$25,000 and over	7

(20)

9. Below are listed a number of things that children can do and things that can happen to them at various ages. Note that the statements are divided into groups according to the ages at which they apply. Think of your twins as they were during the particular age level. When you have the age clearly in mind, indicate whether or not each of the statements was true of one or the other or both twins at this age. If a statement is true for both twins, circle the number under both. If it is true for only one, then circle the number for that twin; if it is true for neither twin, circle the number under neither. You may find it helpful to write the names of "Twin one" and "Twin two" above the respective columns. (Circle one for each item.)

NOTE: Parents of Girls: We have consistently used the pronouns "he" and "his". Whenever this occurs, please translate to "she" and "her". We apologize for this, but we couldn't think of any better alternative.

INFANCY (Birth - Two Years)

IMPORTANT: See instructions on front of booklet for explanation of who is "Twin one" and who is "Twin two"

(7-18) Twin one / Twin two / Both twins / Neither

OK_____(19)

(19-31) Twin one / Twin two / Both twins / Neither

Had colic frequently 1 2 3 4

Learned to walk early (before 10 months) 1 2 3 4

Learned to walk late (after 20 months) 1 2 3 4

Had one or more serious illnesses. (Circle and specify.) _____ 1 2 3 4

_____

Was usually rocked and held when he cried. 1 2 3 4

There were complications at birth. (anoxia, blood disorders, etc.) (Circle and specify.) _____ 1 2 3 4

_____

Wore corrective shoes or leg braces for six months or longer 1 2 3 4

Was easily awakened by noise around the house 1 2 3 4

Was usually left to cry at night when just crying for attention 1 2 3 4

Was cared for by mother at least half of the time when he cried at night 1 2 3 4

Was often allowed to run about the house without clothes 1 2 3 4

Could amuse himself for several hours playing alone 1 2 3 4

Was a warm, powerful child and easy to take care of 1 2 3 4

Was breast fed for two months or longer. 1 2 3 4

Cried a lot 1 2 3 4

Was toilet trained before 18 months of age. 1 2 3 4

Was played with frequently by his mother or some other adult 1 2 3 4

Was fed on a regular schedule rather than when he seemed hungry . . . 1 2 3 4

Soon learned to sleep through the night and awoke only in unusual circumstances. 1 2 3 4

Often cried when put to bed and cried himself to sleep 1 2 3 4

Was generally fun to care for as an infant. 1 2 3 4

Was free to play freely around the house most of the time rather than being kept in a play pen or crib 1 2 3 4

Used a pacifier to suck on for one year or more 1 2 3 4

Could not eat certain foods or formulas because of allergic reactions 1 2 3 4

Took a bottle to bed many nights . 1 2 3 4

CK ______________ (1-6)

(32-49)

	Twin one only	Twin two only	Both twins	Neither twin
Was a premature child (____ months) .	1	2	3	4
Frequently had diarrhea	1	2	3	4

(7-25)

	Twin one only	Twin two only	Both twins	Neither twin
Wore diapers until he trained himself (no special toilet training procedure was used).	5	6	7	8

PRE-SCHOOL (<u>Two</u> to <u>Six</u> Years)

Learned to read before starting the first grade.	1	2	3	4
Was read a bedtime story almost every night.	1	2	3	4
Attended Sunday school or church fairly regularly	1	2	3	4
Learned poems, stories or songs which he would recite for family and friends.	1	2	3	4
Showed signs of sibling rivalry to the birth of a brother or sister (demanding attention, regression, emotional upset, etc.)	1	2	3	4
Learned a child's prayer which he said before meals or before going to bed	1	2	3	4
Was taught such things as numbers, the alphabet, telling time, etc. at home before entering kindergarten or first grade.	1	2	3	4
Attended kindergarten before entering first grade	1	2	3	4
Sometimes wet the bed after the third birthday	1	2	3	4
Had one or more fairly severe fear (ghosts, the dark, certain animals, etc.)	1	2	3	4
Was made to clean up the messes he made in playing around the house .	1	2	3	4
Had occasional temper tantrums. . . .	1	2	3	4
Was finicky about food and was hard to please at meals	1	2	3	4
Usually slept in a room by himself. .	1	2	3	4
Usually slept in a bed by himself . .	1	2	3	4
Had frequent skin rashes	1	2	3	4

