The Psychogenetics of Personality

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General impressions are never to be trusted. Unfortunately when they are of long standing they become fixed rules of life, and assume a prescriptive right not to be questioned. Consequently those who are not accustomed to original inquiry entertain a hatred and a horror of statistics. They cannot endure the idea of submitting their sacred impressions to cold-blooded verification. But it is the triumph of scientific men to rise superior to such superstitions, to desire tests by which the value of beliefs may be ascertained, and to feel sufficiently masters of themselves to discard contemptuously whatever may be found untrue.

Sir Francis Galton

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I.I.G.

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Chapter I

Introduction

Mankind in general and behavioral scientists in particular have long been curious about the basic nature of man. Curiosity and speculation have fortunately given place to experimentation by some of the scientists. One of the desired outcomes of such experimentation is a knowledge of the causes of variation observed in man so that they might be explained, predicted, and controlled. The cause with which the present research is most concerned is genetic; the word is being used in the strict sense to refer to that science launched by Mendel's experimentation with peas. The term psychogenetics appears first to have been used by Hall (1951); it refers to the interdisciplinary science combining the knowledge and procedures of modern genetics with those of psychology. The first objective of psychogenetics is to ascertain whether heredity plays a part in the determination of a psychological characteristic.

Interest in psychogenetics antedated the coining of the term. Darwin (1872), Galton (1883), and Pearson (1902) had all made relevant observations before genes were in use as a construct. Dugdale (1877) and Goddard (1913) had introduced the notorious Jukes and Kallikak families to the reading public. Following the rediscovery of Mendel's work in 1900, a substantial number of efforts were made to apply its principles to animal and human behavior.

Penrose (1944), Hall (1951), Kallmann and Baroff (1955) and Fuller (1960) have provided reviews of this work. Penrose noted that not all transmission in man is Mendelian, but concluded that from the point of view of psychological research other rare (sic) possibilities need not be initially considered. Actually, extremely few psychological unit characters can as yet be recognized and most of the characters are probably graded or quantitative. Hall (1951) foresaw little possibility for developing a science of human psychogenetics because of the barriers to the application of such genetic methods as inbreeding and pedigree analysis. In fact most of the accepted work in psychogenetics has been done with rats and mice (Hall, 1934 ; Heron, 1935; Tyron, 1934; Scott, 1942) and dogs (Mahut, 1958; Scott & Charles, 1954; Scott & Fuller, 1959).

The present research is primarily concerned with that aspect of human psychogenetics broadly termed "Personality". Cattell (1953) has said that "a psychology lacking any dependable or precise knowledge of innate organizations and influences is bankrupt in its theoretical structure and a charlatan in its clinical and educational practices" (p.76). He previously noted (1950) that "until the extent of hereditary influence (on personality) is known the search for environmental origins of traits may be a wild-goose chase" (p. 118).

Psychologists as well as humanitarians in general ought to be vitally concerned with genetics in the atomic era. Human genetics, like the weather, can no longer be dismissed with deterministic

platitudes. Both are forces of Nature which man can influence for better or for worse. Long before Hiroshima, H.J. Muller had won the Nobel Prize for his 1927 experiments demonstrating the gross changes perpetuated in the offspring of the fruit fly following irradiation. He showed that there was a precise linear relationship between the roentgens (r.) of radiation to which the animal was exposed and the number of mutations shown in its offspring; previously known spontaneous mutation rates were speeded up 150 times. Russell (1951) reported that mice have been found to be fifteen times as sensitive to radiations as fruit flies. Sheldon C. Reed (1959) reported the results of an experiment by Bender (1957) on human cells in which only 3.3 r. were required to double the number of chromosome mutations found in the control human tissue culture cells. Ten r. have been recommended as the maximum permissible dose during one man's reproductive lifetime by the National Research Council (1956). Reed (1959) discussed the genetic implications of radiation.

> It is estimated that 4 to 5 per cent of all live births in the United States have gross defects such as mental deficiency, congenital malformations, defects in vision and hearing. Of these about half appear to be of simple genetic origin. They are due to present or past mutations just like those produced by radiations. Consequently, of the next generation of 100,000,000 births in the United States, something like 2,000,000 of the generation will experience genetic defects of the sorts listed just now . . . . the addition of 10 r. of man-made radiation to the natural causes of mutations already present, would add some 50,000 new instances of inherited defects to the next generation. . . . In order to cause mutations, it (radiation) must get to the gonads if the next generation is to be affected. . . . . Why are mutations always thought of as being harmful? If you throw a monkey wrench into a smoothly running motor there is a very large chance you will damage it and only a small one that you will make it run better. (Pp. 899-900)

There is a natural reluctance to accept the supposed determinism that is associated with views that human behavior is genetically influenced. The former is especially true when one thinks of oneself. The ego defenses aroused are in part due to the values placed on free will and equality which are part of the parcel of our democratic way of life. The word "supposed" above was used intentionally. Allport (1937, p. 105) pointed out that the doctrine of genetic determination does not state that personality is inherited, but rather that no feature of personality is devoid of hereditary influences. This means that if the genes are altered the personal characteristics are altered and not that they are determined only by the genes. More recently (Kallmann & Baroff, 1955) it has been noted that the belief that genetically determined disorders are unalterable finished entities was related to the early impression made by congenital anomalies. Considerable progress has been made in demonstrating that some gene-specific disorders are neither congenital nor unchangeable such as diabetes mellitus and Wilson's Disease. Another source of reluctance to become involved in psychogenetic research is the lurid and disquieting history of the eugenics movement.

> In Nazi Germany the positive aspect (of eugenics) was perverted to the doctrine of a race of supermen whose illustrious racial heritage conferred special rights, while the negative aspects were interpreted as permitting the wholesale extermination of elements whom the supermen adjudged undesirable. During that same period there was in the United States a great deal of loose thinking, based primarily upon failure to develop a critical attitude toward both the nature-nurture problem and the precise mathematical consequence of either positive or negative selection. . . . . It is imperative that in this (current) renewal of interest the lessons

> of the past not be forgotten (Neel & Schull, 1954, p. 337).

Hall (1951) hoped that as the science of psychogenetics matured, it would free itself of "distracting excursions into pseudo-problems, chief of which has been the heredity-environment issue" (p. 327). He characterized the latter issue as a legacy from philosophy which had plagued psychology for nearly a hundred years. It is of historical interest to quote some pertinent remarks by John B. Watson.

> There is no such thing as an inheritance of capacity, talent, temperament, mental constitution and characteristics. . . . . Give me a dozen healthy infants, well formed, and my own specified world to bring them up in and I'll guarantee to take any one at random and train him to become any type of specialist I might select — doctor, lawyer, artist, merchant, chief, and yes, even beggar-man thief, regardless of his talents, peculiarities, tendencies, abilities, vocations, and race of his ancestors (1925, pp. 74, 82).

Enlightened summaries of the nature-nurture issue are presented in current differential psychology textbooks (Anastasi, 1958; Tyler, 1956), but they do not use the term psychogenetics, apparently unaware that it deserves separate treatment. After the data of human psychogenetics have been gathered, the question to be answered is, "What limits to the development of personality are set by inheritance?" Answers will range from almost none, to overwhelming for an individual who has Tay-Sach's disease.

By means of twins and objective personality tests, the purpose of the present research is to answer the question, "Are there any measurable genetic influences upon the aspects of human personality tapped by the selected tests?" If the answer is yes, a partial answer to the question, "For which traits?" and an

approximation to the answer to the question, "How much is the contribution of heredity relative to that of environment?" will be presented.

A. General Genetic Principles

The complexity of human genetics plus the author's relatively recent exposure to some of the facts precludes the possibility of an adequate discussion or introduction to other psychologists. Nonetheless, an attempt is made to define some terms and to describe some of the mechanisms which are part of genetics. This minimal information is needed to understand the reasons for some of the research procedures and to understand the implications of the results. A better appreciation of the problems inherent in psychogenetics can be had from appropriate textbooks (e.g. Neel & Schull, 1954) and especially an article by H.J. Muller (1956).

The essence of Mendel's experiments was that single characters (e.g. color) behaved as if determined by paired particles (genes). Two members of a pair of genes (i.e. two gametes) joined to form a zygote, one from the mother and one from the father. When new gametes are formed by the adult from this zygote, the genes separate again, without having influenced each other and do not enter the same gamete. An allele refers to one of a pair of genes that are contrasted in inheritance such as tall (D) and short (d). Man has 23 pairs of chromosomes; members of a pair are termed homologous. Two corresponding or allelic genes occupy the same linear position on homologous chromosomes. Chromosomes are visible microscopically. Genes are arranged in a linear sequence along the length of the chromosome. A gene is a submicroscopic, clearly differentiated functional locus which preserves its identity, produces a specific effect, and is capable of duplicating itself. Genotype is the description of an individual in terms of the genes he possesses;

it can only be inferred by observation of the phenotype. The latter is a description of an individual in terms of its visible characters. Tall is a phenotypic description, in the pea, and may be due to either of two genotypes, DD or Dd. Further complicating matters is the phenocopy, a term applied to environmentally produced abnormalities which mimic traits known to be genetically determined in man. An homozygote is an individual with like genes for the pair under consideration, e.g., DD or dd. An individual with unlike genes for the pair under consideration is termed a heterozygote, e.g., Dd. An individual may be homozygous for some genes and heterozygous for others. In some cases the Mendelian trait displayed by a heterozygote will be intermediate between the phenotypes of the homozygotes; in others possession of one allele produces the trait (dominance), while its allelic partner is unexpressed (recessiveness). Homozygousness is required for the expression of a recessive; a recessive gene in the heterozygous state may be transmitted for hundreds of generations without detection or expression.

A mutation occurs either spontaneously (i.e., for unknown reasons) or in response to environmental agents. It results in failure of a gene to reproduce itself isomorphically. Some genes are referred to as modifiers if they cause quantitative changes in the expression of a major gene. The failure of a major gene to be expressed at all, termed lack of penetrance, may be due to a suppressing effect of modifiers which may be either genetic or environmental. One of the main principles of modern genetics is that the expression of genes is not an independent entity. It is

thought to be a unified action of a field type. A gene does not directly produce a given trait, it sets a chain reaction into motion which may be modified before culminating in the production of a particular trait (Muller, 1956).

One of the concepts most directly relevant to a treatment of human personality is that of polygenic vs. major gene inheritance. The distinction has to do with multi-factor vs. single-factor inheritance. The major gene is one which determins characters by itself (with the exceptions noted above). Intermediate gradations of a trait characterize the additive effect of polygenes which interact to produce the observed continuous distribution. In this multi-factor type of inheritance cumulative contributions are made by various genes which by themselves go unnoticed. It is now considered likely that the hereditary basis of intelligence and height in humans is polygenically determined. Pearson and Kley (1957) caution, however, that it may be erroneous to assume that because behavioral variable s appear to be continuously distributed in the general population, the underlying etiological factors are also thus distributed. They cite the example of intelligence where the extremes of the distribution may constitute discrete series (i.e., both the genius and the low grade mental defective may be determined by major genes). Perhaps both modes of inheritance need to be invoked in order to explain a given distribution. Related to the concept of polygenic inheritance is the construct of the gene threshold. It may be that in order for a trait to be expressed, the number of genetic determiners must reach a certain threshold level (Tyler, 1956). Persons who are

near the threshold may be pushed over it by environmental stresses which a person further from the threshold could withstand.

Perhaps the reader can bear one final clarification attempt before the twin method itself is undertaken. Qualities biologically acquired from the immediate parents and ancestors are called inherited. The term innate includes all that is inherited plus any gene mutations. The term congenital refers most appropriately to chatacteristics acquired in utero. The term constitutional refers to that which, at any age, is least likely to change and/or that which is physiological or somatic in the existing determination of the individual.

B. The Twin Method in Genetic Research

Mice, molds, and fruit flies have contributed greatly to the body of genetic knowledge. Unfortunately, the direct application of this knowledge to the causes of human variation is a tenuous leap. Relatively few methods are available to the researcher in human genetics as a result of such things as uncontrolled mating, small numbers of offspring, heterogeneous environments, and the large number of genes (estimated 40,000 to 80,000) possibly related to human traits. Additional difficulties peculiar to psychogenetics stem from the incommensurableness of psychological traits. This latter difficulty is discussed in the section on reliability and validity.

Of the available methods, the twin method approaches the ideal situation for experimental design. Sir Francis Galton (1875) first called attention to the uniqueness of twins and suggested their usefulness in the appraisal of the nature-nurture problem. The

underlying principle is simple and sound: since monozygotic (MZ) twins have identical genotypes, any dissimilarity between pairs must be due to the action of agents in the environment, either postnatally or intrauterine; dizygotic twins (DZ), while differing genetically, have certain environmental similarities in common such as birth rank and maternal age, thereby providing a measure of environmental control not otherwise possible. When both types of twins are studied a method of evaluating either the effect of different environments on the same genotype or the expression of different genotypes under the same environment is provided. This means that with respect to any given genetically determined trait, there should be found a greater similarity between MZ than between DZ twins.

If both members of a twin pair develop the same phenotype in a given environment, they are called concordant for the trait under study; discordant is the designation for differing phenotypes. When dealing with a single gene difference, such as Huntington's chorea, MZ twins should always be concordant; DZ twins may be either concordant or discordant. The expected difference in concordance can then be used as a measure of the percentage of phenotype variance attributable to Heredity. One measure used is

$$H = \frac{CMZ - CDZ}{100 - CDZ},$$

where CMZ and CDZ are the percentages of concordant MZ and DZ twins. If environment has little effect on the genotype, CMZ will be close to 100% with a smaller value for CDZ; H will estimate the relative contribution of heredity in this instance as 1. H plus the relative

contribution of environment (E) will always have a limit of plus 1.

This method is limited to Mendelian unit characters. Inasmuch as few psychological unit characters are recognized in the normal range of human personality, another approach is needed which allows for estimating H when the traits are determined by multi-genes or polygenes and are continuous rather than discrete. Holzinger (1929) suggested that the best comparison to evaluate the nature-nurture interaction for a quantitative characteristic is a comparison of the intraclass correlation coefficients (R) for MZ with similar coefficients for DZ, like-sexed twins. He gives two formulae for the measure of heritability, one based on the coefficients and another, supposedly equivalent, based on the variance within pairs.

$$(a)\ H = \frac{R_{MZ} - R_{DZ}}{1 - R_{DZ}}$$

$$(b)\ H = \frac{V_{MZ} - V_{DZ}}{V_{DZ}}$$

R_{MZ} = intraclass correlation between MZ twins.

R_{DZ} = intraclass correlation between DZ twins.

V_{MZ} = within MZ pairs variance estimate (mean square).

V_{DZ} = within DZ pairs variance estimate (mean square).

Limitations and Criticisms of the Twin Method.

Inferences drawn from twin data are subject to both statistical and biological biases. It is basic to the kinds of analyses

discussed above that the probability of ascertainment of the "affected" twins be independent of their type. The sample must be proportional to the population of MZ and like-sexed DZ twins before the concordance or the variance used in the formulae can be assumed to be valid. Another statistical defect discovered in the course of this study was that formulae a and b above were not equivalent for the measures of personality traits obtained by means of the tests used. This results from the fact that the intraclass R is a function of both the within and between variances, whereas formula b only uses within variances. It is not paradoxical, therefore, that on measures of some traits in the present study the R for DZ twins was higher than for MZ twins, but the within variance for the MZ twins was higher. As will be shown in the chapter on Results, this defect is probably due to invalid personality scale construction. Loevinger (1943) mentioned other difficulties underlying the use of the variance method, chief among which are the assumption that influences combine additively and the assumption that estimates of the error variance are eliminated from the computation of H. Cattell (1953) replied to each of Loevinger's criticisms and concluded that approximations of a solution to the nature-nurture issue, with an awareness of methodological shortcomings, was better than postponing all research in the area.

Biological biases were reviewed by Price (1950) who divided them into natal factors (e.g. position in utero), lateral inversions, and effects of mutual circulation. No attempt to evaluate these will be made since data are not available. Postnatal biases

are often overlooked with the assumption that the general environment for a pair of twins is the same. Should one of a pair, for example, contract some form of encephalitis with its well known sequelae, the results on personality measurement would be obvious.

The main limitations of twin studies were viewed by Kallman and Baroff (1955) as the following:

> . . .(a) twins cannot be separated before they are born, nor can they be provided with two mothers of different age, personality or health status; (b) two-egg twins are no more dissimilar genotypically than brothers and sisters and like them, are rarely raised in different cultures; therefore, even fraternal twins are unlikely to fall into the extremes of theoretically possible genetic and cultural differences; and (c) the average difference between one-egg twin partners is no precise measure of environmentally produced variation, nor does an increase over the average difference between two-egg twins represent the exact contribution of genetic influences even in relatively comparable environments. (p.303).

Even though the evidence for the sizes and influences of twin method limitations is lacking, Price (1950) was willing to conclude, "In all probability the net effect of most twin studies has been underestimation of the significance of heredity in the medical and behavior sciences" (p. 293).

Chapter II

SOME RELEVANT RESEARCH

A search of the literature failed to reveal any twin studies in which either the Minnesota Multiphasic Personality Inventory (MMPI) or the High School Personality Questionnaire (HSPQ) was used in an effort to examine possible genetic contributions to normal or abnormal personality. Cattell (1955) has reported results using an older version of the HSPQ which will be reviewed below. A considerable body of twin research relevant to the demonstration of genetic influences on intelligence, psychopathological conditions, and even normal personality does exist using other techniques. Some of the results of each of these are reported in the pages that follow.

A. Twin Studies and Intelligence

Newman, Freeman, and Holzinger (1937) conducted the classical twin study in this area. Their sample consisted of 50 pairs of MZ and 50 pairs of same-sex DZ thirteen year old twins. Intraclass correlations for the 1916 Binet IQ's were .88 and .63 for the two classes of twins respectively. Otis IQ's gave correlations of .92 and .62 respectively. The nature-nurture ratios computed from these correlations estimated H at first .68 and then .80. The authors concluded (1937, p. 116) that on the average nearly three-fourths of the variance in intelligence is attributable to nature. While Cattell, et al., (1957) used a different technique from this and did not present

correlations, they concluded that heredity is about twelve times as important as environment between families and twice or more, within families. They used Cattell's culture free test with a sample of 52 pairs of MZ and 30 pairs of DZ aged 11 to 15. In his earlier study (Cattell, et al., 1955) with apparently the same sample but using Factor B of his Junior Personality Questionnaire, he again gave the more important role to heredity.

B. Twin Studies and Psychopathology

By far the majority of psychogenetic research has been done on psychopathology. Almost all results are expressed in terms of concordance which in turn limits interpretation to Mendelian unit characters. Complete and representative ascertainment of the affected twins is crucial to valid results as discussed in the section on the twin method. A minority of these studies utilized objective measures of personality and therefore most of them suffered if errors were made in clinical diagnosis. That conclusions reached from these studies may have little or no application to behavior within the normal range should be obvious if the distinction between quantitative and discrete inheritance is borne in mind. Three categories have been selected as examples of the research in this sub-area: psychoneuroses, manic-depressive psychosis, and schizophrenia.

Psychoneuroses. Eysenck and Prell (1951) boldly entitled their study "The Inheritance of Neuroticism: An Experimental Study". On the basis of their study of 25 pairs of MZ and 25

pairs of DZ school children they classified "the neurotic personality factor" as a biological and largely gene-specific entity, estimating the genetic contribution to this "neurotic unit predisposition" as 80%. This was derived from correlations of .85 and .22 respectively for a neuroticism score extracted from a variety of factorially derived motor and questionnaire tests. In another English study (1953) Shields rated 36 MZ and 26 DZ pairs of 12-15 year old children on a four point scale of psychiatric maladjustment. He found 69% of MZ and 31% of DZ to have the same degree of adjustive difficulty. Carter (1940) using the neuroticism scale of the Bernreuter Personality Inventory (1933) obtained correlations of .63 and .32 for MZ and DZ pairs of children respectively. Slater (1953), an English scientist active in current research in psychiatric genetics, theorized that neurotic symptoms are exaggerations of polygenically determined personality variants and less closely related to a given type of stress than to the basic personality. Sampling deficiencies and lack of awareness about construct validity render these studies to telling criticisms.

Manic-depressive psychosis. Kallmann (1953) is the principal investigator and made use of the adult index cases he found in the New York State mental hospitals. Among his 23 pairs of MZ he found a concordance of 95.7% while it was only 26.3% among 52 pairs of DZ. Both incidences greatly exceed the base rates in the general population of 0.4%. The mode of inheritance appears to be simple, autosomal (not sex linked) dominance with incomplete penetrance. Pedigree studies, which do not come

under the purview of the present study, lend support to the probability of genetic determinism in all the functional psychoses.

Schizophrenia. The most famous twin study on schizophrenia and the one most cited in current literature is the venerable Kallmann investigation (1938; 1946) begun in 1936. He believes the genetic mechanism involved is the inheritance of a single recessive gene producing a predisposition to schizophrenia. Along with this is inherited a polygenically determined constitutional defense system. Despite the multitude of references to the concordance rates for this psychosis in MZ and DZ twins, they all stem from this one study. No revision in the data or its interpretation have ever been made by the author (1959). While the concordance rates always reported are about 85.8% and 14.7% for MZ and DZ twins respectively, a closer examination of the original data reveals obvious and subtle sources of error not even detected by Anastasi (1958). The lack of adequate diagnosis of both zygosity and schizophrenia are sources of such errors. 184 cotwins of the 691 index cases had to be diagnosed in absentia since they were dead at the time the data were collected. Inasmuch as the age range of the twins began at 15, Kallmann corrected for those cotwins not yet psychotic. The above rates were derived after this extrapolation; the uncorrected rates, without provision for the above criticisms, were 69.0% and 10.3%. Another source of error was the assumption that random sampling of all psychotic twins prevailed. It was a reasonable error at the time the study commenced since

it was thought that only one-fourth of all twins were MZ, and this was the obtained proportion. The correct proportion in the United States is nearer one-third (Strandskov and Edelen, 1946). This means that in order for a representative sample of twins to exist, somewhere between 47 and 122 more pairs of MZ twins would be needed. The first number would make his 174 pairs of MZ equal his number of opposite sex fraternal twins (221), while the second would match his sample of same sex fraternal twins (296). It could well be that additional cases might make the concordance rate for MZ twins still lower. One last criticism of this study worth noting was the handling, at the point of computing concordance, of schizophrenia as a homogeneous disease entity. Kallmann provided a suggestion of a meaningful heterogeneity by speaking of a nuclear group and a peripheral group of schizophrenic cases. The former refer to the hebephrenic and catatonic types and the latter to simple and paranoid types. He shows that the latter group had a marriage rate about 1.8 times that of the former. Slater's study (1953) provided one of the few independent checks of the general magnitude of schizophrenia concordance rates in twins. It was 76.3% for his 41 pairs of MZ and 14.4% for 115 DZ pairs. Again the criticism about sampling is appropriate in that only 26% of the total are MZ.

The final study reviewed in this area brings a refreshing and original viewpoint which also is testable. Rosenthal (1959) reasoned that if there were a significant genetic factor in schizophrenia, it is especially likely to be represented in

concordant MZ twins. Conversely, if there is a subgroup of schizophrenia which has either little or no hereditary basis, it should be represented in discordant MZ twins. Using 37 MZ pairs from Slater's study whose complete case histories were available, he tested three hypotheses: (a) Process schizophrenia is found more frequently in concordant MZ pairs and reactive schizophrenia more often in discordant pairs; (b) The psychosis is more severe in concordant MZ twins ; (c) A history of schizophrenic illness will be found more frequently in the families of the concordant pairs. Some support was found for the first two hypotheses and the third was definitely established. The families of the discordant MZ pairs were virtually free from a history of schizophrenia (1 of 13) whereas 60% of the families of concordant pairs (13 of 22) showed evidence of a schizophrenic illness. Rosenthal concluded that there are two broad groups of schizophrenias; in one, (reactive) the genetic contribution is little or absent and, in the other, (process) the genetic contribution is "probably considerable".

C. Twin Studies and Personality Traits in the Normal Range

This area is the one most directly relevant to the present study. Studies reviewed in this section have all used personality tests with normal, school age children. At the time that Newman, Freeman, and Holzinger (1937) were investigating intelligence, they also made an attempt to evaluate the nature and nurture of personality as measured by the tests then available. Their results and conclusions are important because they appear

to have retarded research in this area. The Downey Will-Temperament Test (1923), a motor test of personality whose face validity is limited to its title, showed the fraternals to have higher correlations than the identicals on three of the four subtests. On the Woodworth-Mathews Personal Data Sheet (1923) the intraclass correlations were .56 and .37 for the MZ and DZ pairs respectively, a non-significant difference. From these results the authors concluded (1937, p. 352) "The only group of traits in which identical twins are not much more alike consists of those commonly classed under the head of personality". Criticisms waxed (McNemar, 1938a,b) and interest waned. Further developments awaited the improvement of objective personality tests, the goad of increasing gene mutation rates due to radiations, and the zeal of Raymond Cattell (1953). The programmatic research design of the latter which makes use of hypothetical variances, guessed-at correlations between heredity and environment, and five linearly independent equations was attempted and reported on in 1955 (Cattell, Blewett, and Beloff). The sample consisted of 52 MZ pairs and 32 DZ pairs of 11 to 15 year old school children, plus ordinary sibs, adopted sibs, and unrelated children. Personality measures were for the twelve factors, including intelligence, on the Junior Personality Questionnaire (Cattell and Beloff, 1953) which had reliabilities ranging from .18 to .65 (median .39) for the twins. The results are given in some detail to facilitate comparisons with the present study for the traits with same names. Factors predominantly

environmentally determined were the following: General neuroticism, (C), Tender-Mindedness, (I), Sober, serious vs. Happy-go-lucky, (F), Will control, (Q3), and Relaxed composure vs. Tense, excitable, (Q4). Four factors showed an equal role for heredity and environment but with heredity predominating between families: Liking group action vs. Fastidiously individualistic, (J), Dominance, (E), Socialized morale (K) (not on the HSPQ), and Phlegmatic temperament vs. Excitability (D). Only three factors showed a predominance of heredity: Stiff, aloof vs. Warm, sociable, (A), Shy, sensitive vs. Adventurous, (H), and Intelligence, (B). The authors recognized the tentativeness of their results and concluded that their design needed to be carried out on a scale "at least two or three times as large". In a subsequent report (Cattell, Stice, and Kristy, 1957) on the same sample but with the Objective-Analytic Test Battery (Cattell, 1955) an approximation for eleven personality factors was offered. Only intelligence, of the factors mentioned above, resulted in a ratio with heredity predominating. Cattell's design still remains programmatic.

Results of a twin study conducted at the University of Michigan using the JPQ were not available at this time, but Anastasi (1958) reported that Cattell's results could not be corroborated. An incidental observation in the delinquency study conducted by Hathaway and Monachesi (1953) is worth reporting. They found 26 pairs of twins, same-sex and opposite-sex of unknown zygosity, and computed intraclass

correlations for their MMPI results. Of the 10 clinical scales scored, only Scale 4 (Psychopathic deviate) and Scale 0 (Social introversion) were significantly different from zero. The correlations were .43 and .46 respectively, both significant at the .01 level. The authors observed that these kinds of data offered "provocative implications".

Chapter III

METHODS

A. Selection of the Twin Sample

Few studies endeavor to enumerate the entire population and then to sample from it. In sound twin methodology, it is essential that the sample be a miniature of the population of twins. This ensures proportional representation of the two kinds of twins and allows accurate genetic analysis with the computed nature-nurture ratios or concordance rates. It is also essential that the groups in the sample be matched on as many variables as possible so that differences in variance cannot be attributed to differences in age, sex, intelligence, socio-economic status, or other factors which may influence personality other than those under investigation: heredity, environment, and error.

All class cards for the over thirty-one thousand children in public school grades nine through twelve in the cities of Minneapolis, Saint Paul, and Robbinsdale, Minnesota were examined. Opposite sexed fraternal twins were not included in the study in order to eliminate the questionable procedure of comparing a boy with a girl on the same personality traits. All children with the same last name, same sex, same address, and same birthdate were recognized as the twin population available.

The best data available to date about the incidence of

twin births in the United States "White" population is that of Strandskov and Edelen (1946). They report that 1.129 per cent of all births are twin births. Of these, one-third are opposite-sexed fraternals, one-third are same-sexed fraternals, and one-third are identicals. The best known twin studies (Newman, et al., 1937; Kallman,1946) assumed that only one-fourth of all twins are identical. The effects of this assumption were discussed in the review of the literature.

A total of 163 pairs of same-sex twins were located in the schools' files of 31,307 children. Based on the incidence of twin births, 1.129%, the expected incidence of same-sex twins would have been 237 pairs. Due to mortality however, Allen (1955) found that the incidence of twins at one month of age had already been lowered to .87 pairs per 100 children (.87%). Based upon this incidence, the expected number of same-sex twin pairs in the entire population would have been 182. After one month of age, the mortality of twins is the same as that of single born survivors. By subtracting the known mortality rate in the general population for children reaching the age of 15 (5%), the final expected number of same-sex twin pairs was 173.[1] At the time the present study was conducted, there were no adolescent twins in either the correctional or mental institutions (not counting the two housing mental defective and brain damaged cases) of the state. It would appear that the entire population of same-

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[1]Dr. Elving Anderson provided the information leading to the evaluation of the sampling adequacy.

sex adolescent twins in the public high schools of the three communities was enumerated.

The parents of all pairs in Minneapolis and Robbinsdale and of those in the largest high school in Saint Paul were sent a letter describing the project and a return postcard on which was printed a medical release authorizing blood typing (Appendix A). After ten days, telephone calls were made to those who had not returned the card indicating the voluntary participation of their children. After another ten days, a second and last, hopefully persuasive, telephone call was made. The net result of these efforts was 26 pairs of boys and 48 pairs of girls. By the end of the study six pairs of twins had defaulted for various reasons. Only one pair was lost as a result of fear of the intravenous removal of the blood specimen. One of another pair had cerebral palsy and could not take the personality tests in the standard manner. The remaining four pairs were unavailable at the times provided for the tests which were Saturday afternoons and mornings.

The final study sample,then, consisted of 23 pairs of boys and 45 pairs of girls. This represented 43.4% and 75.0% respectively of the total possible pairs available in the schools sampled. The 68 pairs, disregarding sex, represented 60.2% of the total possible 113 pairs in the schools sampled. Cattell et al., (1955; 1957) was able to enlist the cooperation of only 52 pairs of MZ and 32 DZ pairs in the age range 11-15 with "excellent cooperation" in New York City, Boston,

and Chicago. The sample of the present study compares favorably in size with the majority of twin studies reported in the psychological literature. In representativeness, it is superior to the majority. The simplest explanation for the preponderance of girls over boys is the well-known reluctance of adolescent boys to volunteer their spare time for taking paper and pencil tests, especially on Saturdays. The children came from 13 different high schools (all that were sampled), some of which included a ninth grade, and 5 different junior high schools. Participation ranged from eight out of eight pairs to three out of eight in the high schools. There was a tendency toward better participation as the economic level of the neighborhood increased.

After the parents of a twin pair had returned the signed authorization for participation and blood typing, an appointment was made to drive the pair to the Minneapolis War Memorial Blood Bank. An appointment was then made for the personality tests. The children were tested in small groups ranging up to twelve pairs. Almost all the testing was done on Saturday afternoons at Minneapolis and Saint Paul neighborhood YMCA's, churches, or schools.[2] These facilities were made available gratis. At the time of testing, the children filled out a personal history data sheet (Appendix A), the Minnesota Multiphasic Personality Inventory (MMPI),

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[2] Indebtedness is acknowledged to the Roosevelt YMCA, Northside YMCA, Northeast YMCA, Dr. N.C. Kearney, Dr. F.C. Gamelin, the Linden Hills Congregational Church.

and the High School Personality Questionnaire (HSPQ); they were weighed, measured for height, fingerprinted, and photographed. The entire procedure usually took between three and four hours for each group.

Mr. John D. Douthit, Identification Officer with the Minnesota Bureau of Criminal Apprehension, fingerprinted about half of the twins and after being tutored in the technique, the author fingerprinted the balance. The Faurot Inkless Method was used with acceptable results and a considerable saving of time. It makes use of a colorless fluid and chemically sensitive paper. An ordinary bathroom scale was used for weighing. Height measurement was against a wall and is estimated to be probably correct within 5 millimeters. Photography was done by the author with a 35 mm. camera; both a front view and a profile were shot of the head and shoulders.

Some descriptive characteristics of the sample are presented in Table 1. By a procedure described in the next section, the 68 pairs of twins were classified into 34 pairs of MZ and 34 pairs of DZ. That this split corresponds to the theory is both a stroke of luck and an illustration of the representativeness of the sample. In addition to obtaining Otis IQ's on the sample, they were obtained for 30 more pairs of twins who had not volunteered in Minneapolis and Robbinsdale so that any selection for intelligence might be revealed. It should be noted that this accounts for the IQ's of 86.7% of the total possible population of same-sex twins in the schools used. A sampling bias was revealed by the mean IQ of 97 for

the non-sample twins compared to means of 105 and 108 for the MZ and DZ samples respectively. A t test for the differences showed that both study samples were statistically significantly higher than the non-volunteers.

Table 1

Descriptive Characteristics of the Sample

Character	MZ	DZ	Combined
Pairs of Boys	12	11	23
Pairs of Girls	22	23	45
Age 14	0	2	2
Age 15	15	4	19
Age 16	9	13	22
Age 17	7	10	17
Age 18	3	5	8
Grade 9	7	5	12
Grade 10	15	11	26
Grade 11	7	11	18
Grade 12	5	7	12
Level of Paternal Occupation[a]			
I & II	15	9	24
III	7	13	20
V & VI	12	12	24
Mean Otis IQ	105	108	107
IQ Standard Deviation	12	12	12

[a] The Minnesota Scale for Paternal Occupations, Institute of Child Welfare, University of Minnesota.

B. Criteria for the Diagnosis of Zygosity and an Evaluation of their Relative Efficiency

One of the most serious criticisms of twin research is the inaccuracy of zygosity diagnosis. In reaching a judgment in the past, reliance has been placed on an evaluation of the type of birth membrane or the degree of physical resemblance between the twins. The birth membranes are unreliable because while MZ twins are more frequently monochorionic, (i.e., a single membrane surrounding both fetuses) the presence of two chorions is known to occur with both MZ and DZ twins (Steiner, 1935). In addition, when studying adult or adolescent twins, one is hard pressed to find any accurate information about the birth membrane. In evaluating the extent of physical resemblance, geneticists have used such traits as sex, height, weight, eye color, hair color and form, familial appearance, and some type of fingerprint or palmprint analysis. Although there is an unavoidable subjective element in evaluating many of these characteristics, one expert has estimated the error to be no greater than one in ten (Newman, 1940). That this estimate may be in error is demonstrated below.

If twins differ in sex or any other known inherited characteristic, they cannot be MZ twins. However, if the characteristics are alike, the possibility still remains that the twins are DZ. Given a number of simply inherited and widely distributed traits, a probability statement as to the zygosity of the

twin pair may be made. Any final statement about zygosity, no matter how many characteristics are identical, will be a probability one.

Numerous criteria were examined in this study with the hope that the various suggestions in the literature for the diagnosis of zygosity might be objectively evaluated against the recognized best method of extensive blood typing recently quantified by Smith and Penrose (1955). Blood alone was compared with blood combined first with height, second with a difference in total fingerprint ridge count, and then with both height and ridge count. The accuracy of just fingerprints and just height was ascertained. Three groups of judges - geneticists, psychologists, and artists, - looked at photographs of the twins for another datum.

All blood specimens were drawn and typed by the Minneapolis War Memorial Blood Bank Inc. It was accomplished at an estimated cost of twenty dollars per pair.[3] The following blood group systems (Race and Sanger, 1958) were used: ABO, MNS, Rhesus (CDEce), P, Lutheran (Lu), Kell (K), Duffy (Fy), Kidd (Jk), and Lewis (Le).[4]

Smith and Penrose (1955), following a suggestion of Race and Sanger (1958), have tabulated the probabilities necessary

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[3] It was only through the generosity and the interest in research of Dr. G.A. Matson, who provided the anti-sera, medical technologists, and nurses gratis, that the expensive procedure of extensive blood typing was possible.

[4] Mrs. Jane Swanson painstakingly typed the 136 specimens of blood.

for an objective determination of the likelihood of dizygosity based on phenotypic sib–sib gene frequencies for the above blood groups. The general principles of their method are explained and illustrated. The first problem is to ascertain the basic probability of occurrence of the two kinds of twins. While they use a figure of 2.33:1 (70:30) in favor of DZ twins, the figure for the United States would be 1.9269:1 (Strandskov and Edelen, 1946). This represents the odds in favor of the DZ contingency and is called the initial relative probability in favor of a DZ pair, p_oD. The initial odds are modified as soon as another specific character in a particular twin pair is known. This requires knowledge of the incidence of differences between the measurements of the character in the two types of twins. For example, for same-sex twins the relative probability is determined by the frequency of same sex and different sex in DZ pairs, that is, about 50%. This independent relative probability that the pair is DZ, called p_1D, results in a combined probability of their being DZ of $p_oD \times p_1D$ or $1.9269 \times .5000$. It is possible to combine the observations on any number of traits in this way so that

$$p^D = p_oD \times p_1D \times p_2D \times \ldots \ .$$

The total probability that the twins are DZ, then, is

$$pD / (1 + pD),$$

and the probability that they are MZ is

$$1 / (1 + pD).$$

The relative chances in favor of the DZ contingency for the above nine blood group systems, differences in total fingerprint ridge count,[5] and differences in height are tabulated. The nine systems result in forty six discriminable phenotypes. The largest system, Rhesus, for example, consists of nineteen phenotypes. In this study, the following characteristics were used for the determination of zygosity by the Smith and Penrose (1955)method: initial odds, likeness in sex, likeness in nine-blood groups, difference in total ridge count, and difference in standing height. The criteria for final zygosity determination consisted of everything but the last two items. Probabilities resulting from including the latter information are also presented and evaluated.