Had frequent chest congestion and wheezing	5	6	7	8
Was encouraged to fight back when attacked by other children	5	6	7	8
Was easy to train (to keep clean, to respect property, etc.)	5	6	7	8
Attended nursery school	5	6	7	8
Did not have any serious illnesses. .	5	6	7	8
Demonstrated some unusual talent before entering school (e.g., music, dancing, singing, mathematics, etc.) (Circle and specify.) ______________ ______________________________	5	6	7	8
Was frequently destructive (marred furniture, marked walls, broke things, etc.).	5	6	7	8
Was a very affectionate child	5	6	7	8
Demanded a great deal of attention from adults.	5	6	7	8
Often followed his mother around, hanging on her skirts.	5	6	7	8
Had a pet dog or cat.	5	6	7	8
Was shy around stranger	5	6	7	8
Occasionally had night terror. (awoke frightened at night). . . .	5	6	7	8
Liked to show-off in front of guests	5	6	7	8
Sucked his thumb.	5	6	7	8
Had one or more imaginary companions	5	6	7	8
Had birthday parties which several children his own age attended. . .	5	6	7	8
Was taught to speak a language other than English	5	6	7	8

(26-43)

Twin one way
Twin the other way
Both twins
Neither twin

(44-61)

Twin one way
Twin the other way
Both twins
Neither twin

Would cry when his parents went out and left him with a baby sitter 1 2 3 4

Would often fight with other children without provocation. 1 2 3 4

Pajamas covering the hands, bitter substances, or other devices were used one or more times to prevent thumb-sucking 1 2 3 4

Did not like to be dirty. 1 2 3 4

Was frequently cared for by the father while the mother went out 1 2 3 4

Was left one or more times with relatives, friends or at home with a sitter while the parents took a vacation of one week or longer. 1 2 3 4

Had a definite bed time and was made to go to bed whether he wanted to or not. 1 2 3 4

CHILDHOOD (Six to Twelve Years)

Attended Sunday school or church fairly regularly. 1 2 3 4

Was very active and always running, jumping or playing some active game. 1 2 3 4

Was taken by his parents to visit a zoo (did not include school trips). . . . 1 2 3 4

Was often picked on or teased by other children. 1 2 3 4

Picked out most of the clothes that were bought for him. 1 2 3 4

Was often ill in bed. 1 2 3 4

Had speech errors in pronouncing correct speech before 1 2 3 4

Stuttered or stammered. 1 2 3 4

Was finicky about what he would have to please at meals. 1 2 3 4

Walked in his sleep 1 2 3 4

Was often asked to move all his playing, with or his parents knowing where he was or what he was doing 1 2 3 4

Had a definite bed time and was made to go to bed whether he wanted to or not 1 2 3 4

Helped care for younger brothers or sisters 1 2 3 4

Usually kept parents' instructions . . . 1 2 3 4

Wanted to quit school one or more times 1 2 3 4

Had friends over for lunch or dinner 1 2 3 4

Spent a great deal of his time at home reading. 1 2 3 4

Was taken on a camping trip or other outing one or more times by his father. 1 2 3 4

Was a member of the Cub or Brownie Scouts. 1 2 3 4

Took private lessons in music 1 2 3 4

Had a quick temper 1 2 3 4

Often asked his parents for suggestions of things to do 1 2 3 4

Had regular jobs around the house that were his responsibility. 1 2 3 4

Ran away from home one or more times 1 2 3 4

Bit his fingernails. 1 2 3 4

Was given a regular allowance which he could spend as he wished 1 2 3 4

Had some unusual temper tantrums . . . 1 2 3 4

Had one or more minor severe fears (the dark, the dark, certain animals, etc.). 1 2 3 4