The example worked out in Table 2 is the actual data for pair MZ-1. The twins of this pair are both females; the blood groups for both are O, MNSs, CDe/Ce, Le(a-), K-, Fy(a+), Jk (a+), Lu(a-), and P-. The difference in their total ridge count is 1. The difference in their stature is 6 mm.

It follows that the probability that the twins are monozygotic is 1 / (1+ pD) or 0.9552 using the blood criteria only and 0.9950 using the remaining two characters. The blood, ridge count, and height characters for all the MZ twins are presented in Appendix B.

As a result of the blood typing, 34 pairs of twins were diagnosed definitely as DZ, that is, they differed on at least

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[5] Calculated from the highest of two counts for a whorl, zero for arches.

Table 2

Calculated Probability in Favor of a Dizygotic Contingency

for Twin Pair MZ-1

Character	Independent Relative Chance
Initial Odds	1.9246
Likeness in sex	0.5000
Likeness in ABO	0.6891
Likeness in MNS	0.4556
Likeness in Rhesus	0.5021
Likeness in Lewis	0.8681
Likeness in Kell	0.9485
Likeness in Duffy	0.8036
Likeness in Kidd	0.8531
Likeness in Lutheran	0.9614
Likeness in P	0.5699
Total relative chance pD (blood)	0.0470
Total chance pD/ (1+pD)	0.0448
Difference in ridge count	0.2288
Total relative chance (blood + ridges)	0.0107
Total chance	0.0106
Difference in stature	0.4671
Total relative chance (blood + stature)	0.0219
Total chance	0.0214
Total relative chance (all of above)	0.0050
Total chance	0.0050

one of the independently determined blood groups. Tests were stopped as soon as a single blood difference was found in order to save antisera and time. Using only blood in the method illustrated above, the remaining 34 pairs were diagnosed as MZ at an exact probability of .05 or less. In other words the probability resulting from the Smith and Penrose method guarantees a correct diagnosis of MZ 95 times out of 100. Actually three of the probabilities were slightly over .05 (viz. .0558, .0722, and .0722) but were rounded to the lower figure with the rationalization that it was the closest commonly accepted P level. Table 3 reveals the accuracy of zygosity determination for the five possible combinations of blood, fingerprints, and height.

Table 3

Accuracy of Smith and Penrose Zygosity Determination

P Levels	.005	.01	.05	.1	.1
Blood Only	0	1	33	0	0
Blood + Prints	1	18	11	3	1
Blood + Height	0	8	21	0	5
Height + Prints	0	0	0	11	23
Blood + Height + Prints	11	11	6	2	4

The last two columns in the above table reveal the number of false negatives obtained as more information is added to the system beyond the blood groups. It seems paradoxical that while additional information increased the accuracy of some of the diagnoses, it was at the expense of serious errors, e.g. using all the characters resulted in 22 pairs at the .01 level or better, but at the expense of 6 pairs failing to meet the criterion of the .05 level. The primary reasons for this are the lack of cross validation and the small samples upon which the fingerprint and height probabilities are calculated, 52 and 50 pairs of MZ respectively. This resulted in a range of differences too narrow to allow for those found in the present sample of MZ twins. The probability figure given was too much in the DZ direction to be overcome by any amount of additional information. Eight pairs of MZ twins had differences of ridge count which were tabulated at probabilities greater than 1.0 in favor of the DZ contingency. Similarly, five pairs were "penalized" for differences in height larger than the tabulated ones for the 50 pairs of MZ twins on which they were based. Differential growth rates during adolescence may have been another attenuating factor in the use of the probabilities attached to differences in height.

Let us turn now to two different analyses of the fingerprints, one clinical and the other statistical. Given the 68 pairs of fingerprints and no information as to the base rates, i.e., incidence of DZ and MZ twins in the sample, how accurately can

an expert diagnose the two kinds of twins? Mr. Douthit undertook this task and was able to correctly identify 30 MZ pairs and 23 DZ pairs. Instrumental in his clinical decisions were three components (Cummins and Midlo, 1943): differences in pattern slope for paired fingers; similarities in slope but different patterns; and, differences in the range of ridge count for paired fingers. His decisions were not purely clinical in the Meehl (1954) sense of the word in that he actually assigned different weights to these components, subjectively, and had a "feeling" for the score a pair of prints obtained. The statistical method used was simply to assign what appeared to be the optimum cutting score (Meehl and Rosen, 1955) to the distribution of differences between total ridge count. This cutting score was then cross validated by applying it to the original distribution (Smith and Penrose, 1955) from which the aforementioned probabilities were determined. A cutting score of 30 classified 33 of 34 MZ pairs correctly and 20 DZ. This score correctly classified 51 of the original 52 MZ pairs at the expense of misclassifying 39 of 101 (38.6%) like-sex siblings. The clinical and statistical methods tied in their accuracy for diagnosing the entire present sample with both hitting 78% . Both Newman, et al. (1937) and Slater (1953) make use of some aspects of fingerprints in their diagnosis of zygosity.

Judgments of photographs constituted the final method of zygosity determination evaluated in this section. A summary of all the methods attempted is then presented. Three groups

of three judges were utilized; geneticists, child psychologists, and artists.[6] Although these front and profile pictures of the head were black and white 35 mm. contact prints, expressions of dissatisfaction with their quality were minimal. Results of the photograph judgment are shown in Table 4.

Table 4

Accuracy of Zygosity Diagnosis from Photographs

Judge	Geneticists	Psychologists	Artists
	MZ%–DZ%–Total %	MZ%–DZ%–Total %	MZ%–DZ%–Total %
1	74 – 71 – 72	47 – 85 – 66	79 – 91 – 85
2	97 – 74 – 85	68 – 65 – 66	62 – 76 – 69
3	94 – 59 – 76	59 – 82 – 71	74 – 91 – 82

It is obvious that previous estimates (Newman, 1940) of a ten per cent error in the diagnosis of zygosity by general appearance are highly subject to doubt. Even allowing for the quality of photographs and the absence of the cues from the twins' physical presence, the median accuracy for all nine judges of 72% seemed to be significantly less than 90%. Poor reliability of judgments may be inferred from the fact that only for 13 MZ pairs and 14 DZ pairs were there one or no inaccurate judgments. There were a total of 84 errors in judging

[6]The author is grateful for the assistance of (geneticists) Vivian Phillips, Elizabeth Reed, S.C. Reed, (child Psychologists) J.E. Anderson, Mildred C. Templin, R.D. Wirt and (artists) L. Safer, Carol Safer, Ann Wolfe Graubard.

the MZ twins and 70 errors in judging the DZ twins. Judging the MZ girls seemed to be the most difficult. To the extent that the data in Table 4 were stable, only the geneticists made sufficient allowance for the variability that existed between MZ twins.

Summary. For the sake of clarity of exposition, the accuracy of zygosity determination for all the methods described thus far are presented in Table 5.

It should be noted that the three columns cannot be evaluated independently of each other. A judge of the photographs or fingerprints could maximize his accuracy in one category at the expense of the other. It is the final column which conveys the most meaning. The blanks in the table derive from the fact that the DZ twins were absolutely removed from further consideration by the blood typing methodology in the Smith and Penrose (1955) scheme. Blood typing alone is sufficient for the accuracy needed in research pointed toward the computation of ratios purporting to demonstrate the influence of heredity. None of the twin studies reported in the psychological literature thus far have utilized a procedure equivalent to the accuracy described here.

Table 5

Accuracy Summary for Methods of Zygosity Determination

Method	MZ%	DZ%	Total %
Blood ($P \leq .05$)	100	100	100
Blood + Height	85	-	-
Blood + Ridge Cnt.	88	-	-
Blood + Ht. + R.C.	82	-	-
Height + R.C.	0%	-	-
Fingerprints–Clinical	88	68	78
Fingerprints–Statistical	97	59	78
Photos – Best Geneticist	97	74	85
Photos – Best Psychologist	59	82	71
Photos – Best Artist	79	91	85
Photos – Pooled Judges (6/9 agreement)	68	88	78

C. The Personality Tests Used and Their Reliability and Validity with Adolescents

Personality measurement is beset by numerous internecine battles and subjective arguements so that selection of the test instruments often reveals the investigator's biased frame of reference. Adjectives associated with the poles of one of the continua involved, clinical vs. statistical, are listed by Meehl (1954). Projective tests vs. objective tests could well be conceptualized as belonging to these two poles respectively although the projective element in objective tests has been brilliantly documented (Meehl, 1945). Both instruments used to measure personality in this study come under the category of objective. Within this category there are two types of tests: one which is derived empirically and the scales may be said to have functional unity; and, another, which is derived via factor analysis and the scales may be said to have statistical unity. Both types were used in this study in order to mitigate criticisms of a parochial point of view. The Minnesota Multiphasic Personality Inventory (MMPI) was selected as the exemplification of the first type and the High School Personality Questionnaire (HSPQ), the latter.

Widespread usage of the MMPI precludes the necessity for a detailed description (Hathaway & McKinley, 1951). Its use with normal children at the junior and senior high school levels may be questioned by the uninitiated, but this too is

is documented (Hathaway & Monachesi, 1953; Wirt & Briggs, 1959). While the test derives from a psychiatric background as evidenced by the scale names, the literature abounds with examples of its utility in the non-clinical setting. Numbers have even been assigned to avoid the psychiatric implications of the names (Welsh, 1948). The group form of the test was used along with Hankes answer sheets and scored in the usual fashion for the four validity indicators and ten clinical scales, one through zero (or Hypochondriasis through Social Introversion). In addition, six experimental scales (Hathaway and Briggs, 1957), Ego Strength, Anxiety, Repression, Dominance, Dependency, and Social Status were scored and analyzed but were only reported in Appendix E. The five scales requiring a K correction were analyzed after the correction had been made.

Contemporary recognition of the fact that a test has many reliabilities and many validities is reflected in the writings of Loevinger (1957), Cronbach and Meehl (1955), and Meehl and Rosen (1955). Old-fashioned definitions are sufficient in the present context. Unless otherwise specified, the former means test-retest correlation and the latter means correlation with some criterion chosen to demonstrate that "a test measures what it is supposed to measure". A distinction between traits and constructs should be noted following Loevinger (1957),

> Traits exist in people; constructs (here usually about traits) exist in the minds and magazines of psychologists. .... Construct connotes construction and artifice;yet what is at issue is validity with respect to exactly what the psychologist does not construct: the validity of the test as a measure of traits which exist prior to and independently of the psychologist's act of measuring. (p. 642).

That traits will be considered as real is especially appropriate to the area of psychogenetics.

Table 6 gives the test-retest correlations for a sample of 55 ninth grade girls (Hathaway and Monachesi, 1953) and also of 100 normal adults for comparison (Hathaway and McKinley 1951).

Table 6

MMPI Test-Retest Correlations for Adults and Adolescents

Scale	L	F	K	1	2	3	4	5	6	7	8	9	0
Adults	46	75	76	81	66	72	80	91	56	90	86	76	93
Adolescents	48	51	66	59	51	52	46	-	50	48	60	55	-

The HSPQ is new to the literature of personality tests and requires more exposition than the MMPI. Cattell, Beloff, and Coan (1958) constructed this instrument by factor analysis especially for adolescents 12 through 17 years in the tradition of the Cattell laboratory (1946; 1950). It is an improvement of his Junior Personality Questionnaire (1953) and a downward extension of his more famous 16 PF for adults (1950). It is said to cover all the major dimensions involved in any comprehensive view of individual differences in personality (Cattell et al., 1958).

It consists of 280 forced choice items, all of which are scored, which form 14 independent, equal length, scales. Although printed in two forms of 140 items each, the authors

recommend the use of both[7] to obtain sufficient reliability. It is also suggested that raw scores rather than standard scores be used for research purposes and this suggestion was also followed. The scale designations and their titles are given in Table 7.

Test-retest correlations based on 112 children aged 13 through 15 tested two weeks apart with the full test are given in Table 8.

In the opinion of the constructors, validity for the 14 scales is satisfactorily established. The main technique used to demonstrate this is the computation of a multiple correlation from factor-item correlations. This gives a median r of 81. Although no correction for "Test-Taking Attitude" is used, there are equal numbers of "Yes" and "No" keyed answers on each scale.

It should be obvious that the reliabilities of the MMPI and the HSPQ are on much firmer ground than the validities. Unfortunately, the magnitude of the test-retest correlations has no direct bearing on the construct validity of a scale (Loevinger, 1957). An inherent difficulty in measuring personality traits is the observation that they change with the passage of time and intervention. After the data of the present study are analyzed, there should be more evidence for the validity, or lack thereof, of the various scales. At the

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[7] Personal communication, Dr. R.B. Cattell, Feb. 5, 1959.

Table 7

HSPQ Symbols and Titles[a] for Test Dimensions

Symbol	Low Score	High Score
A	Stiff, Aloof	Warm, Sociable
B	Mental Defect	General Intelligence
C	General Neuroticism	Ego Strength
D	Phlegmatic Temperament	Excitability
E	Submissiveness	Dominance
F	Sober, serious	Enthusiastic
G	Casual, undependable	Super Ego Strength
H	Shy, sensitive	Adventurous, thick-skinned
I	Tough, realistic	Esthetically sensitive
J	Liking group action	Fastidiously individualistic
O	Confident Adequacy	Guilt Proneness
Q2	Group Dependency	Self-Sufficiency
Q3	Uncontrolled, lax	Controlled, showing will power
Q4	Relaxed composure	Tense, excitable

[a] A mixture of technical and popular

least one might expect significant correlations between MZ twin siblings. Another expectation would be the absence of negative correlations between either class of twins unless there were some parsimonious explanation of a within pair interaction on a trait.

Table 8

Reliability of HSPQ Scales

Scale	A	B	C	D	E	F	G	H	I	J	O	Q2	Q3	Q4
Correlation	74	75	77	78	72	68	71	80	79	69	72	70	73	78

D. Intraclass Correlation Analysis of Personality Traits

Following the diagnosis of zygosity and the collection of the personality test data, each scale of the two tests and the IQ from the school records were analyzed by means of the intraclass correlation coefficient for the two classes of twins. The resulting 64 coefficients were obtained from 64 simple one-way analyses of variance using T scores for the MMPI, raw scores for the HSPQ, and Otis IQ's.

Haggard's (1958) book on the intraclass correlation gives a detailed exposition of the method used here. Although the intraclass correlation was formerly computed by calculating the interclass correlation after constructing a symetrical table with double entries for a pair of scores and then dividing by two, it now is recognized as a simple function of variances. Haggard (1958, p. 11) gives this formula for the computation:

$$R = \frac{BCMS - WMS}{BCMS + WMS} .$$

BCMS = between classes (twin pairs) mean square
WMS = within classes (twin pairs) mean square

This means that the unbiased estimate of R may be obtained in terms of the mean squares (i.e., variance estimates) of the analysis of variance table. This formula is thespecific one to use for pairs of scores. The relationship of F, the variance ratio, to R is given by

$$F = \frac{1 + R}{1-R} .$$

The level of statistical significance of R is identical with that of the corresponding F (i.e., BCMS / WMS). In other words the hypothesis that an observed R could have come from a population with a true correlation of zero can be tested by the F-ratio computed from the same mean squares, with the appropriate degrees of freedom, as were used to obtain R. In the present case the degrees of freedom are always 33 for BCMS and 34 for WMS. It should be noted that the F-table is appropriate only for the one tailed test required in the analysis of variance; that is, only for the probability values that BCMS > WMS, which is appropriate to the general hypothesis under test in this study.

In order to test the significance of the difference between two independently obtained R's, they were converted into Fisher's z, using a table (Fisher and Yates, 1953), which has an approximately normal distribution with variance

$$s^2 = \frac{k}{2(c-2)\ (k-1)}.$$

where k is the number of individuals within a class, i.e, 2, (MZ or DZ twins), and c is the number of classes,i.e., 34 (pairs).

The distribution of the difference between the corresponding z values is approximately normal with variance

$$s_d^2 = \frac{k_1}{2(c_1 - 2)\ (k_1 - 1)} + \frac{k_2}{2(c_2 - 2)\ (k_2 - 1)}.$$

Dividing the difference between z's by the square root of the above gives a normal deviate, the P-value of which is found in the usual manner. Again a one-tailed test of significance was appropriate and was used. In the present study the standard

error of the difference between any two z's is always .25.

Recapitulating, the objectives of this intraclass correlation analysis of traits are (a) to demonstrate that the traits are significantly and positively correlated in MZ twins and may or may not be that way in DZ twins and (b) to demonstrate that for any given genetically determined trait the correlation within MZ pairs will be significantly greater than that within DZ pairs.

Subsequent to this analysis, the nature-nurture ratios were computed as described in the section "The Twin Method in Genetic Research" using the independently obtained WMS or within variances. It should be noted that the two procedures, intraclass correlation analysis and computation of nature-nurture ratios, are almost independent. Criticisms of the latter do not apply to the former which sticks to the data language and traditional methods of statistical inference.

E. Configural and Holistic Analyses of Personality Similarity

Following a scale by scale analysis in an effort to establish greater similarity among MZ than among DZ pairs, one of the two personality tests was selected for holistic profile analyses. The MMPI was chosen both because the initial scale analyses showed it to be the more valid instrument and because MMPI results have been treated extensively in the literature. Recent emphasis on the study of profiles has resulted from the realization that interpretation of an individual's set of scores must frequently be based on the pattern of scores rather than examination of one scale at a time or the use of a linear sum of the scale deviations. General and specific methodological difficulties arise which weaken any confidence that may be attached to the quantification of profile similarity. Only a few of the difficulties noted by students of the problem (Cronbach & Gleser, 1953; Gilberstadt, 1952; Meehl, 1950; Mosel & Roberts, 1954; Osgood & Suci, 1952) will be discussed.

Similarity as a general quality of personality is nebulous but necessary for communication. Cronbach and Gleser (1953) say,

> ...similarity is not a general quality. It is possible to discuss similarity only with respect to specified dimensions (or complex characteristics). This means that the investigator who finds that people are similar in some set of scores cannot assume that they are similar in general. He could begin to discuss general similarity only if his original measurement covered all or a large proportion of the significant dimensions of personality. (p. 457).

Pragmatic (Jamesian) considerations dictate that a large proportion of the significant dimensions are tapped and that approximations are better than abstaining from research. Other general methodological difficulties involve the loss of information by reducing the relationship between two configurations to a single index; lack of comparability between indices of similarity; and, violations of assumptions about ratio scales, uncorrelated measures, and equal reliability among subtests.

There are two aspects of profiles which matching may involve: the shape or configuration of scores and the general elevation from the mean of the norm group. It is logical to distinguish between matching for absolute agreement, in which both shape and elevation are considered, and, relative agreement, in which only shape is considered. Three statistical and one clinical indices of similarity were computed for the two classes of twins. In addition, the profile of each twin was coded according to the methods of both Hathaway (1947) and Welsh (1948) to facilitate further clinical assessment by the reader. These are given in Appendices F and G.

1. Statistical Indices

Rank-difference correlation. This well known measure, Spearman's Rho, was the first index computed. It yielded a nonarbitrary number which reflected similarity of shape but disregarded elevation. One of its disadvantages was that an r of 1.00 did not necessarily indicate perfect similarity and another was that two pairs of profiles with the same coefficient need not be equally similar. Rho's were calculated from the

Welsh codes; ties were resolved by using the scales in numerical order.

D coefficient. Cronbach and Gleser (1953) devote considerable attention to this index which is designed to reflect both shape and elevation. The D coefficient is based on the geometric principle that in a space of N mutually orthogonal dimensions, the distance between two points is equal to the square root of the sum of the squared differences between the coordinates of the points on each dimension. Since profiles may be considered as points in N space, where N equals the number of scales (i.e., 10), the distance between them serves as a measure of similarity. Note that orthogonality does not obtain for the MMPI. The D coefficient results in an arbitrary number whose value depends on the number of scales.

Concordance of test verbal behavior (TT'). In the context of discovery it was decided to compute the absolute percentage of MMPI items answered in the same direction by a pair of twins, i.e., one twin's answer sheet was used to score the others.[8] Of course the MMPI was not designed to be used this way and in this instance serves primarily as an item pool. The percentage of agreement for the 566 items has been termed TT', to signify the comparison of one twin with his sibling. No provision was made for the few items which are repeated, but any question omitted by either twin was subtracted from 566 before the percentage was calculated.

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[8] Thanks are due Marianne Briggs for this arduous task.

2. Clinical Index

Visual judgment. The only quantifiable clinical index of similarity used was the accuracy of visual judgment in sorting the profiles into four categories: Very Similar, Similar, Dissimilar, and Very Dissimilar. By accuracy was meant the number of MZ pair profiles placed in the first two categories and the number of DZ in the last two. Three psychologists skilled in the use of the MMPI were the judges.[9] Instructions for the forced rectangular sort are given in Appendix H. Another indication of similarity was provided by comparison of the accuracy of visual judgment in the extreme categories with the overall accuracy.

Recapitulating, the objective of each of the above four procedures was to demonstrate a greater similarity of personality as measured by the MMPI for the MZ twins than for the DZ twins.

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[9] The author is grateful for the assistance of Drs. Jan Duker, Harold Gilberstadt, and Robert Wirt, who acted as judges.

Chapter IV

Results

The presentation of the findings are organized around the two personality tests used; first the factored test, HSPQ, with its fourteen scales, and then the empirically derived test, MMPI, with its ten clinical scales, are discussed. This is followed by the results of the configural and holistic MMPI profile analyses. Nature-nurture ratios are presented separately after their respective correlation analyses. In the present chapter, findings are not discussed from the standpoint of their possible interpretations or implications. Such discussion is deferred for the next chapter.

A. Cattell's Factored Test

The excellent matching of the two classes of twins and their representativeness of adolescents in general may be inferred from the mean scores on the 14 scales. Means and standard deviations for the MZ and DZ groups combined and by sex are presented in Appendix C along with the same data for Cattell's normative group (1958). Intraclass correlation coefficients for the MZ and DZ twins and their significance from zero are given in Table 9. The 28 analyses of variance from which they were derived are presented in tabular form in Appendix D. Six of the fourteen factors resulted in zero order correlation coefficients for the MZ twins. That the DZ should obtain significant correlations on four of these six was paradoxical.

Table 9

HSPQ Intraclass Correlations for MZ and DZ Twins and Their Significance from Zero

Factor	MZ R	P	DZ R	P
A	19		27	
B	60	***	61	***
C	28		38	*
D	21		47	**
E	16		41	**
F	47	**	12	
G	49	**	42	**
H	38	*	20	
I	55	***	47	**
J	26		-04	
O	45	**	38	*
Q2	60	***	15	*
Q3	30	*	12	
Q4	27		32	*

* Significant at .05 level
** Significant at .01 level
*** Significant at .001 level

The factor derivation of all the scales and their low intercorrelations permitted acceptance and interpretation of the remaining eight scales on their own merit. Factors B, F, G, H, I, O, Q2, and Q3 at this point in the analysis have the potential for showing a predominance of hereditary determinism.

In Table 10 are presented the results of testing whether or not the correlation between MZ pairs is significantly greater than that between DZ. All R's were first converted to Fisher's z's.

The MZ twins were significantly higher than the DZ on only three HSPQ factors, F, J. and Q2. Factor J, however, has been eliminated from further consideration by the preceding analysis. The results from both the correlation analyses then left only two factors, F, Sober, serious vs. Enthusiastic, Happy-go-lucky, and Q2, Group dependency vs. Self-sufficiency, which appeared to have significant genetic (i.e., gene determined) components.

The nature-nurture ratios for the HSPQ scales, computed only from the within pair variances, are presented in Table 11. Within the limits of the assumptions for this analysis, this attempt at quantification of the proportion of scale variance accounted for by heredity gives positive results for six of the fourteen factors. Factors E, Submissiveness vs. Dominance, H, Shy, sensitive vs. Adventurous, and J, Liking group action vs. Fastidiously individualistic, showed appreciable variance accounted for by heredity but with environment predominating. Factors F, Q2, and O, Confident adequacy vs. Guilt proneness,

Table 10

One-tailed Test of the Difference Between MZ and DZ HSPQ Scale Intraclass Correlations

Factor	MZ z	DZ z	Difference	Normal Deviate	P
A	.189	.275	-.086	-.344	
B	.701	.709	-.008	-.032	
C	.286	.401	-.115	-.460	
D	.213	.516	-.303	-1.212	
E	.159	.434	-.275	-1.100	
F	.508	.119	.389	1.556	.06
G	.535	.446	.090	.360	.36
H	.395	.200	.195	.780	.22
I	.617	.516	.101	.404	.34
J	.265	-.036	.301	1.204	.12
O	.486	.385	.101	.404	.34
Q2	.687	.166	.532	2.128	.02
Q3	.310	.126	.184	.736	.23
Q4	.272	.335	-.063	-.252	

Table 11

HSPQ Scale Nature-Nurture Ratios

Factor	V DZ	V MZ	Difference	H
A	7.2500	6.5147	.7353	.10
B	2.5441	2.4117	.1324	.05
C	4.8088	4.6470	.1618	.03
D	3.8382	6.2058	-2.3676	.00
E	5.9117	4.1029	1.8088	.31
F	8.9705	3.9117	5.0588	.56
G	3.3088	3.3970	-.0882	.00
H	7.2352	4.4705	2.7647	.38
I	5.6617	5.3088	.3529	.06
J	6.7205	4.7647	1.9558	.29
O	8.1617	4.4117	3.7500	.46
Q2	5.5441	2.4264	3.1177	.56
Q3	4.7205	4.1764	.5441	.12
Q4	3.3382	6.2794	-2.9412	.00

showed about equal contributions of heredity and environment (.56, .56, and .46).

Results of the Otis IQ analysis. The results of the school administered intelligence test are given at this point because Factor B of the HSPQ is a brief, twenty item, measure of intelligence. Intraclass correlations for the MZ and DZ twins were .83 and .59 respectively, both significant at the .001 level with the first significantly greater than the second at the .02 level. The nature-nurture ratio computed from the Otis within variances was .62. This means that 62 per cent of the intelligence variance measured by the Otis is accounted for by hereditary factors.

B. The Minnesota Multiphasic Personality Inventory

Once again the excellent matching of the two classes of twins and their representativeness of adolescents in general may be observed from the mean scores on the three validity scales and the ten clinical scales. Means and standard deviations for the MZ and DZ groups combined and by sex are presented in Appendix C along with the same data for the adolescents in the Hathaway and Monachesi study (1953). Intraclass correlation coefficients for the twins and their significance from zero are given in Table 12. The 20 analyses of variance from which they were derived are presented in tabular form in Appendix D. Results for the six experimental scales are given in Appendix E. Nine of the ten MMPI scales were significantly different from zero at the .01 (sic) level for the MZ twins and all ten were of a higher order than the

Table 12

MMPI Intraclass Correlations for MZ and DZ Twins and Their Significance from Zero

Scale	MZ R	P	DZ R	P	Reliability[a]
1 (Hs)	40	**	23		.59
2 (D)	45	**	08		.51
3 (Hy)	46	**	42	**	.52
4 (Pd)	56	***	23		.46
5 (Mf)	48	**	34	*	-
6 (Pa)	46	**	21		.50
7 (Pt)	54	***	24		.48
8 (Sc)	58	***	25		.60
9 (Ma)	22		-09		.55
0 (Si)	57	***	09		-

* Significant at the .05 level
** Significant at the .01 level
*** Significant at the .001 level

[a] Test-retest reliabilities for a sample of 55 public school adolescent girls with an interval of 9 months. (Hathaway and Monachesi, 1953)

corresponding correlation for DZ twins. It will be noted that for six of the eight MZ scale correlations for which reliability data were available, the order of magnitude is about the same, and for two of these scale, 4 and 7, the obtained R actually exceeded the correlation over time for the same person.

The results of testing whether or not the correlation between MZ pairs is significantly greater than that between DZ are presented in Table 13. All R's were first converted to Fisher's z's. The MZ twins appeared to be significantly higher than the DZ on seven of the ten MMPI scales (P less than or equal to about the 10 per cent level).[10] Scale 9, Hypomania, was eliminated from further consideration by the preceding analysis. The results from both the correlation analyses then left six scales, 2, Depression, 4, Psychopathic deviate, 6, Paranoia, 7, Psychasthenia, 8, Schizophrenia, and 0, Social Introversion, which appeared to have significant genetic (i.e., gene determined) components.

The nature-nurture ratios for the MMPI scales, which only utilize within pair variances, are presented in Table 14. Within the limits of the assumptions for this kind of analysis, this attempt at quantification of the proportion of scale variance accounted for by heredity gave positive results for six of the ten scales. Scales 7, 8, and 9 showed appreciable variance accounted for by heredity but with environment predominating. Scales 2 and 4 showed about equal contributions of heredity and environment. Scale 0, Social introversion, showed a predominance of variance (.69) accounted for by heredity. The value of H for the Si Scale is of the same magnitude as that found in this study and others for intelligence as measured by standard IQ tests.

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[10] A Type II error was considered to be more serious at this stage of psychogenetic research.

Table 13

One-tailed Test of the Difference Between MZ and DZ MMPI Scale Intraclass Correlations

Scale	MZ z	DZ z	Difference	Normal Deviate	P
1 (Hs)	.424	.230	.194	.776	.22
2 (D)	.479	.075	.404	1.616	.05
3 (Hy)	.503	.443	.060	.240	.40
4 (Pd)	.636	.229	.407	1.628	.05
5 (Mf)	.522	.359	.163	.652	.26
6 (Pa)	.503	.208	.295	1.180	.12
7 (Pt)	.601	.243	.358	1.432	.08
8 (Sc)	.656	.254	.402	1.608	.05
9 (Ma)	.228	-.095	.323	1.292	.10
0 (Si)	.643	.091	.552	2.208	.01

Table 14

MMPI Scale Nature-Nurture Ratios

Scale	V DZ	V MZ	Difference	H
1	48.9411	41.8529	7.0882	.15
2	90.6323	50.6911	39.9412	.44
3	31.0147	38.0735	-7.0588	.00
4	110.6911	59.3235	51.3676	.46
5	61.7941	53.8529	7.9412	.13
6	76.4117	71.8970	4.5147	.06
7	64.2941	42.8676	21.4265	.33
8	93.8970	66.3088	27.5882	.29
9	150.9558	113.0588	37.8970	.25
0	90.9558	27.9705	62.9853	.69

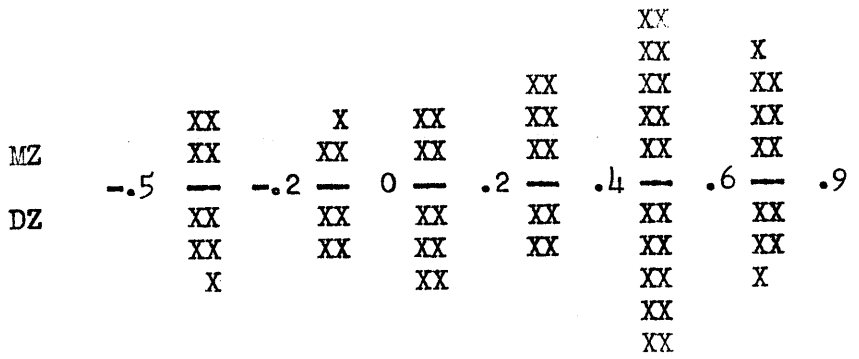
C. The Configural and Holistic Analyses

Rank-difference Correlations for the Coded MMPI Profiles.

Figure 1 shows the distribution of the Spearman Rho's for the 68 pairs of profiles by twin type. There was a tendency for the MZ pairs to have more highly correlated profiles; seven vs. fifteen correlations higher than .4. It is obvious from the distribution that no cutting score can be established which could validly discriminate between the two kinds of twins on the basis of their rank-difference correlations.

Figure 1

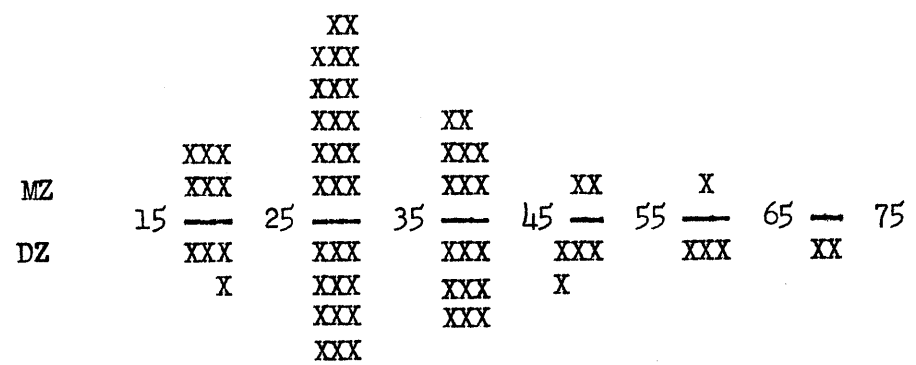
Distribution of MZ and DZ MMPI Profile Code Rho's



D Coefficient. Figure 2 shows the distribution of D coefficients for the 68 pairs of profiles by twin type. This index, it will be recalled, results in an arbitrary number with the characteristics of an ordinal scale. There was a strong tendency for the MZ pairs to have a lower D (i.e., be less dissimilar); 23 vs. 16 less than 35 and 3 vs. 9 greater than 45. It is obvious from this distribution also that a cutting score cannot discriminate between the two kinds of twins without too many errors.

Figure 2

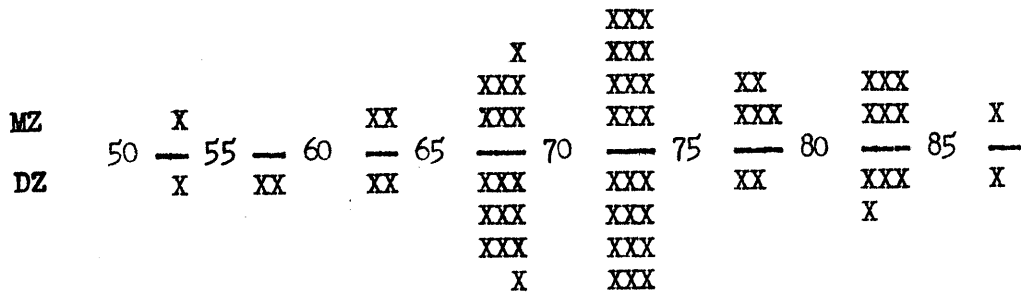
Distribution of MZ and DZ MMPI Profile D Coefficients



Concordance of Test Verbal Behavior (TT'). The percentage of MMPI test items answered in the same direction for a pair of twins is plotted in Figure 3. The distribution of TT' for the MZ and DZ pairs showed a pronounced tendency for the MZ's to have a higher concordance of same responses to the items; 12 vs. 7 pairs greater than 75% and 10 vs. 15 DZ pairs less than 70%. This attempt to demonstrate holistic similarity of personality does not appear to be any more successful than the two previous techniques.

Figure 3

Distribution of MZ and DZ MMPI Item Agreement Percentages (TT')



Visual Judgment of Profile Similarity. The extent to which the judges' clinical assessment of personality similarity agreed with the known zygosity of the twin pairs is revealed in Table 15. A pooled rating for each pair (2 of 3, or 3 of 3 votes) led to an improvement over even the best judge. When only the agreement with zygosity of the 34 profile pairs which were sorted the extreme piles of Very similar and Very Dissimilar, was computed for each judge, the improvement was noteworthy. Meehl (1959) anticipated the superiority of the clinician for this kind of task. These results were very supportive of the general

hypothesis that the greater the gene similarity, the greater the personality similarity. The large amount of variability available to the same genotypes, however, is shown by the fact that the judges' pooled ratings classified ten of the thirty-four pairs of MZ twin profiles as dissimilar. Conversely, the lack of variability available to genotypes with approximately only half of their genes in common is shown by the fact that twelve of the thirty-four DZ pairs were classified as similar.

Table 15

Agreement of Visual Judgments of MMPI Personality Similarity with Twin Zygosity

Judge	Total Sort	Extreme Pile Sort
A	64.7 %	67.6 %
B	61.8 %	73.5 %
C	58.8 %	58.8 %
Pooled	67.6 %	-

Chapter V

Discussion

In the introductory chapter the purpose of the present research was said to be to answer the question of whether there is any measurable influence of hereditary factors upon the aspects of human personality tapped by the selected objective personality tests. Furthermore, it was proposed, in logical extension of this purpose, to attempt a quantitative approximation of the hereditary influence relative to the influence of environmental factors for the aspects of personality found to be so influenced. Since evidence for the quantification derived from the traditional comparison of identical with fraternal twins by means of the non-rigorous method of nature-nurture ratios, the approximations are recognized as suggestions for further research (Cattell, 1953). While it was noted that the scales of personality tests are constructs, the discussion which follows is in terms of the underlying biophysical traits which the constructs hopefully reflect.

The results have been presented — the answer to the initial question is "Yes". In the pages which follow, the discussion of the findings is organized into three major sections. The first treats with the specific traits demonstrated to have been influenced by hereditary factors together with some of the implications of these data for personality theory and for the practice of clinical psychology. The second involves the apparent failure of the holistic analyses of personality to

support strongly the findings of the trait analyses and the implication for theories about the structure of personality. Lastly, some suggestions for further research in psychogenetics are made. To what extent can the results of the present study be applied to human behavior in general? The representativeness of the twin sample of adolescents in general suggests that this kind of extrapolation is fairly safe. Whether the further extrapolation to adults in general can safely be made is left to the reader. Another important question is the extent to which these data from normal, non-hospitalized individuals can be applied to identifiable, psychiatrically ill individuals. The heuristic value of an affirmative answer to this latter question is too great to be passed by. A possibility that the extremes of distributions for some psychological characteristics constitute discrete series is also apropos (Pearson and Kley, 1957).

A. The Personality Traits with Genetic Components

A total of eight measured traits out of a possible twenty-four in the two tests met the criterion classifying them as significantly influenced by hereditary factors, i.e., correlations between MZ twins were significantly higher than those between DZ twins. Traits F and Q2 were the only survivors of the fourteen HSPQ measures. A better idea of what they measure can be obtained from the list of adjectives given in the manual (Cattell et al., 1958).