Was taken on family vacations one or more times (not including visits to relatives). 1 2 3 4

(7-23)	Twin one only	Twin two only	Both twins	Neither twin	(...)	Twin one only	Twin two only	Both twins	Neither twin
Would often be so busy playing that he would skip meals entirely, or just grab a bite and run.	9	0	x	y	One or more of his grade school teachers was invited to dinner or to be a guest in the home. . .	9	0	x	y
Did not enjoy attending school. . . .	9	0	x	y	Missed an extensive amount of school work in one or more years due to travel, illness or other reasons	9	0	x	y
Had friends over to spend the night .	9	0	x	y	Had rules which governed the time spent watching TV and/or the programs seen	9	0	x	y
Had a personality conflict or other non-academic difficulty with a teacher which required a visit to the school by the parents. . .	9	0	x	y					

ADOLESCENCE (Twelve to Eighteen Years)

Spent a great deal of his time at home reading.	9	0	x	y	Had a definite curfew or time when he was to be home on weekend nights.	9	0	x	y
Attended church or Sunday school regularly	9	0	x	y	Walked in his sleep one or more times	9	0	x	y
Had serious discussions with parents about sex	9	0	x	y	Had rules which governed the time spent watching TV and/or the programs seen	9	0	x	y
Brought friends home to play or study once a week or more on the average	9	0	x	y	Belonged to the Boy Scouts or Girl Scouts	9	0	x	y
Frequently disagreed openly with parents	9	0	x	y	Other major extracurricular activities (athletics, music, dramatics, etc.)	9	0	x	y
Often talked over personal problems with parents	9	0	x	y	Was never seen with a drink while in high school	9	0	x	y
Took sleeping pills or tranquilizers one or more times	9	0	x	y	Liked to paint pictures	9	0	x	y
Was jealous of another child (brother, sister, girl or boy friend) . . .	9	0	x	y	Had a sweet tooth--ate candy like most boys or girls	9	0	x	y
Bit his fingernails	9	0	x	y	Liked to help in the kitchen	9	0	x	y
Had an automobile accident with more than $50.00 in damage.	9	0	x	y	Had a positive interest and was really sure	9	0	x	y
Was given money for their monthly reward for good grades in school.	9	0	x	y	Resembled them more than more in personality than the other.	9	0	x	y
Parents have tried to influence his occupational choice	9	0	x	y	Resembled them more in personality than the other.	9	0	x	y
Needed to eat three or more meals only served food	9	0	x	y	[illegible]	9	0	x	y

(40-48)	Twin one only	Twin two only	Both twins	Neither twin
Was often the first one in the house to get up in the morning .	9	0	x	y
Went out on the average of three or more nights a week.	9	0	x	y
Was punished or criticized at a rate of one or more times a month for staying out too late .	9	0	x	y
Parents objected to his association with one or more of his boy-friends.	9	0	x	y
Parents objected to his association with one or more of his girl-friends.	9	0	x	y
Was not permitted to read certain books.	9	0	x	y
Was frequently allowed to take the family car for a drive with friends	9	0	x	y
Made his own bed.	9	0	x	y
Had definite chores or duties at home which were his responsibility. .	9	0	x	y

(49-[illegible])	Twin one only	Twin two only	Both twins	Neither twin
Wore braces to straighten his teeth	9	0	x	y
Parents required that he spend a specified amount of time each week studying	9	0	x	y
Had a personality conflict or other non-academic difficulty which required a visit to school by the parents.	9	0	x	y
Was not permitted to go out on school nights under ordinary circumstances.	9	0	x	y
Was a light sleeper	9	0	x	y
Was not allowed to smoke.	9	0	x	y
Had a room of his own	9	0	x	y
One or more of his high school or junior high teachers was invited to dinner or to be a guest in the home	9	0	x	y
Wanted to quit school one or more times and had to be persuaded to continue	9	0	x	y

10. Which of the following things were true of your home when your twins were young? (From birth to six years.) If an item was true of the twins' home during this age period, circle the number under "True;" if not, circle the number under "False." (Circle one for each item.)