F:	Glum, Sober, Serious	versus	Enthusiastic, Happy-go-lucky
	Silent, Introspective	vs.	Talkative
	Depressed	vs.	Cheerful

Concerned, Brooding	vs.	Serene
Incommunicative, Sticks to inner values	vs.	Frank, Expressive, Mercurial
Languid, Slow	vs.	Quick, Alert

Factor Q2 is not thought to be clearly established; the low end is called Group Dependency and the high end, Self-Sufficiency. The item content suggests a person who is resolute and accustomed to making his own decisions, alone, while the low end describes a person who would tend to go with the group, value social approval, and be conventional and fashionable. A synthesis of these two traits is provided by Cattell's large second-order factor, Extraversion vs. Introversion, which is composed of four factors. Two of the four are F and Q2. Tying in neatly with the MMPI findings which are discussed next is a study on the construct validity of the 16 PF (Karson and Pool, 1957). It will be recalled that the latter Cattell test is considered to be the adult form of the HSPQ. Karson and Pool (1957) found the highest MMPI scale correlate of F to be Scale 0 (Social introversion) and the highest MMPI scale correlate of Q2 to be Scale 0 also with correlations of -.48 and .32 respectively.

Positive findings for six of the ten MMPI clinical scales: 2 (Depression), 4 (Psychopathic deviate), 6 (Paranoia), 7 (Psychasthenia), 8 (Schizophrenia), and 0 (Social-introversion), suggest a number of exciting possible implications.

Jung (1933) posited introversion as one of the two major "attitudes" present in all personality. The type and the stereotype have since become a part of everyday language. Eysenck

(1947, 1956) isolated introversion-extraversion as one of the two (now three) dimensions of personality by a factor analysis of ratings and personal data on 700 neurotic soldiers. He considers his findings to represent a confirmation of the theoretical ideas of Jung. Genetic factors are given a prominent place in Eysenck's typology; his twin study (1956) using statistics similar to those in the present study, found a tentative value for H on a factored measure of introversion-extraversion of .62.

The trait of introversion as measured by the MMPI may have implications for a genetic theory of schizophrenia. This hypothesis derives from the fact that patients with very high scores on Scale 0 are clinically described as "schizoid" plus the suggestion of Kallmann (1953) and others that the schizoid individual may represent the genetic "carrier state" of the recessive schizophrenic gene. In other words, the schizoid individual may represent the heterozygote and the schizophrenic may represent the homozygote. If the schizoid carrier can be identified, Kallmann's hypothesis about recessivity is no longer tenable. The mode of inheritance must then be that of incomplete dominance.[11] The latter could then explain the familial occurence of schizophrenia. The magnitude of the nature-nurture ratio for Scale 0 was the largest found in the present study. Its value suggests that the contribution of heredity is more than twice as great as that of environment to the trait of

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[11] Dr. S.C. Reed pointed this out to the author.

introversion and puts it into the class with intelligence as attributes with demonstrably heavy genetic determination. The belief in the genetic contribution to intelligence has come to have a fairly secure status in contemporary psychology; the results of this investigation indicate that a similar status is appropriate for the more purely personality trait of introversion.

The results concerning the five remaining MMPI scales, 2, 4, 6, 7, and 8, lend support to the general idea that psychopathology in human beings has a substantial genetic component, especially the psychoses. While the following arguments lack sufficient rigor to prove such an hypothesis, they are none the less supportive. In Multiphasic parlance, 6, 7, and 8 are known as the psychotic triad because of their frequent elevation in patients so diagnosed. Although the MMPI scales were derived in part from the descriptive background of Kraepelinian terminology as modified in clinical practice, they were not expected to measure pure traits or to represent discrete entities (Hathaway and Meehl, 1956). It was observed that by starting with the test and then examining "test-similar" patients (e.g., those with the same two scales highest), a fruitful kind of "typology" resulted. Hathaway and Meehl (1951; 1956) presented the MMPI results of almost two thousand psychiatric inpatients. The various two point codes which can be formed from the above five scales appear to account for a substantial proportion of these patients' code types. These authors described the characteristics of nine of the possible twenty-eight two point code types (i.e.,

combining 24 and 42, omitting Scales 5 and 0, and excluding noncoded and single-digit cases). Five of these nine important types are combinations of the five scales found in this present study to have a measurable genetic component.

The characteristics of these five code types are in line with the genetic hypothesis. For the 27's psychosis had a slight edge over psychoneurosis with the commonest diagnosis being psychotic depression. For the 28's a majority of diagnoses were psychotic, either depression or schizophrenia. "Heredity, defined here rather crudely simply as psychosis in siblings or parents, tended to be unfavorable in these individuals (Hathaway and Meehl, 1956, p. 143)". The 46's were half conduct disorders and one-third psychotics, chiefly schizophrenia. Of the 68's, the majority (three-fifths) were psychotic, chiefly schizophrenic. Among the 78's the diagnoses were split evenly between psychosis and neurosis. The last pattern did not occur even once in their control group of normals. Two scales were found to occur predominantly among normals, 3 and 9, neither of which in the present study showed genetic influences.

Recent research on the 27 type (Gilberstadt and Duker, 1960) showed that it could be analyzed into three sub types: "pure" 27's, 274's, and 278's for a population of psychiatric inpatient veterans. Everyone of the 274's was a chronic alcoholic. This type of alcoholic may have a constitutional basis. The 278's were characterized by the diagnosis of chronic undifferentiated schizophrenia and had much in common with descriptions in the literature of pseudoneurotic schizophrenia.

The latter finding is supported by Peterson's (1954) isolation of a group initially diagnosed as neurotic but subsequently manifesting schizophrenia. The mean profile of Peterson's 33 false negatives began with 872. Another idea which may derive some support from the data of the present study is that of the "constitutional psychopath". Scale 4 alone elevated or in combination with 6 and/or 8 accounted for a substantial proportion of patients diagnosed as psychopathic deviates in the Atlas for the Clinical Use of the MMPI (Hathaway and Meehl, 1951).

A discussion of the results of the attempted quantification of hereditary influences adds some new information but it is not on the same firm footing as the correlational results. Twelve of the twenty-four traits measured by the two tests showed at least an appreciable genetic component. By appreciable is meant one-third or more of the trait variance accounted for relative to the contribution of environmental factors (this required an H of .25 or more so that H divided by one minus H equalled one-third). HSPQ traits F, Q2, and O showed about equal roles for heredity and environment. The evidence for F and Q2 gains some added stability by the replication of the findings in this part of the analysis. Trait O in the 16 PF (Karson and Pool, 1957) correlated most highly, .77, with MMPI Scale 7 (Psychasthenia) and .54 with Scale 0 (Social-introversion). Scale 7 was also found to have an appreciable genetic component in the present study. Three more HSPQ traits survived the criterion, E, H, and J. H along with F and Q2 formed three of the four factors in Cattell's second-order factor Extraversion vs. Introversion. In

the study using the JPQ (Cattell et al., 1955) both E and J were found to have appreciable genetic components. Five of the six MMPI scales surviving the correlation criterion also appeared in the nature-nurture analysis as having at least an appreciable genetic component. Scale 6 did not meet the criterion and Scale 9 was added. Only Scale 0 (Social-introversion), as noted above, was predominantly genetically determined. Scales 2 and 4 showed about equal contributions of heredity and environment.

One of the practical applications of these kinds of data in the fields of mental hygiene, clinical psychology, and psychiatry is the rank ordering of traits and types from most to least susceptible to therapeutic intervention. Perhaps an analogy from medicine will illustrate the idea. A patient suffering from both an infectious disease and some congenital defect would first of all be treated for the former. Only after that had been attended to would therapeutic efforts be directed toward the relatively less treatable defect. In the present context, for example, a schizoid individual would be considered a poorer therapeutic bet than a hysteric or a hypochondriac. An individual presenting a multitude of any of the traits discussed above would have his therapist draw up a "battle plan" making use of the rank ordered traits. The poor prognosis of the psychoses associated with high scores on the genetically influenced MMPI scales is well documented by Wirt and Simon (1959).

Genetic Component of Intelligence. Results of the analysis of HSPQ factor B (General Intelligence) did not confirm the large

genetic component usually ascribed to it. The use of the school administered Otis Test, however, did replicate the findings of Newman et al., (1937) which gave hereditary factors approximately twice as much weight as environmental ones. One of the reasons the HSPQ scale did not lead to positive results is its restriction in range for a sample of older, brighter than average adolescents. The restriction in range probably reduced the magnitude of the correlation coefficients from which the analysis proceeds. It is apparently too much to expect of a twenty item intelligence test for it to meet the standards of the Otis or Binet tests. The fact that Cattell et al. (1955) were able to replicate the usual results with a twelve item Factor B on the JPQ is partly due to the lower age range of the sample, 11 - 15, and largely due to his correcting all data for the attenuation of unreliability. With the fairly low reliabilities obtaining in personality tests, such procedures can very easily lead to deceptive inflation of the results so corrected. As an illustration the correlation between MZ twins on Scale 6 (Paranoia) was corrected; the value of .46 was inflated to .83 thereby making it higher than all the other scales so corrected.

Factorially Derived Scales vs. Empirically Derived Scales. The positive correlational results for two of the fourteen HSPQ factors could almost have been attributed to chance. In comparison with the positive results for six of the ten MMPI scales, the harvest from the factorially derived personality test looks poor. The validity of at leagt six of the fourteen HSPQ scales

was cast into doubt by the finding that there was a zero order correlation between identical twins on them. Many psychologists (e.g., Hall and Lindzey, 1957) have noted that factors derived by factor analysis are often not psychologically meaningful and do not agree with reality. The entire enterprise of factor analysis has been taken to task for failing to be truly contributory to either theory or applied problems (Jenkins and Lykken, 1957). Allport's (1937) pre-World-War II views are still apropos:

> The factors thus obtained represent only average tendencies. Whether a factor is really an organic disposition in any one individual life is not demonstrated. All one can say for certain is that a factor is an empirically derived component of the average personality, and that the average personality is a complete abstraction. This objection gains point when one reflects that seldom do the factors derived in this way resemble the dispositions and traits identified by clinical methods when the individual is studied intensively . . . . . In brief, ... (factors) risk the accusation that they are primarily mathematical artifacts (pp. 244-245).

Allport objected to the factorial conception of the single personality as a system of independent elements, the elements being the same in different personalities, but varying in prominence. At the same time he espoused a trait-conception of a single personality as a system of focal but interdependent substructures, the units being essentially different in every personality. The fact that the scales of the MMPI do correlate with one another to greater or lesser degrees may thus be contributory to their valid measurement of "focal but interdependent sub-structures". The empirical derivation of the MMPI scales was such as to allow Nature to be carved at the joints.

Physical vs. Psychological Traits. Any research dependent upon correlation coefficients in making its points is subject to the criticism that statistical significance rather than worldly significance has been demonstrated. Some twin research has been done with physiological variables thus permitting an evaluation of the general order of magnitude of the correlations found between MZ twins on the personality scales. For 15 of the 24 MZ correlations the magnitude was greater than .40; 7 of the 15 were greater than .50. Newman et al. (1937) found the following correlations between MZ twins (age partialed out) on some physical traits: standing height, .93, weight, .82, "speed of decision", .45, and finger tapping speed, .66. Jost and Sontag (1944) in their search for genetic factors in the functioning of the autonomic nervous system, found a correlation of .49 between MZ twins (only 6 pairs) compared to one of .29 for ordinary siblings on a measure called "autonomic balance". The latter was a composite score of seven measures including such things as skin resistance, pulse pressure, salivation, and heart period. The findings of correlations above .40 in personality research is itself a noteworthy accomplishment (Loevinger, 1955). Even in comparison with the sizes of correlations reported for physical, hence more obvious, traits, there is the suggestion that the results of the present study may have more than just statistical significance.

B. The Fate of Attempts at a Holistic View of Personality

Although all three statistical measures of MMPI profile similarity, Rho, D, and TT', tended to support the hypothesis of greater personality similarity between isogenic individuals,

only the clinical judgments of similarity gave substantial support. Inasmuch as the statistical method usually surpasses the clinical in psychology (Meehl, 1954), these findings need further explanation. The fact that none of the holistic attempts supported the hypothesis as well as the trait by trait approach was also contrary to the expectation that the whole of personality was greater (i.e., more meaningful) than the sum of its parts. Factors favoring successful clinical prediction have been suggested by Meehl (1959). One factor proposed was the clinician's use of unanalyzed stimulus-equivalences which did not proceed by explicit rules because the rules were laws of mental life not yet known. Another was the clinician's ability to proceed from a known fact to a construct with numerous dynamic implications and thence to a valid deduced fact, i.e., the clinician as a theory-mediator and as a hypothesis-builder. Perhaps the most directly relevant factor he mentioned was the clinician's ability to analyze a configural relationship existing between predictor variables and a criterion, when the function is not derivable on rational grounds.

> Typically the clinician reports that his inferences from the profile are based partly upon discriminations he has learned to make among various 'patterns' which arise in an extended clinical experience. Usually these patterns are grouped into categories or types . . . . What seems to be happening is that an unknown configurated mathematical function is being approximately expressed via the graphical mode, utilizing the fact that differences and similarities of visual gestalten can be perceived without the percipient's knowing the underlying formula (p. 103).

By "configurated" Meehl meant a specific kind of non-linearity produced by significant interaction effects among pairs or triads of the predictor variables. "Most simply put, . . . the influence of one predictor is not invariant with respect to values of the others" (p. 103).

The generally disappointing results for the holistic analyses has implications for the structure of personality. Hall and Lindzey (1957) in their discussion of organismic theory noted that ever since Descartes split the individual into the separate but interacting body and mind, psychologists have attempted to put them together again and to treat man as a unified whole. The idea has been almost universally accepted. Difficulties arise for a theory of personality espousing the holistic view because of the paucity of testable hypotheses generated. "If totality is not articulated, it is likely to be an incomprehensive blur; it can then be extolled, but not understood" (Allport, 1937, p. 343). It would seem that the holistic analyses attempted in the present study, with the possible exception of the clinical judgments, gave equal importance to each of the variables in the personality profile and thus made a "blur". The power of just a two-point Hathaway code (Hathaway and Monachesi, 1953; Meehl, 1959; Wirt and Briggs, 1959) as a predictor supports this possibility. That useful personality description proceeds from what is unique about the individual is a principle taught by both Allport and Hathaway. If taxonomy in psychology is valued, the isolation of what Allport called central traits - and Cattell, source traits - would appear to

be conducive to the taxonomic enterprise. Within the limits of the present research it is necessary to agree with Allport (1937), without, however, subscribing to his entire theoretical position - -

> Traits, attitudes, habits, and sentiments are the guarantors of stability. They are class concepts, and it is impossible to write an adequate psychology of personality without their aid. . . . . The truth of the matter is that the total organization of personality is still a new and poorly formulated problem in psychology. It is a many-sided issue whose solution yet lies in the future. (p. 365).

C. Some Suggestions for Further Research

The general design of the present study was very satisfactory and could easily be replicated. Use of the twin method in psychogenetic research has not even begun to be fully exploited. Now that the determination of zygosity is on a firm footing, truly isogenic individuals can be utilized in research. School age twins are not as difficult to locate as formerly believed. Their cooperation in scientific endeavors is substantial enough to warrant the expenditures of time and money in finding and blood typing them. This cooperation may have been the result of the publicity given to mental health or to the general emphasis and value placed on scientific research in the post-sputnik era. The present research has generated a number of both small-scale and large-scale research ideas in the area of psychogenetics. The former involve replications of the present study with a number of improvements, the latter, mass testing programs.

The methodology of profile similarity could have been improved somewhat. The measure D could have been amended to allow for differential weighting of the components as discussed by

Cronbach and Gleser (1953). TT' used all the items in the MMPI; future use of this index should only use the items on the ten clinical scales, a considerably fewer number than 550. A suggestion for adding to the techniques of construct validation is suggested by the finding that some personality scales had zero order correlations between MZ twins. It seems reasonable to include such findings as weakening or, when not zero, strengthening specifications in the nomological network of the construct along with such usual data as the mean scores of groups with specific characteristics (e.g., Wirt, 1955; Gottesman, 1959). Correlations between MZ twins in the present study on the hundreds of scales derived from the MMPI will be published at some future time after the data have been put onto IBM cards.

If other studies were to be set up along the lines of the present one, one of the desirable additions would be the measurement of more traits. Preferably the scales measuring the traits would be empirically derived as were the MMPI scales and further, they would not necessarily be associated with psychopathology. The additional traits would be those useful for description and prediction in such settings as school and colleges, the armed forces, industry, and adoption agencies. Gough's (1957) California Personality Inventory would be selected as meeting many of these requirements.

Another desirable change which would shed light on the psychogenetics of psychopathology would be the use of adult psychiatrically ill twin index cases and their siblings. The

validity of the generalizations made in the discussion chapter about psychopathology based on the data from normal adolescents could then be tested.

Kallmann's (1953) large scale studies in psychiatric genetics could be more accurately done by combining the methods of the present study and his techniques of the contingency method or the twin-family method. In addition to the error of zygosity determination, Kallmann depends upon the accuracy of clinical diagnoses. The clinical diagnosis would be replaced by the "psychometric diagnosis" embodied in a two or three point MMPI code. This would elevate the code to the level of a hypothetical construct where it rightly belongs. The contingency method compares the base rates (i.e., incidence of diagnosis "X") for representative samples of consanguineous and nonconsanguineous groups. The results of such a procedure then indicate whether or not "X" occurs more frequently in blood relatives of unselected index cases than is to be expected from the base rate in the general population. This would mean, for example, taking all psychiatrically hospitalized patients, preferably but not necessarily twins, with a psychometric diagnosis of e.g., 278. Most probably these patients would carry a clinical diagnosis of schizophrenia of some type. All of their available close relatives would then be tested - - nephews and nieces, first cousins, grandchildren, half siblings, parents, full siblings and children. It would then have to be verified that the chance of "being a 278" in comparable environments increases in direct

proportion to the degree of blood relationship to a 278 index case. If such evidence were to be found, supporters of purely environmental causation would be forced to demonstrate that a consistent increase in morbidity is found associated with particular environmental circumstances in the absence of blood relationships.

> In order to establish the hereditary nature of a psychosis beyond the possibility of random contingency and in relation to the interaction of predispositional genetic elements and various precipitating or perpetuating influences acting from without, the best available procedure is the twin-study method in conjunction with an ordinary sibling study. . . . . This approach (the twin-family method) provides six distinct categories of sibship groups reared under comparable environmental conditions; . . . . (Kallmann, 1946, p. 311).

Use of the twin-family method combined with the suggestions from the present research would necessitate the location of DZ and MZ twin index cases with a 278 diagnosis (other combinations of genetically influenced traits would work as well, e.g., 68's, 80's, etc.). Their siblings, co-twins, half-siblings, and step-siblings would then be tested. If the assumed genetic factor is negligible, the statistical expectation would be that the base rates of the code types for full siblings and DZ twin partners should be about the same. MZ twins would be expected to show the highest concordance followed by DZ twins and full siblings. Half-siblings with only one parent in common should be between the ordinary siblings and the unrelated step-siblings if the construct depends on the degree of relationship instead of the environmental similarities. The number of index cases needed in order to obtain a significant number of pure code types would be enormous and would require the

cooperation of the state hospitals of both New York and California, for example.

There are a number of interesting questions raised by the results and their interpretation in this present study. Some of them may be worth answering by research. Do the apparently healthy parents of psychiatrically ill individuals carry the recessive or incompletely penetrant genes responsible for the illness? Could the hypothetical carrier be demonstrated by personality testing? What are the psychometric personality characteristics of the offspring of two parents with known code types, i.e., when a male with Scales 4 and 8 elevated mates with a female of the same type, how many, if any, of their children would be of that type? Would such kinds of data support the findings of the present study in regard to which traits or trait combinations had genetic components? By the method of co-twin control (Gesell and Thompson, 1941), could the susceptibility to change of such a genetically dominated trait as introversion be tested? Inasmuch as the Scales 1 (Hypochondriasis) and 3 (Hysteria) were conspicuously free from genetic influences, and since they are most frequently found elevated in the psychoneuroses, does this mean that this kind of affliction is due solely to learning? And finally, would society ever accept eugenic suggestions based on some future state of excellence of knowledge about the human psyche?

Chapter VI

Summary

The present study was carried out in the context of psychogenetics, the interdisciplinary science combining the knowledge and procedures of modern genetics with those of psychology. The first objective of psychogenetics is to ascertain whether heredity plays a part in the determination of a psychological characteristic. By means of twins and objective personality tests, the purpose of the present research was to answer the question, "Are there any measurable genetic influences upon the aspects of human personality tapped by the selected tests?". The data showed that the answer was yes. It then became possible to seek an answer to the further questions, "For which traits?", and "How much is the contribution of heredity relative to that of environment?". A partial answer to the former was obtained and an approximation to the answer of the latter question was attempted.

After introducing some general principles of modern genetics, the twin method itself was described. When both monozygotic (MZ) and dizygotic (DZ) twins are studied, a method of evaluating either the effect of different environments on the same genotype or the expression of different genotypes under the same environment is provided. This means that with respect to any given genetically determined trait, there should be found a greater similarity between MZ than between DZ twins. Some limitations and criticisms of the twin method were discussed. Representative twin studies relevant to the demonstration of genetic influences on intelligence,

psychopathological conditions, and normal personality traits were reviewed. Kallmann's (1946) twin studies on schizophrenia were critically evaluated.

Thirty-four pairs of MZ and thirty-four pairs of DZ, same-sexed adolescent twins from the public high schools of Minneapolis, Saint Paul, and Robbinsdale, Minnesota served as the sample. The entire population of same-sexed twins among the over thirty-one thousand children in the above schools was enumerated. The study sample of 23 pairs of boys and 45 pairs of girls represented 43% and 75%, respectively, of the total possible pairs available in the schools sampled. Disregarding sex, the sample represented 60% of the total possible 113 pairs in the schools used.

At the time of testing, the children filled out a personal history data sheet, the Minnesota Multiphasic Personality Inventory (MMPI), and Cattell's High School Personality Questionnaire, (HSPQ); they were weighed, measured for height, fingerprinted, and photographed. The diagnosis of zygosity was made on the basis of serology. Nine independent blood group systems were used. This resulted in 100% accuracy in the diagnosis of DZ twins and at least 95% accuracy in the diagnosis of MZ twins. A contribution to methodology in twin diagnosis was made by the comparison of the accuracies of various methods and their combination. The latter methods used height, fingerprint ridge count, clinical judgments of fingerprint patterns, and judgments of photographs by geneticists, psychologists, and artists. It was concluded that blood typing alone is sufficient for the accuracy needed in psychogenetic research, and none of the twin

studies reported in the psychological literature thus far have utilized a procedure equivalent to the accuracy described here.

Each scale of the two personality tests and the school recorded Otis IQ were first analyzed by means of the intra-class correlation coefficient for the two classes of twins. The resulting 64 coefficients were obtained from simple one-way analyses of variance. Subsequent to this analysis, the nature-nurture ratios were computed; H (heritability) is defined as the proportion of personality scale variance attributable to heredity. The correlation analysis of the 14 HSPQ scales resulted in two factors, F, Sober, serious vs. Enthusiastic, Happy-go-lucky, and Q2, Group dependency vs. Self-sufficiency, which appeared to have significant genetic (i.e., gene determined) components. The correlation analysis of the 10 MMPI scales resulted in six, Scale 2, (Depression), Scale 4 (Psychopathic deviate), Scale 6(Paranoia), Scale 7 (Psychasthenia), Scale 8(Schizophrenia), and Scale 0 (Social introversion), which appeared to have significant genetic components.

Within the limits of the assumptions, the attempt at quantification of the proportion of scale variance accounted for by heredity gave positive results for 6 of the HSPQ factors. Factors E, Submissiveness vs. Dominance; H, Shy, sensitive vs. Adventurous; and J, Liking group action vs. Fastidiously individualistic, showed appreciable variance accounted for by heredity but with environment predominating. Factors F, Q2, and O, Confident adequacy vs. Guilt proneness, showed about equal contributions of heredity and

environment. The same kind of analysis of the MMPI gave positive results for 6 of the 10 scales. Scales 7 (Psychasthenia), 8 (Schizophrenia), and 9 (Hypomania) showed appreciable variance accounted for by heredity but with environment predominating. Scales 2 (Depression) and 4 (Psychopathic deviate) showed about equal contributions of heredity and environment. Scale 0 (social introversion) showed a predominance of variance (H = .69) accounted for by heredity. The value of H for the Otis IQ in this study was .62.

Following the scale by scale analysis, three holistic statistical analyses and one clinical holistic analysis of the MMPI profiles were done. The rank-difference correlations (rho) for the coded MMPI profiles, the generalized distance function (D), and a measure of test item verbal behavior concordance (TT^1) all showed a tendency for the MZ profile pairs to be more similar. The tendency was not strong enough to discriminate between the two classes of twins on the basis of any of the three measures. Visual judgments of profile similarity by three experts were very supportive of the general hypothesis that the greater the gene similarity, the greater the personality similarity. The pooled accuracy of the agreement of visual judgments of MMPI profile similarity with twin zygosity was 68%.

The implications of the data for personality theory and the practice of clinical psychology were discussed along with possible reasons for the apparent failure of the holistic analyses of personality strongly to support the findings of the

trait analyses. Within the context of polygenic inheritance (i.e., continuous distributions) of personality traits, the data were interpreted as supporting theories about a genetic etiology for some kinds of psychoses. Notions about "constitutional psychopaths" and "constitutional alcoholics" received some support from the interpretation of the data. One of the suggested practical applications of these kinds of data in the mental health field was the rank ordering of traits and personality types from most to least susceptible to therapeutic intervention.

Some suggestions for further research were made. It was noted that the use of the twin method in psychogenetic research has not even begun to be fully exploited. A replication of the Kallmann (1953) twin studies on psychopathology was proposed which would substitute a psychometric MMPI diagnosis for the psychiatric one. Some questions were raised in a heuristically provocative manner in the hope that behavioral scientists would be challenged by and tempted into the vast and relatively unexplored area of human psychogenetics.

Appendix A

Letter to Parents and Forms

UNIVERSITY OF MINNESOTA
COLLEGE OF SCIENCE, LITERATURE, AND THE ARTS
MINNEAPOLIS 14

ENT OF PSYCHOLOGY

The University of Minnesota Department of Psychology with the cooperation of the Minneapolis, St. Paul, and Robbinsdale public schools is conducting a scientific study of the attitudes and interests of all the like twins in grades 9 through 12. There are only two pairs of brother-brother and two pairs of sister-sister twins in each one thousand school children, so you can see that your twins are not common and therefore important to the study.

We are writing to ask you to allow your children to voluntarily participate. This would mean that at a time convenient to them, either after school or on Saturdays, they would be answering a series of interesting and enjoyable true-false questions. It is essential to the success of this study to identify each pair of twins in regard to whether they are identical or fraternal, sometimes called one-egg and two-egg twins. This cannot be done accurately by looking at them; in fact, mistakes are made even when they look very much alike. Only the analysis of fingerprints and the routine typing of a small sample of blood can tell for certain whether twins are identical. We, therefore, request your permission for us to have this done. The Minneapolis War Memorial Blood Bank has generously made their facilities and experienced staff available to us. With your consent an appointment will be made and transportation to and from the bank furnished.

All information gathered in the study is treated as confidential. You will receive a card with the results of the blood typing which could be very useful in some future emergency. Your cooperation in this worthwhile study will contribute greatly to helping science understand people better. Please complete the enclosed postcard and return it to us. If you have any questions, feel free to contact us any evening after six at PA 1-5195.

Sincerely yours,

Irving I. Gottesman

Dr. Robert D. Wirt
Associate Professor

Medical Release Form
(Printed on a Return Postcard)

STAND-JOR.

I hereby give permission for my Twins _____ and _____ to voluntarily participate in your Twin Study. They may be fingerprinted and qualified medical personnel may draw a blood specimen for typing purposes. I hereby release the Minneapolis War Memorial Blood Bank Inc., or its staff, from all claims that may arise by reason of any of the procedures relative to the blood typing.

_____
(Signature of parent)

TWIN STUDY DATA SHEET

Please Print. School:

Name: Place of Birth:
Last First Middle Telephone:
Date of Birth:
Address:

Father's Name: Occupation: Age:

Mother's Name: Occupation: Age:

Name of family doctor:
Were you born in a hospital? If not, where?

Present grade in school: Grade of your twin:

Religion: Nationality:

Names and Ages of your sisters and brothers:
1. 3.
2. 4.
Give the names, ages, and relationships of any other twins in your family:

Color of eyes: Color of hair: Is hair wavy or straight?

Describe and locate any birthmarks or moles:

Height:
Which hand do you write or throw with? Weight:
Have you ever had any head injury or other serious injuries?
Explain:

Have you ever been absent from school for more than one week?
Explain:

In what ways do you think you differ from your twin, physically:

In what ways, in personality:

List some important advantages of being a twin:

List some important disadvantages:

Do you and your twin go around in the same crowd or gang?
Until what age did you dress alike: Do you now dress alike frequently:
Do your family treat you differently from your twin? Explain:

NAME: School:
Homeroom Teacher:

List your favorite hobbies, clubs, interests, and sports in which you participate:

Make a check in the proper column to indicate whether or not you have had any of the following illnesses or difficulties, and if so, at what age.

	Yes	No		Yes	No
Mumps	I	I	Measles	I	I
Scarlet Fever	I	I	Chicken Pox	I	I
Whooping Cough	I	I	Diphtheria	I	I
Bronchitis	I	I	Pneumonia	I	I
Rheumatic Fever	I	I	Nervous Breakdown	I	I
Diabetes	I	I	Fits or Convulsions	I	I
Polio	I	I	Fainting spells	I	I
Tuberculosis	I	I	Meningitis	I	I
Anemia	I	I	Severe, frequent headaches	I	I
Frequent colds	I	I	Speech difficulties	I	I

List any allergies you have:

Do you were eyeglasses? Does your twin?
List any physical handicap you now have, if any, and comment about any significant omission in the above description of your past or present health status:

What are your plans after graduation from high school?

What job or occupation have you chosen for your life work?

Appendix B

Blood, Fingerprint, and Height Characteristics of the MZ Twins with Zygosity Type Probabilities

Appendix B

Blood, Fingerprint, and Height Characteristics of the MZ Twins

MZ Pair	Sex	ABO	MNS	Rh	Le	K	Fy	Jk	Lu	P	Ridge Count A	Ridge Count B	Height (cm.) A	Height (cm.) B	Prob.[a] I	Prob.[b] IV
1	F	O	MNSs	CDe/Ce	-+	-+	+	+-	-	-	105	104	166.2	165.6	.0448	.0050
2	F	A1	NsNs	CDe/ce	-+	-+	+	+-		+	72	101	161.7	161.7	.0722	.0446
3	F	O	MsMs	cde/ce	-+	-+	+	+-	-	-	112	119	158.4	155.2	.0391	.0082
4	F	A1	NSNs	cDE/ce	-+	-+	+	+-		+	68	77	154.0	152.3	.0456	.0057
5	F	O	MSMs	CDe/Ce	-+	-+	-	+-	-	+	118	144	163.5	163.5	.0480	.0236
6	F	A1	NsNs	CDe/ce	-+	-+	+	+-		+	138	167	150.9	160.3	.0722	.4188
7	F	A1	MSMs	cde/ce	-+	-+	+	-+		-	105	128	156.4	157.1	.0260	.0126
8	F	A2	MNSs	CDe/ce	-+	-+	-	+-		-	39	39	170.2	168.8	.0281	.0031
9	F	A1B	MsNs	CDe/Ce		-+	+	+-		+	119	111	165.8	165.8	.0393	.0049
10	F	A1	NSNs	CDe/Ce	--	-+	+	+-		+	116	147	158.5	163.9	.0543	.3898
11	F	A2	MSMs	cde/ce	-+	-+	+	+-		+	132	150	165.0	161.5	.0429	.0297
12	F	A2B	MSNS	cde/ce		-+	-	+-		-	34	39	168.6	165.1	.0130	.0026

Appendix B, Continued

MZ Pair	Sex	ABO	MNS	Rh	Le	K	Fy	Jk	Lu	P	Ridge Count A	Ridge Count B	Height (cm.) A	Height (cm.) B	Prob.[a] I	Prob.[b] IV
13	F	A1	MSMs	cDE/ce	+-	-+	+	+-		+	98	144	161.0	160.1	.0315	.3270
14	F	A1	MNSs	CDe/Ce	-+	-+	-	+-		+	144	127	151.5	154.6	.0508	.0168
15	F	A1	MNSs	CDe/Ce	-+	-+	-	+-		+	144	149	151.5	147.3	.0508	.0961
16	F	A1	MNSs	CDe/Ce	-+	-+	-	+-		+	127	149	154.6	147.3	.0508	.2300
17	F	A2	MNSs	CDe/ce	+-	-+	-	+-		+	130	134	172.8	173.1	.0262	.0029
18	F	O	MsMs	CDe/cE	-+	-+	+	-+	-	+	70	84	147.0	148.8	.0341	.0058
19	F	O	NsNs	cDE/ce	-+	-+	+	+-	-	-	263	261	162.9	163.3	.0398	.0044
20	F	A1	MSMs	CDe/cE	-+	-+	-	+-		+	96	93	160.9	161.7	.0399	.0044
21	F	O	NsNs	CDe/ce	-+	-+	+	++	-	-	254	262	160.1	159.4	.0508	.0064
22	F	B	MsNs	cde/ce	-+	++	-	+-		+	47	32	164.0	164.8	.0220	.0038
23	M	A1	MNSs	cDE/ce	-+	-+	-	+-		-	101	123	174.2	173.7	.0258	.0094
24	M	O	MNSs	CDe/ce	-+	-+	-	+-	-	+	168	168	182.6	182.6	.0558	.0063
25	M	O	MSNS	CDe/Ce	--	-+	-	++	-	+	213	218	170.4	170.4	.0396	.0044

Appendix B, Continued

MZ Pair	Sex	ABO	MNS	Rh	Le	K	Fy	Jk	Lu	P	Ridge Count A	Ridge Count B	Height (cm.) A	Height (cm.) B	Prob.[a] I	Prob.[b] IV
26	M	B	MNSs	cDE/ce	−+	−+	+	−+		−	88	103	172.7	171.4	.0181	.0031
27	M	A1	MNSs	CDe/ce	+−	−+	−	+−		+	190	202	172.0	175.5	.0348	.0081
28	M	O	MNSs	cde/ce	−+	−+	+	−+	−	+	99	111	171.0	171.0	.0425	.0053
29	M	A2	MSMs	CDe/ce	−−	−+	+	−+		+	183	152	166.5	167.6	.0321	.0195
30	M	A1B	MsMs	cDE/ce		−+	+	+−		−	150	128	189.4	188.0	.0195	.0071
31	M	O	MNSs	CDe/ce	−+	−+	+	−+	−	−	59	38	170.6	171.9	.0323	.0119
32	M	A2	NsNs	CDe/ce	−+	−+	+	+−		+	160	143	186.6	186.2	.0548	.0097
33	M	O	MSMS	CDe/Ce	−−	−+	+	+−	−	−	145	174	164.5	164.5	.0385	.0235
34	M	A1	MSMs	cDE/ce	−+	−+	+	+−		+	41	39	149.0	155.7	.0495	.0791

Note. − − For definition of blood group symbols see Chap. III B.

[a] This probability figure is computed only from initial odds, likeness in sex, and blood.

[b] This figure is computed from Prob. I plus fingerprint and height data.

Appendix C

MMPI and HSPQ Means and Standard Deviations for Twins and Norm Groups

Table 16

MMPI Means for MZ and DZ: Sexes Combined

Scale	MZ	SD	DZ	SD
L[a]	46		46	
F[a]	55		54	
K	53.0	9.8	54.4	8.3
1	51.8	8.3	51.2	7.9
2	50.7	9.5	50.3	9.9
3	53.7	8.4	52.0	7.3
4	58.4	11.6	60.6	11.9
5	51.7	10.1	53.8	9.7
6	57.1	11.5	57.0	9.8
7	56.8	9.6	57.5	9.2
8	60.7	12.4	60.4	11.2
9	59.1	12.0	57.3	11.8
0	54.1	8.0	53.7	10.0

[a] Scores for these scales are medians.

Table 17

MMPI Means for MZ and DZ Females

Scale	MZ	SD	DZ	SD	Ninth-Grade Girls[a]	SD
L	46[b]		46[b]		49.0	8.0
F	54[b]		52[b]		55.0	10.8
K	53.1	10.1	55.5	8.4	54.0	5.8
1	49.4	6.4	50.5	7.9	48.0	7.5
2	49.3	9.2	49.4	9.1	48.0	7.7
3	53.0	8.0	51.9	6.9	51.0	8.0
4	54.8	11.7	59.6	12.7	60.0	9.8
5	51.7	11.1	54.1	10.0	56.0	9.1
6	55.8	12.4	55.2	9.3	50.0	9.9
7	54.9	9.2	56.5	8.2	54.0	7.9
8	58.4	11.4	58.5	9.6	57.0	8.8
9	58.1	12.8	56.7	11.9	56.0	10.5
0	52.6	7.2	53.5	9.7	53.0	7.8

[a] A random sample of 200 public-school girls from the Hathaway & Monachesi study (1953).

[b] These scores are medians.

Table 18

MMPI Means for MZ and DZ Males

Scale	MZ	SD	DZ	SD	Ninth-Grade Boys[a]	SD
L	46[b]		44[b]		48.0	7.1
F	58[b]		58[b]		57.0	8.6
K	52.6	9.5	52.0	7.9	54.0	8.4
1	56.3	9.6	52.6	8.1	50.4	8.5
2	53.3	9.7	52.2	11.4	52.0	9.9
3	55.0	9.1	52.1	8.2	51.7	7.5
4	64.8	8.2	62.6	10.2	59.5	10.8
5	51.7	8.3	53.3	9.2	52.3	8.8
6	59.4	9.7	60.6	10.0	52.9	9.0
7	60.3	9.6	59.7	10.8	56.2	9.8
8	65.0	13.4	64.3	13.3	59.1	10.0
9	61.0	10.6	58.6	11.6	59.5	10.6
0	56.9	8.9	54.0	10.8	51.4	8.0

[a] A random sample of 200 public-school boys from the Hathaway & Monachesi study (1953).