(58-[illegible])	True	False
The whole family gathered regularly for meals.	x	y
The father took a good deal of responsibility for the care of the twins.	x	y
A nurse or housekeeper took a good deal of responsibility for the care of the twins.	x	y
The mother had [illegible] responsibility than the care of [illegible] and family	x	y
The family lived in the home of grandparents or other relatives	x	y
There was good agreement between the parents concerning child-rearing practices.	x	y
One or more of the twins' grandparents lived in the same town.	x	y
There was a grandparent or other person living in the home for a year or longer.	x	y

([illegible])	True	False
The father had a job which often required him to be away from home at night	x	y
The family usually said grace or a prayer before meals	x	y
The family lived in a house of their own.	x	y
The family lived in an apartment building.	x	y
The mother was mainly responsible for punishing the twins when they were bad	x	y
The father was mainly responsible for punishing the twins when they were bad	x	y
There was a lot of fighting and competition between the twins	x	y
The parents [illegible]	x	y

11. At what ages were the following things true of the twins. Circle the ages at which each item occurred. "0" indicates from birth to one year, "1" indicates the year in which the twins were one year old, etc. (Circle as many ages as apply for each item. If the event in a particular item did not occur at all, circle the letter "x" at the end of the row.)

FOR EXAMPLE: If the father was away from home for three years when the twins were ages six through eight and again for a year when the twins were ten, you would indicate it thus: CL_____ (1-6) (7-8)

Father was absent from home.
0 1 2 3 4 5 (6) (7) (8) 9 (10) 11 12 13 14 15 16 17 18 x

The twins were cared for by a nurse or baby sitter during the day.
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 x

Mother was absent from home for six months or more during the year.
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 x

Father was absent from home for six months or more during the year.
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 x

The child was hospitalized one or more times during the year. (Exclude birth.)
Twin one 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 x
Twin two 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 x

The family moved from one town to another.
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 x

The family moved from one house or apartment to another in the same town.
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 x

A parent was incapacitated by a serious illness for six months or more during the year.
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 x

A parent died.
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 x

A grandparent, aunt or uncle who was close to the twins died.
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 x

Went away to boarding school or military school for six months or more during the year.
Twin one 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 x
Twin two 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 x

Attended summer camp for one week or more.
Twin one 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 x
Twin two 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 x

Took private piano, violin or other musical lessons. (Do not include music instruction in school.)
Twin one 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 x
Twin two 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 x

The twins were separated for more than six months during the year.
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 x

12. Parents use many different forms of discipline to train their children. Some of the more common ones are listed below. Indicate to what extent each was used in the training of the twins, both as young children (before six) and as older children (after six). Try to indicate how the twins were actually treated rather than what now seems correct. (Circle one number in each row as young children and one number in each row as older children or adolescents.)

	YOUNG CHILDREN			OLDER CHILDREN AND ADOLESCENTS			
	Never used	Occasionally used	Frequently used	Never used	Occasionally used	Frequently used	
Spanking.	1	2	3	4	5	6	(44-45)
Withdrawal of privileges (movies, TV, reduced allowance, etc.). . .	1	2	3	4	5	6	
Temporary restriction of activities (sat on a chair, sent to room, etc.)	1	2	3	4	5	6	
Extra duty (wash dishes, clean house, etc.).	1	2	3	4	5	6	
Tangible reward for good behavior (money, candy, etc.).	1	2	3	4	5	6	
Verbal scolding (labeling as bad boy or girl, bawling out, etc.) .	1	2	3	4	5	6	
Reasoning (explain reasons why certain behavior is or is not desirable).	1	2	3	4	5	6	
Rejection, withdrawal of love . .	1	2	3	4	5	6	
Praise for good behavior.	1	2	3	4	5	6	
Comparison with friends or siblings.	1	2	3	4	5	6	
Threat of severe punishment (death, desertion, incarceration)	1	2	3	4	5	6	

13. How strict was the discipline of the twins?

Very strict 7
Strict 8 (46)
Firm 9
Somewhat easy-going or permissive. . 0
Very easy-going or permissive. . . . x

14. How consistent was the discipline of the twins? Could they always count on the same response from the parents for a given action or did it vary from time to time?