[b] These scores are medians.

Table 19

HSPQ Means for MZ and DZ: Sexes Combined

Scale	MZ	SD	DZ	SD	Norm	SD
A	12.3	2.8	12.2	3.1	10.4	2.8
B	15.2	2.5	15.7	2.5	12.8	3.2
C	9.3	2.5	9.8	2.8	9.5	2.8
D	9.6	2.8	9.2	2.7	9.6	2.5
E	8.9	2.2	8.7	3.2	9.4	2.9
F	9.8	2.6	10.2	3.2	9.9	2.7
G	11.7	2.6	11.7	2.4	12.2	3.1
H	8.1	2.7	9.2	3.0	8.6	3.1
I	10.1	3.4	10.4	3.3	11.4	3.0
J	10.3	2.5	10.8	2.6	10.5	2.5
O	10.3	2.8	10.2	3.6	10.7	3.1
Q2	9.7	2.4	10.1	2.6	10.6	2.6
Q3	9.7	2.4	9.5	2.3	11.2	2.6
Q4	10.0	2.9	8.9	2.2	9.4	2.8

Table 20

HSPQ Means for MZ and DZ Females

Scale	MZ	SD	DZ	SD	Norm	SD
A	13.0	2.6	12.7	2.8	11.2	2.6
B	15.2	2.4	15.6	2.4	13.6	2.8
C	8.6	2.2	9.4	2.6	8.6	2.8
D	9.6	3.2	9.2	2.7	9.4	2.7
E	8.3	2.2	7.8	2.9	8.6	2.9
F	10.2	2.5	10.4	3.1	10.1	2.8
G	11.8	2.3	12.1	2.4	12.8	3.0
H	8.0	2.5	9.1	3.1	8.1	3.4
I	11.6	2.6	11.9	2.3	13.2	2.5
J	10.4	2.4	11.0	2.3	11.3	2.3
O	10.8	3.0	10.8	3.5	11.0	3.3
Q2	9.0	2.2	10.0	2.4	10.3	2.6
Q3	9.7	2.3	9.4	2.3	11.6	2.4
Q4	10.6	2.4	9.2	2.3	9.8	2.8

Table 21

HSPQ Means for MZ and DZ Males

Scale	MZ	SD	DZ	SD	Norm	SD
A	11.1	2.9	11.1	3.6	9.8	2.7
B	15.1	2.6	15.9	2.9	12.0	2.9
C	10.5	2.6	10.8	2.9	10.3	2.8
D	9.5	2.1	9.2	2.8	9.8	2.6
E	9.9	2.0	10.5	2.9	10.0	2.9
F	9.2	2.7	9.5	3.3	9.1	2.8
G	11.4	3.1	10.8	2.1	11.6	3.0
H	8.3	2.9	9.6	2.8	9.1	3.2
I	7.4	3.0	7.3	2.8	9.8	2.3
J	10.1	2.8	10.1	3.0	9.8	2.5
O	9.5	2.2	8.9	3.5	10.4	3.2
Q2	11.0	2.3	10.4	2.9	10.8	2.6
Q3	9.8	2.7	9.6	2.5	10.8	2.5
Q4	8.9	3.5	8.3	1.9	9.1	2.8

Appendix D

Analyses of Variance of HSPQ and MMPI Scales

Appendix D

HSPQ Scale Analyses of Variance

MZ Scale A

Source of Variance	SS	df	MS	F
Total	535.2206	67		
Between Pairs	313.7206	33	9.5066	
Within Pairs	221.5000	34	6.5147	1.4592 (R .1867)

DZ Scale A

Source of Variance	SS	df	MS	F
Total	660.5148	67		
Between Pairs	414.0148	33	12.5459	
Within Pairs	246.5000	34	7.2500	1.7304 (R .2675)

MZ Scale B

Source of Variance	SS	df	MS	F
Total	405.8824	67		
Between Pairs	323.8824	33	9.8146	
Within Pairs	82.0000	34	2.4117	4.0695 (R .6054)

DZ Scale B

Source of Variance	SS	df	MS	F
Total	433.6912	67		
Between Pairs	347.1912	33	10.5209	
Within Pairs	86.5000	34	2.5441	4.1354 (R .6105)

MZ Scale C

Source of Variance	SS	df	MS	F
Total	429.2353	67		
Between Pairs	271.2353	33	8.2192	
Within Pairs	158.0000	34	4.6470	1.7687 (R .2776)

DZ Scale C

Source of Variance	SS	df	MS	F
Total	517.2206	67		
Between Pairs	353.7206	33	10.7188	
Within Pairs	163.5000	34	4.8088	2.2289 (R .3806)

MZ Scale D

Source of Variance	SS	df	MS	F
Total	524.7648	67		
Between Pairs	313.7648	33	9.5080	
Within Pairs	211.0000	34	6.2058	1.5321 (R .2101)

DZ Scale D

Source of Variance	SS	df	MS	F
Total	485.6912	67		
Between Pairs	355.1912	33	10.7633	
Within Pairs	130.5000	34	3.8382	2.8042 (R .4742)

MZ Scale E

Source of Variance	SS	df	MS	F
Total	325.8089	67		
Between Pairs	186.3089	33	5.6457	
Within Pairs	139.5000	34	4.1029	1.3760 (R .1582)

DZ Scale E

Source of Variance	SS	df	MS	F
Total	664.8824	67		
Between Pairs	463.8824	33	14.0570	
Within Pairs	201.0000	34	5.9117	2.3778 (R .4079)

MZ Scale F

Source of Variance	SS	df	MS	F
Total	460.5295	67		
Between Pairs	327.5295	33	9.9251	
Within Pairs	133.0000	34	3.9117	2.5372 (R .4684)

DZ Scale F

Source of Variance	SS	df	MS	F
Total	680.5295	67		
Between Pairs	375.5295	33	11.3796	
Within Pairs	305.0000	34	8.9705	1.2685 (R .1183)

MZ Scale G

Source of Variance	SS	df	MS	F
Total	443.2206	67		
Between Pairs	327.7206	33	9.9309	
Within Pairs	115.5000	34	3.3970	2.9234 (R .4902)

DZ Scale G

Source of Variance	SS	df	MS	F
Total	378.5148	67		
Between Pairs	266.0148	33	8.0610	
Within Pairs	112.5000	34	3.3088	2.4362 (R .4179)

MZ Scale H

Source of Variance	SS	df	MS	F
Total	477.4706	67		
Between Pairs	325.4706	33	9.8627	
Within Pairs	152.0000	34	4.4705	2.2061 (R .3762)

DZ Scale H

Source of Variance	SS	df	MS	F
Total	602.2353	67		
Between Pairs	356.2353	33	10.7950	
Within Pairs	246.0000	34	7.2352	1.4920 (R .1974)

MZ Scale I

Source of Variance	SS	df	MS	F
Total	781.8089	67		
Between Pairs	601.3089	33	18.2214	
Within Pairs	180.5000	34	5.3088	3.4323 (R .5487)

DZ Scale I

Source of Variance	SS	df	MS	F
Total	716.6324	67		
Between Pairs	524.1324	33	15.8828	
Within Pairs	192.5000	34	5.6617	2.8053 (R .4744)

MZ Scale J

Source of Variance	SS	df	MS	F
Total	429.2353	67		
Between Pairs	267.2353	33	8.0980	
Within Pairs	162.0000	34	4.7647	1.6995 (R .2591)

DZ Scale J

Source of Variance	SS	df	MS	F
Total	434.7500	67		
Between Pairs	206.2500	33	6.2500	
Within Pairs	228.5000	34	6.7205	.9299 (R -.0362)

MZ Scale O

Source of Variance	SS	df	MS	F
Total	534.8824	67		
Between Pairs	384.8824	33	11.6631	
Within Pairs	150.0000	34	4.4117	2.6436 (R .4511)

DZ Scale O

Source of Variance	SS	df	MS	F
Total	859.6912	67		
Between Pairs	582.1912	33	17.6421	
Within Pairs	277.5000	34	8.1617	2.1615 (R .3674)

MZ Scale Q2

Source of Variance	SS	df	MS	F
Total	398.5148	67		
Between Pairs	316.0148	33	9.5762	
Within Pairs	82.5000	34	2.4264	3.9466 (R .5956)

DZ Scale Q2

Source of Variance	SS	df	MS	F
Total	437.8089	67		
Between Pairs	249.3089	33	7.5548	
Within Pairs	188.5000	34	5.5441	1.3626 (R .1535)

MZ Scale Q3

Source of Variance	SS	df	MS	F
Total	398.1177	67		
Between Pairs	256.1177	33	7.7611	
Within Pairs	142.0000	34	4.1764	1.8583 (R .3002)

DZ Scale Q3

Source of Variance	SS	df	MS	F
Total	360.9853	67		
Between Pairs	200.4853	33	6.0753	
Within Pairs	160.5000	34	4.7205	1.2870 (R .1254)

MZ Scale Q4

Source of Variance	SS	df	MS	F
Total	570.9853	67		
Between Pairs	357.4853	33	10.8328	
Within Pairs	213.5000	34	6.2794	1.7251 (R .2660)

DZ Scale Q4

Source of Variance	SS	df	MS	F
Total	328.6324	67		
Between Pairs	215.1324	33	6.5191	
Within Pairs	113.5000	34	3.3382	1.9528 (R .3226)

MMPI Scale Analyses of Variance

MZ Scale 1 (Hypochondriasis)

Source of Variance	SS	df	MS	F
Total	4642.5295	67		
Between Pairs	3219.5295	33	97.5615	
Within Pairs	1423.0000	34	41.8529	2.3310 (R .3995)

DZ Scale 1

Source of Variance	SS	df	MS	F
Total	4224.5295	67		
Between Pairs	2560.5295	33	77.5918	
Within Pairs	1664.0000	34	48.9411	1.5854 (R .2264)

MZ Scale 2 (Depression)

Source of Variance	SS	df	MS	F
Total	6084.5148	67		
Between Pairs	4361.0148	33	132.1519	
Within Pairs	1723.5000	34	50.6911	2.6070 (R .4455)

DZ Scale 2

Source of Variance	SS	df	MS	F
Total	6559.6912	67		
Between Pairs	3478.1912	33	105.3997	
Within Pairs	3081.5000	34	90.6323	1.1629 (R .0753)

MZ Scale 3 (Hysteria)

Source of Variance	SS	df	MS	F
Total	4727.6912	67		
Between Pairs	3433.1912	33	104.0360	
Within Pairs	1294.5000	34	38.0735	2.7325 (R .4641)

DZ Scale 3

Source of Variance	SS	df	MS	F
Total	3534.8676	67		
Between Pairs	2480.3676	33	75.1626	
Within Pairs	1054.5000	34	31.0147	2.4234 (R .4157)

MZ Scale 4 (Psychopathic Deviate)

Source of Variance	SS	df	MS	F
Total	9003.5295	67		
Between Pairs	6986.5295	33	211.7130	
Within Pairs	2017.0000	34	59.3235	3.5687 (R .5622)

DZ Scale 4

Source of Variance	SS	df	MS	F
Total	9538.6324	67		
Between Pairs	5775.1324	33	175.0040	
Within Pairs	3763.5000	34	110.6911	1.5810 (R .2251)

MZ Scale 5 (Masculine-feminine Interest)

Source of Variance	SS	df	MS	F
Total	6874.1177	67		
Between Pairs	5043.1177	33	152.8217	
Within Pairs	1831.0000	34	53.8529	2.8377 (R .4788)

DZ Scale 5

Source of Variance	SS	df	MS	F
Total	6274.5295	67		
Between Pairs	4173.5295	33	126.4705	
Within Pairs	2101.0000	34	61.7941	2.0466 (R .3435)

MZ Scale 6 (Paranoia)

Source of Variance	SS	df	MS	F
Total	8928.6324	67		
Between Pairs	6484.1324	33	196.4888	
Within Pairs	2444.5000	34	71.8970	2.7329 (R .4642)

DZ Scale 6

Source of Variance	SS	df	MS	F
Total	6421.9412	67		
Between Pairs	3823.9412	33	115.8770	
Within Pairs	2598.0000	34	76.4117	1.5164 (R .2052)

MZ Scale 7 (Psychasthenia)

Source of Variance	SS	df	MS	F
Total	6173.2206	67		
Between Pairs	4715.7206	33	142.9006	
Within Pairs	1457.5000	34	42.8676	3.3335 (R .5384)

DZ Scale 7

Source of Variance	SS	df	MS	F
Total	5632.9412	67		
Between Pairs	3446.9412	33	104.4527	
Within Pairs	2186.0000	34	64.2941	1.6246 (R .2379)

MZ Scale 8 (Schizophrenia)

Source of Variance	SS	df	MS	F
Total	10385.6912	67		
Between Pairs	8131.1912	33	246.3997	
Within Pairs	2254.5000	34	66.3088	3.7159 (R .5759)

DZ Scale 8

Source of Variance	SS	df	MS	F
Total	8349.8089	67		
Between Pairs	5157.3089	33	156.2820	
Within Pairs	3192.5000	34	93.8970	1.6643 (R .2493)

MZ Scale 9 (Hypomania)

Source of Variance	SS	df	MS	F
Total	9733.0589	67		
Between Pairs	5889.0589	33	178.4563	
Within Pairs	3844.0000	34	113.0588	1.5784 (R .2243)

DZ Scale 9

Source of Variance	SS	df	MS	F
Total	9251.2206	67		
Between Pairs	4118.7206	33	124.8097	
Within Pairs	5132.5000	34	150.9558	.8267 (R-.0948)

MZ Scale 0 (Social-introversion)

Source of Variance	SS	df	MS	F
Total	4293.0589	67		
Between Pairs	3342.0589	33	101.2745	
Within Pairs	951.0000	34	27.9705	3.6207 (R .5671)

DZ Scale 0

Source of Variance	SS	df	MS	F
Total	6693.2206	67		
Between Pairs	3600.7206	33	109.1127	
Within Pairs	3092.5000	34	90.9558	1.1996 (R .0907)

MZ Otis Intelligence Quotient

Source of Variance	SS	df	MS	F
Total	9110.7648	67		
Between Pairs	8326.7648	33	252.3262	
Within Pairs	784.0000	34	23.0588	10.9427 (R .8325)

DZ Otis Intelligence Quotient

Source of Variance	SS	df	MS	F
Total	9788.5147	67		
Between Pairs	7725.0147	33	234.0914	
Within Pairs	2063.5000	34	60.6912	3.8571 (R .5882)

MZ MMPI K Scale

Source of Variance	SS	df	MS	F
Total	6488.8677	67		
Between Pairs	4313.3677	33	130.7081	
Within Pairs	2175.5000	34	63.9852	2.0427 (R .3427)

DZ MMPI K Scale

Source of Variance	SS	df	MS	F
Total	4650.2795	67		
Between Pairs	2224.7795	33	67.4175	
Within Pairs	2425.5000	34	71.3382	.9450 (R -.0282)

Appendix E

Analyses of the Six MMPI Experimental Scales

MZ Scale Es (Ego-Strength)

Source of Variance	SS	df	MS	F
Total	4588.1177	67		
Between Pairs	2770.1177	33	83.9429	
Within Pairs	1818.0000	34	53.4705	1.5698 (R .2217)

DZ Scale Es

Source of Variance	SS	df	MS	F
Total	4562.9853	67		
Between Pairs	3299.4853	33	99.9844	
Within Pairs	1263.5000	34	37.1617	2.6905 (R .4580)

MZ Scale A (Anxiety)

Source of Variance	SS	df	MS	F
Total	7013.1177	67		
Between Pairs	5030.1177	33	152.4278	
Within Pairs	1983.0000	34	58.3235	2.6134 (R .4465)

DZ Scale A

Source of Variance	SS	df	MS	F
Total	5111.2206	67		
Between Pairs	2610.7206	33	79.1127	
Within Pairs	2500.5000	34	73.5441	1.0757 (R .0364

MZ Scale R (Repression)

Source of Variance	SS	df	MS	F
Total	7850.0589	67		
Between Pairs	4998.0589	33	151.4563	
Within Pairs	2852.0000	34	83.8823	1.8055 (R .2871)

DZ Scale R

Source of Variance	SS	df	MS	F
Total	6856.1177	67		
Between Pairs	3528.1177	33	106.9126	
Within Pairs	3328.0000	34	97.8823	1.0922 (R .0440)

MZ Scale Do (Dominance)

Source of Variance	SS	df	MS	F
Total	6974.0000	67		
Between Pairs	5044.0000	33	152.8484	
Within Pairs	1930.0000	34	56.7647	2.6926 (R .4583)

DZ Scale Do

Source of Variance	SS	df	MS	F
Total	4592.5295	67		
Between Pairs	2756.5295	33	83.5311	
Within Pairs	1836.0000	34	54.0000	1.5468 (R .2147)

MZ Scale Dy (Dependency)

Source of Variance	SS	df	MS	F
Total	6198.5148	67		
Between Pairs	4680.0148	33	141.8186	
Within Pairs	1518.5000	34	44.6617	3.1753 (R .5210)

DZ Scale Dy

Source of Variance	SS	df	MS	F
Total	5130.9853	67		
Between Pairs	3187.4853	33	96.5904	
Within Pairs	1943.5000	34	57.1617	1.6897 (R .2564)

MZ Scale St (Social status)

Source of Variance	SS	df	MS	F
Total	3810.8824	67		
Between Pairs	2781.8824	33	84.2994	
Within Pairs	1029.0000	34	30.2647	2.7854 (R .4716)

DZ Scale St

Source of Variance	SS	df	MS	F
Total	6518.9853	67		
Between Pairs	4950.4853	33	150.0147	
Within Pairs	1568.5000	34	46.1323	3.2518 (R .5296)

Table 22

MMPI Experimental Scale Correlations

Scale	MZ R	P	DZ R	P
Es	22		46	* *
A	45	* *	04	
R	29	*	04	
Do	46	* *	21	
Dy	52	***	26	
St	47	* *	53	***

Table 23

One-tailed Test of Significance of Difference

Between MZ and DZ Experimental Scale Correlations

Scale	MZ z	DZ z	Difference	Normal Deviate	P
Es	.226	.495	-.269	-1.076	
A	.479	.036	.443	1.772	.04
R	.295	.044	.251	1.004	.16
Do	.495	.218	.277	1.108	.13
Dy	.577	.262	.315	1.260	.10
St	.513	.590	-.077	-.308	

Table 24

Experimental Scale Nature-Nurture Ratios

Scale	DZ V[a]	MZ V[a]	Difference	H
Es	37.1617	53.4705	-16.3088	.00
A	73.5441	58.3235	15.2206	.21
R	97.8823	83.8823	14.0000	.14
Do	54.0000	56.7647	-2.7647	.00
Dy	57.1617	44.6617	12.5000	.22
St	46.1323	30.2647	15.8676	.34

[a] Within classes mean square

Appendix F

Welsh Coded MMPI Profiles with Rho, D, and TT'

For All Twins

Appendix F

Twin	Welsh Code	Rho	D	TT'
MZ-1A	9-35 684/1027:	.31	33	79
MZ-1B	5'-90/81 73: 426#			
MZ-2A	87"693'204-1/: 5#	.78	24	69
MZ-2B	8*"6943'720-1/5:			
MZ-3A	9-80376/5: 142#	.38	27	78
MZ-3B	9580/42 731: 6#			
MZ-4A	9'-78 46/2301: #5	-.43	45	71
MZ-4B	03-1274/6859:			
MZ-5A	543-12807/6: #9	.60	34	86
MZ-5B	4'38-571 69/20:			
MZ-6A	9"4'75-28 03/16:	.50	62	64
MZ-6B	849"7263'01-/5:			
MZ-7A	4-237981/056:	.12	40	72
MZ-7B	9-7/836041: 25#			
MZ-8A	6-53/20 1487: 9#	-.38	35	80
MZ-8B	7-86 413/902: 5#			
MZ-9A	49-3168527/0:	.62	18	72
MZ-9B	9-4871360/25:			
MZ-10A	6'0-43 28179/5:	-.20	34	72
MZ-10B	98 74-6312/50:			
MZ-11A	5-042819/67: 3#	.30	21	71
MZ-11B	5-32 10/87 496:			
MZ-12A	45 2783/106: 9#	-.13	27	81
MZ-12B	9-5384/06127:			
MZ-13A	59-60/314 278:	.46	29	72
MZ-13B	9'568-7/0423: 1#			
MZ-14A	34-18756/20: 9#	-.42	39	71
MZ-14B	7-986/0243:15#			

Note. MZ Pairs 1-22 are Female, DZ Pairs 1-23 are female.