Always very consistent 7 (47)
Usually consistent 8
Often inconsistent 9
Usually inconsistent 0

15. To what extent were they threatened with punishment that was not actually carried out?

Threats of punishment always followed through. . . . 7 (48)
Threats of punishment usually followed through . . . 8
Threats of punishment sometimes followed through . . 9
Threats of punishment rarely followed through. . . . 0

16. Parents usually follow fairly definite patterns in raising their children. Below are listed some of the ways in which these patterns can differ. Please indicate the general patterns that were actually followed in raising the twins. If the twins were treated more like the statement on one side of the page than the other, circle one of the numbers on that side. If neither statement is particularly descriptive or if both apply equally, circle one of the numbers in the middle. The headings "Very," "Fairly," etc. refer to the degree to which a statement is descriptive (Circle one in each row.)

(57-71)

	Very	Fairly	Slightly	Neither or Both	Slightly	Fairly	Very	
Mother takes responsibility for raising the twins.	1	2	3	4	5	6	7	Father takes responsibility for raising the twins.
Punishment for misbehavior is the main method of control.	1	2	3	4	5	6	7	Praise for good behavior is the main method of control.
Parents give the twins as many things as they can afford.	1	2	3	4	5	6	7	Parents restrict the twins' possessions.
There is a lot of contact between parents and child. Do many things together.	1	2	3	4	5	6	7	Parents and child pursue their interests independently with little contact or interaction.
Parents attempt to train the twins to give up baby ways as soon as possible (early toilet training, early weaning, prevention of thumb sucking, etc.)	1	2	3	4	5	6	7	Parents let the twins develop in their own way, at their own speed.
Home is calm, quiet and peaceful.	1	2	3	4	5	6	7	Home is lively, with lots of excitement and many things going on.
Mother is overtly demonstrative of love for the twins with much hugging, kissing and expression of affection.	1	2	3	4	5	6	7	Mother is not overtly demonstrative of love for the twins.
Father is overtly demonstrative of love for the twins with much hugging, kissing and expression of affection.	1	2	3	4	5	6	7	Father is not overtly demonstrative of love for the twins.
Parents let the twins do whatever they want to.	1	2	3	4	5	6	7	Parents actively direct the behavior and interests of the twins.
Parents attempt to make the twins as independent and self-sufficient as possible, and let them work their own way out of difficulties.	1	2	3	4	5	6	7	Parents try to shelter the twins from unnecessary stress and smooth the way as much as possible.
Parents want the twins to do well in whatever they undertake and push them to work and try hard in order to achieve to the maximum of their ability.	1	2	3	4	5	6	7	Parents leave it up to the twins to determine how much they undertake and how hard they work.
Parents set many rules and regulations for the twins to live by.	1	2	3	4	5	6	7	Parents let the twins set their own limits.
Mother is stricter with the twins than the father.	1	2	3	4	5	6	7	Father is stricter with the twins than the mother.
Mother has much love and affection for the twins.	1	2	3	4	5	6	7	Mother has little love and affection for the twins.
Father has much love and affection for the twins.	1	2	3	4	5	6	7	Father has little love and affection for the twins.

x (69)

17. The following items are concerned with differences between the twins. Indicate for which twin each statement is most appropriate. (See instructions on front of booklet for explanation of "Twin one" and "Twin two.") (Circle one for each item.)