Twin	Welsh Code	Rho	D	TT'
MZ-15A	7-986/0243: 15#	.41	27	72
MZ-15B	8-637 91/504: 2#			
MZ-16A	8-637 91/504: 2#	.23	29	77
MZ-16B	34-18756/20: 9#			
MZ-17A	09-58 17 6/234:	.09	30	66
MZ-17B	9-8764/30125:			
MZ-18A	9"6'80-5241/37:	.50	41	52
MZ-18B	685'24 01-397/			
MZ-19A	64'987-530 21/	.51	25	71
MZ-19B	6'48372-01 59/			
MZ-20A	8"6 47'90-52/13:	.11	53	66
MZ-20B	720-685/1394:			
MZ-21A	513078 6/492:	.24	25	80
MZ-21B	59-48 137/60: 2#			
MZ-22A	6'90-87/25 31: 4#	.56	31	74
MZ-22B	9-750/28 643: 1#			
MZ-23A	5-24103 89/76:	-.00	32	73
MZ-23B	4578-63091/2:			
MZ-24A	1'4728-3509/6:	-.16	40	68
MZ-24B	687'94 10-/352:			
MZ-25A	8'7206-439/15:	.48	33	66
MZ-25B	9'840-7261/3: 5#			
MZ-26A	49'3-68175/02:	.77	31	81
MZ-26B	46'3-18/92705:			
MZ-27A	47'3812-6059/	.17	27	80
MZ-27B	13'2670-5498/			
MZ-28A	3-16 497 8/520:	.21	37	70
MZ-28B	9'78-536/140: 2#			
MZ-29A	0-47 869/512: 3#	.63	26	75
MZ-29B	748-1906/23: 5#			
MZ-30A	436'78-129/50:	.56	39	67
MZ-30B	8"617'493-20/5:			

Twin	Welsh Code	Rho	D	TT'
MZ-31A	9'47-68 315/02:	.41	24	74
MZ-31B	5694-3728/01:			
MZ-32A	8*4"6271'390-/5:	.59	37	61
MZ-32B	8*9"47'60-213/5:			
MZ-33A	0'42-5/89 1376:	.83	27	81
MZ-33B	4089-52167/3:			
MZ-34A	89'405-62/173:	.81	23	69
MZ-34B	809'47-62/513:			

DZ Twins

DZ-1A	78-503/612 49	-.42	34	72
DZ-1B	456 93 18/27: 0#			
DZ-2A	98 06 7-25/413:	.40	28	71
DZ-2B	04-6857/29 13:			
DZ-3A	0-58 71 24/36: 9#	-.30	30	82
DZ-3B	43 81 2796/05:			
DZ-4A	5-62489 307/1:	.52	21	68
DZ-4B	4'96-53870/21:			
DZ-5A	4*" '8956-2703/1:	.75	38	71
DZ-5B	489-357/2610:			
DZ-6A	7"82460'-319/:5#	.15	65	68
DZ-6B	9-70 3 84/16 25:			
DZ-7A	9487-3126 50/	-.46	30	74
DZ-7B	67-51 40 238/9:			
DZ-8A	9'874-0516/3: 2#	.46	30	72
DZ-8B	6-87901/5243:			
DZ-9A	34 85/176 29: 0#	.24	23	83
DZ-9B	9-5 148 63/702:			
DZ-10A	4" '7-6 2381/905:	.53	41	81
DZ-10B	6-3/49 708 125:			
DZ-11A	5-9470/183 6: 2#	.66	25	69
DZ-11B	5'47-698 301/2:			

Twin	Welsh Code	Rho	D	TT'
DZ-12A	056'4823-71/: 9#	-.10	56	73
DZ-12B	4"89 6'7-3510/2:			
DZ-13A	0'7-25/486: 31 #9	-.31	57	72
DZ-13B	4'8-17 639/502:			
DZ-14A	45'86-902/731:	.33	41	69
DZ-14B	49'78-632/15 0:			
DZ-15A	519-6387/24: 0#	.18	27	71
DZ-15B	35-4718 260/9:			
DZ-16A	9'48-6573/0: 12#	-.04	45	78
DZ-16B	60 287/49 31 5:			
DZ-17A	798-5 60/431: 2#	.58	28	63
DZ-17B	90 47 6/8 35 2: 1#			
DZ-18A	0'78-6249/31: 5#	.28	37	71
DZ-18B	1'7 83 04-269/5:			
DZ-19A	5'9-13 7/8 204: 6#	.57	24	73
DZ-19B	5-89701/62 3: 4#			
DZ-20A	4'6817-923 50/	.54	26	64
DZ-20B	4"9'6780-253/1			
DZ-21A	04-2 31 786/59:	-.20	73	50
DZ-21B	8*9"147 36'02-5/			
DZ-22A	46 39 87/51 20:	.44	25	85
DZ-22B	8-374 91 0/6: 25#			
DZ-23A	509/1374: 862#	.51	40	67
DZ-23B	9'5-14 873/20: 6#			
DZ-24A	78 4-6931/05: 2#	.69	27	76
DZ-24B	8'147-3609/25:			
DZ-25A	965-4/82703: 1#	.17	30	66
DZ-25B	089 3467/512:			
DZ-26A	642'307-1759/	-.04	50	68
DZ-26B	49-381 67/52: 0#			

Twin	Welsh Code	Rho	D	TT'
DZ-27A	4-890 6 27/153:	.12	28	75
DZ-27B	046-251/3789:			
DZ-28A	87'621 349-50/	.09	39	65
DZ-28B	84-539 76/102:			
DZ-29A	68'907-45/21: 3#	.63	42	67
DZ-29B	4"68'972-10/3: 5#			
DZ-30A	8*7"49'631-520/	.40	52	59
DZ-30B	89'07-564/123:			
DZ-31A	9*"4'56-837/10: 2#	.84	36	82
DZ-31B	594-873/6210:			
DZ-32A	78-190/264: 35#	.17	45	65
DZ-32B	7'204-5 8613/9:			
DZ-33A	08"724'569-13/	-.19	59	55
DZ-33B	4537-186/209:			
DZ-34A	6"8'427-1539/0:	.39	50	73
DZ-34B	2608 13/4795:			

Appendix G

Hathaway Coded MMPI Profiles with Age, Grade, I.Q., and Paternal Occupation Rating for All Twins

Appendix G

Twin	Hathaway Code		Age	Grade	IQ	P.O.[a]
MZ-1A	93-72-	(55) 9:4:17			102	
MZ-2A	9-6243	(70) 7:4:15	17	11	101	V
MZ-2A	87693'241-	(34) 1:10:12			106	
MZ-2B	86943'72-X	(49) 1:19:6	15	10	106	V
MZ-3A	98-214	(45) 3:3:10			111	
MZ-3B	9-613	(51) 3:4:9	15	10	100	V
MZ-4A	9'78-1	(20) 2:3:11			132	
MZ-4B	31-98	(41) 4:6:13	17	11	122	II
MZ-5A	43128-9	(66) 7:4:23			109	
MZ-5B	4'387-	(57) 3:2:25	16	10	117	II
MZ-6A	94'72-6	(61) 4:3:13			109	
MZ-6B	8497263'1-	(43) 1:15:6	15	10	112	III
MZ-7A	4237-6	(43) 6:4:16			100	
MZ-7B	9-21	(34) 5:5:9	16	10	98	II
MZ-8A	6-97841	(55) 1:3:15			96	
MZ-8B	786-2	(37) 4:5:20	17	12	97	I
MZ-9A	49316-	(53) 0:5:9			109	
MZ-9B	948-	(49) 4:4:16	15	9	105	III
MZ-10A	6'4-	(43) 5:7:13			107	
MZ-10B	987463-	(45) 7:2:26	15	9	112	III
MZ-11A	-376	(63) 4:6:15			89	
MZ-11B	-694	(68) 3:5:12	15	9	98	II
MZ-12A	-96	(53) 7:2:20			105	
MZ-12B	9-72	(57) 2:2:16	15	10	109	III
MZ-13A	9-8	(68) 1:5:11			117	
MZ-13B	9'687-132	(66) 1:7:5	15	9	118	V
MZ-14A	34187-9	(53) 1:3:24			124	
MZ-14B	798-13	(39) 2:3:10	15	10	123	I
MZ-15A	798-13	(39) 2:3:10			123	
MZ-15B	8637-24	(47) 2:5:19	15	10	116	I

Note - MZ pairs 1-22 and DZ, 1-23 are females.

[a]Rating according to the Minnesota Scale for Paternal Occupations.

Twin	Hathaway Code		Age	Grade	IQ	P.O.
MZ-16A	8637-24	(47) 2:5:19			124	
MZ-16B	34187-9	(53) 1:3:24	15	10	116	I
MZ-17A	98-	(59) 4:8:14			89	
MZ-17B	98-21	(41) 4:6:13	18	12	90	VI
MZ-18A	96'8-	(57) 7:13:7			89	
MZ-18B	68'241397-X	(74) 10:26:11	15	9	89	V
MZ-19A	64'98732-	(59) 1:10:10			101	
MZ-19B	6'48372-	(53) 2:8:18	15	10	93	V
MZ-20A	86 47'9-3	(53) 4:7:10			98	
MZ-20B	7268-493	(55) 5:2:13	15	9	94	II
MZ-21A	-	(57) 3:3:16			113	
MZ-21B	948-2	(66) 0:1:18	17	11	113	II
MZ-22A	6'98-413	(45) 0:7:5			111	
MZ-22B	97-1346	(53) 3:1:12	17	11	108	V
MZ-23A	24-6	(65) 1:2:9			112	
MZ-23B	478639-	(65) 1:7:10	16	11	121	II
MZ-24A	1'47283-	(55) 5:7:16			79	
MZ-24B	687'941-	(49) 3:11:9	16	11	87	V
MZ-25A	8'726439-	(43) 4:8:10			86	
MZ-25B	9'847-	(34) 3:8:9	16	10	107	III
MZ-26A	49'3681-2	(53) 4:2:19			92	
MZ-26B	46'318-	(41) 4:2:18	17	10	94	III
MZ-27A	47'38126-	(55) 3:4:26			104	
MZ-27B	13'26749-	(59) 5:4:21	18	12	104	II
MZ-28A	316-2	(47) 2:3:21			116	
MZ-28B	9'78-2	(53) 1:5:8	17	12	123	III
MZ-29A	478-321	(49) 3:2:12			97	
MZ-29B	748196-3	(39) 5:8:17	16	11	104	III
MZ-30A	436'7812-	(48) 5:1:18			90	
MZ-30B	8617'4932-	(45) 2:6:18	16	10	89	III
MZ-31A	9'47 683-2	(51) 1:6:12			97	
MZ-31B	6943-	(65) 6:6:11	18	12	91	VI
MZ-32A	846271'39-X	(47) 3:20:15			115	
MZ-32B	8947'62-X	(49) 1:21:6	16	10	115	V

Twin	Hathaway Code		Age	Grade	IQ	P.O.
MZ-33A	42-67319	(59) 3:3:12	15	9	121	V
MZ-33B	4892-	(59) 4:5:14			111	
MZ-34A	89'46-3	(61) 2:10:8	16	10	112	II
MZ-34B	89'476-3	(49) 2:7:10			102	

DZ Twins

DZ-1A	78-94	(59) 3:2:12	17	11	111	III
DZ-1B	469-7	(57) 7:2:19			109	
DZ-2A	98 67-31	(51) 5:5:12	16	10	117	III
DZ-2B	468-31	(53) 5:7:10			95	
DZ-3A	87-9	(57) 5:4:19	14	9	131	III
DZ-3B	438-	(43) 6:3:21			115	
DZ-4A	62489-	(63) 1:2:14	16	10	87	III
DZ-4B	4'96 387-	(59) 1:6:13			94	
DZ-5A	4'8962-1X	(66) 2:16:17	17	11	108	II
DZ-5B	489-16	(51) 2:9:14			129	
DZ-6A	78246'3-	(39) 5:5:15	18	12	115	V
DZ-6B	97-	(41) 4:2:18			120	
DZ-7A	94873-	(51) 2:3:16	18	11	99	III
DZ-7B	6714-9	(57) 3:1:18			100	
DZ-8A	9'874-23	(57) 5:4:15	17	11	93	II
DZ-8B	6879-3	(49) 3:1:14			88	
DZ-9A	34-92	(53) 6:1:23	16	10	100	III
DZ-9B	9148-2	(59) 6:6:21			96	
DZ-10A	4'762-	(45) 2:5:21	16	11	130	I
DZ-10B	6-21 87	(41) 3:2:15			125	
DZ-11A	94-263	(68) 3:1:18	17	11	113	V
DZ-11B	4769-	(70) 5:3:13			94	
DZ-12A	6'482371-9	(70) 5:6:16	16	10	104	III
DZ-12B	489 6'731-	(57) 5:15:9			102	
DZ-13A	72-91368	(53) 4:2:9	18	12	105	V
DZ-13B	4'817-2	(47) 4:1:23			110	
DZ-14A	4'869-13	(74) 1:10:11	15	9	111	III
DZ-14B	49'786-	(45) 2:6:12			107	

Twin	Hathaway Code		Age	Grade	IQ	P.O.
DZ-15A	19638-	(66) 5:3:13			95	
DZ-15B	347-	(63) 9:1:23	15	9	101	V
DZ-16A	9'486-21	(57) 2:1:15			108	
DZ-16B	6-13	(43) 1:3:15	18	12	99	II
DZ-17A	7986-213	(59) 1:7:3			103	
DZ-17B	9-123	(41) 1:3:15	17	11	119	I
DZ-18A	786-1	(37) 3:5;11			114	
DZ-18B	1'7 834269-	(41) 2:3:15	17	11	106	V
DZ-19A	9-642	(70) 3:2:12			98	
DZ-19B	8-432	(63) 4:4:16	17	12	88	V
DZ-20A	4'6817923-	(53) 7:7:22			96	
DZ-20B	49'67823-	(59) 2:11:9	16	10	112	V
DZ-21A	42 317-9	(45) 3:7:17			90	
DZ-21B	89147 36'2-X	(59) 1:21:10	14	9	99	V
DZ-22A	46-2	(49) 1:1:21			121	
DZ-22B	8374-2	(32) 4:3:23	17	11	127	I
DZ-23A	-268473	(55) 6:6:11			132	
DZ-23B	9'14-6	(63) 4:5:14	18	12	114	II
DZ-24A	78 469-2	(45) 1:6:13			108	
DZ-24B	8'147 36-	(45) 3:10:15	16	10	109	III
DZ-25A	96-137	(61) 2:10:6			121	
DZ-25B	89-1	(49) 1:3:14	16	11	109	III
DZ-26A	642'3718	(51) 3:4:12			109	
DZ-26B	4938-2	(45) 2:4:20	15	10	131	II
DZ-27A	489-3	(43) 3:2:15			112	
DZ-27B	462-98	(55) 4:6:11	16	11	103	III
DZ-28A	87'621 349	(57) 3:4:16			118	
DZ-28B	8439-2	(57) 4:5:14	16	10	120	II
DZ-29A	68'974-31	(53) 2:13:5			91	
DZ-29B	468'9721-	(39) 3:14:13	15	9	87	V
DZ-30A	8749'631-Z	(55) 6:17:15			102	
DZ-30B	89'76-3	(57) 0:14:10	16	10	91	VI

Twin	Hathaway Code		Age	Grade	IQ	P.O.
DZ-31A	94'683-21	(65) 1:4:15			113	
DZ-31B	948-12	(67) 0:2:12	17	12	115	III
DZ-32A	7819-3462	(37) 1:5:16			107	
DZ-32B	7'2486-	(59) 5:6:12	16	10	103	III
DZ-33A	8724'6913-	(69) 0:13:6			118	
DZ-33B	437186-9	(63) 2:3:20	17	12	129	V
DZ-34A	68'427139-	(59) 4:7:21			105	
DZ-34B	268-9	(41) 3:7:15	16	10	92	V

Appendix H

Instructions to MMPI Profile Sorters

SORTING INSTRUCTIONS

THE GOAL OF THIS SORTING TASK IS TO COMPARE YOUR JUDGMENTS OF PROFILE SIMILARITY WITH SOME EXTERNAL CRITERION MEASURE. ALL PROFILE PAIRS ARE OF SAME-SEX ADOLESCENTS IN THE PUBLIC HIGH SCHOOLS OF MINNEAPOLIS AND ST. PAUL.

I WOULD SUGGEST THAT YOU FIRST OF ALL LOOK THROUGH THE SHEAF OF 68 PROFILE SHEETS, EACH WITH A PAIR OF PROFILES, TO OBSERVE THE APPARENT RANGE OF DIFFERENCES BETWEEN A PAIR.

THE NEXT STEP IS TO SORT INTO TWO PILES OF 34 SHEETS EACH * SIMILAR AND DISSIMILAR.

THEN SORT EACH OF THESE INTO TWO PILES OF 17 SHEETS EACH. THIS WILL LEAVE YOU WITH FOUR PILES OF 17 SHEETS EACH WHICH I HAVE LABELED AS FOLLOWS:

VERY SIMILAR SIMILAR DISSIMILAR VERY DISSIMILAR

Note that while similarity refers ultimately to similar personality patterns, visual geometry alone takes you a long way. After that you may want to think in terms of syndromes, code types, or diagnoses within the divisions psychosis, neurosis, and character disorder.

Your results, as compared with the unique criterion, will be given to you shortly after I have tabulated your sort. Thank you for your efforts, skill, and time.

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