CM_____ (1-6)

Which twin: (7-30)	Twin one	Twin two	Neither twin	I don't know
Was born first.	1	2	3	4
Weighed more at birth	1	2	3	4
Learned to walk first	1	2	3	4
Was toilet trained first.	1	2	3	4
Received more attention from the mother	1	2	3	4
Received more attention from the father	1	2	3	4
Did better work in grade school (1st to 6th grades).	1	2	3	4
Was more friendly as a young child. .	1	2	3	4
Had a better appetite as a young child.	1	2	3	4
Was closer to the mother.	1	2	3	4
Was closer to the father.	1	2	3	4
Had more minor illnesses as a child .	1	2	3	4
Had stricter discipline as a child. .	1	2	3	4
Had stricter discipline as an adolescent	1	2	3	4
Had a date first.	1	2	3	4
Is more interested in art	1	2	3	4
Is more interested in business. . . .	1	2	3	4
Is more interested in mechanics . . .	1	2	3	4
Is more interested in science	1	2	3	4
Is more interested in politics. . . .	1	2	3	4
Is more interested in dramatics . . .	1	2	3	4
Is more interested in athletics . . .	1	2	3	4
Is more interested in helping others.	1	2	3	4
Is more interested in religion. . . .	1	2	3	4

(31-55)	Twin one	Twin two	Neither twin	I don't know
Studies harder	1	2	3	4
Reads more	1	2	3	4
Watches TV more.	1	2	3	4
Sleeps more.	1	2	3	4
Has saved more money	1	2	3	4
Has more dates	1	2	3	4
Was spanked more often as a child.	1	2	3	4
Was rocked and held more often as a child	1	2	3	4
Cried more as a child.	1	2	3	4
Learned to swim first.	1	2	3	4
Learned to ride a bicycle first. .	1	2	3	4
Learned to drive a car first . . .	1	2	3	4
Started menstruation first (for boys leave blank).	1	2	3	4
Voice changed first (for girls leave blank)	1	2	3	4
Usually decides what the two of them will do together	1	2	3	4
Is more dependable	1	2	3	4
Is more curious.	1	2	3	4
Is more imaginative.	1	2	3	4
Is more original	1	2	3	4
Is more outgoing	1	2	3	4
Is more self-confident	1	2	3	4
Is more sensitive.	1	2	3	4
Is more talkative.	1	2	3	4
Is shyer	1	2	3	4
Is more temperamental.	1	2	3	4

18. Were the twins dressed alike? (Circle one.)

Almost always 1
Part of the time. . . . 2 (56)
Rarely or never 3

19. As children (ages 6 to 12) did the twins tend to play together or separately? (Circle one.) (57)

They were almost always together. 1
They were usually together but sometimes played apart . . 2
They usually played apart but sometimes were together . . 3
They almost never played together 4

---

20. As adolescents (ages 12 to 18) did the twins tend to spend their time together? (Circle one.)

They were almost always together. 1 (58)
They were usually together but sometimes apart. 2
They usually were apart but sometimes together. 3
They were almost never together 4

---

21. Did the twins have the same teacher in school? (Circle one.)

Usually had the same teacher. 1 (59)
Sometimes the same, sometimes different 2
Usually had different teachers. 3

---

22. Did the twins sleep in the same or separate rooms? (Circle one.)

Separate rooms most of their life 1 (60)
Usually slept in separate rooms 2
Usually slept in the same room. 3
Slept in the same room most of their life 4

---

23. Many parents of twins try to treat both children exactly alike. Others make an effort to treat them differently. In raising the twins which of these methods have you followed? (Circle one.)

We have tried to treat them exactly the same. 1 (61)
We tended to treat them alike 2
We have tried to treat them differently 3
We tended to treat them differently 4
At times we treated them alike, at other times, differently . 5

---

24. As you know there are two kinds of twins: identical twins which have the same heredity, and fraternal twins which have different heredity. Which kind are your twins? (Circle one.)

I am certain they are identical twins 1 (62)
I think they are identical twins, but am not certain. 2
I don't know which kind they are. 3
I think they are fraternal twins, but am not certain. 4
I am certain they are fraternal twins 5

---

25. What, in your opinion, are the most striking differences between the twins? _____

_____

_____

_____

_____

26. What do you feel is the main cause of these differences? _____

_____

_____

_____

_____

APPENDIX IV

Items Included in Different Treatment Score

If the parent responded "twin 1 only" or "twin 2 only", the following items were scored 1. If the parent responded "both twins" or "neither twin" the item was scored 0.

Infancy (Birth to Two Years)

was usually rocked and held when he cried

Was usually left to cry alone when just crying for attention

Was cared for by his father at least half of the time when he cried at night

Was often allowed to run about the house without clothes

Was breast fed for two months or longer

Was played with frequently by his mother or some other adult

Was fed on a regular scedule rather than when he seemed hungry

Was allowed to play freely around the house most of the time rather than being kept in a play pen or crib

Used a pacifier to suck on for one year or longer

Took a bottle to bed most nights

Preschool (Two to Six Years)

Was read a bedtime story almost every night

Attended Sunday School or church fairly regularly

Was taught such things as numbers, the alphabet, telling time etc. at home before entering kindergarten or first grade

Attended kindergarten before entering first grade

Was make to clean up the messes he made in playing around the house

Usually slept in a room by himself

Usually slept in a bed by himself

Attended nursery school

Did not have any serious illness

Had a birthday party which several children his own age attended

Was taught to speak a language other than English

Pajamas covering the hands, bitter substances, or other devices were used one or more times to prevent thumb-sucking

Was frequently cared for by the father while the mother went out

Was left one or more times with relatives, friends, or at home with a sitter while the parents took a vacation of one week or longer

Had a definite bed time and was made to go to bed whether he wanted to or not

Childhood (Six to Twelve Years)

Attended Sunday school or church fairly regularly

Was taken by his parents to visit a zoo

Was often away from home all day playing, without his parents knowing where he was or what he was doing

Had a definite bed time and was made to go to bed whether he wanted to or not

Helped care for a younger brother or sister

Was taken on a camping trip or other outing one or more times by his father

Was a member of the Cub or Brownie Scouts

Helped care for a younger brother or sister

Had regular jobs around the house that were his responsibility

Was given a regular allowance which he could spend as he wished

Was taken on family vacations of a week or more (not including visits to see relatives)

Missed an extensive amount of school work in one or more years due to travel, illness or other reasons

Had rules which governed the time spent watching TV and/or the programs seen

Adolescence (12-18 Years)

Attended church or Sunday school regularly

Was given money or other tangible reward for good grades in school

Parents have tried to influence his occupational choice

Had definite curfew or time when he was to come home on weekend nights

Had rules which governed the time spent watching TV and/or the programs seen

Belonged to the Boy Scouts or Girl Scouts

Was never allowed to drink alchoholic beverages

Parents objected to his association with one or more of his boyfriends

Parents objected to his association with one or more of his girlfriends

Was not permitted to read certain books

Was frequently allowed to take the family car for a drive with friends

Made his own bed

Had definite chores or duties at home which were his responsibility

Wore braces to straighten his teeth

Parents required that he spend a specific amount of time each week studying

Was not permitted to go out on school nights under ordinary circumstances

Was not allowed to smoke

Had a room of his own

The following items were scored 1 if the parent responded "twin 1" or "twin 2". If the parent responded "neither twin" or "I don't know" the item was scored 0.

Recieved more attention from the mother

Recieved more attention from the father

Had stricter discipline as a child

Had stricter discipline as an adolescent

Was spanked more often as a child

Was rocked and held more often as a child

The following items were scored according to specific keys:

Were the twins dressed alike? (rarely or never = 1)

As children (ages 6 to 12) did the twins tend to play together or separately? (Usually or never = 1)

As adolescents (ages 12-18) did the twins tend to spend their time together? (usually apart or never together=1)

Did the twins have the same teacher in school? (usually different teachers = 1)

Did the twins sleep in the same or separate rooms? (usually different rooms scored 1)

Many parents of twins try to treat both children exactly alike. Others make an effort to treat them differently. In raising your twins, which of these methods have you followed? (tried or tended to treat them differently = 1)