Twenty-Two Invalidating Aspects of the Minnesota Study of Twins Reared Apart (MISTRA)

(ABRIDGED VERSION)

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Note: This is an abridged (roughly 6,000 words) version of a critique of the "Minnesota Study of Twins Reared Apart." Please see the **2018 full version** (roughly 30,000 words) for a much more detailed analysis.

Abbreviations: **16PF** = 16 Personality Factor Questionnaire; **DZA** = dizygotic (fraternal) twins reared apart; **IQ** = intelligence quotient; **MZA** = monozygotic (identical) twins reared apart; **MZT** = monozygotic (identical) twins reared together; **MISTRA** = Minnesota Study of Twins Reared Apart; **SES** = socioeconomic status; **TRA** = twins reared apart (study); **WAIS** = Wechsler Adult Intelligence Scale.

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The Minnesota Study of Twins Reared Apart

Headlines and titles send strong messages to the public about the reported findings from twin research: "Twins Separated at Birth Reveal Staggering Influence of Genetics," "How Genes Shape Personality," "Born That Way," "Are We Hardwired?," "Mean Genes," "Twin Brothers Separated at Birth Reveal Striking Genetic Similarities," "Life of Crime Is in the Genes, Study Says," "Study Raises the Estimate of Inherited Intelligence," "The Gene Bomb," and so on. Pulitzer Prize winning author Lawrence Wright, in his 1997 book about twin studies and behavioral genetic research *Twins: And What They Tell Us About Who We Are*, wrote that "the science of behavioral genetics, largely through twin studies, has made a persuasive case that much of our identity is stamped on us from conception; to the extent that our lives seem to be pre-chosen—all we have to do is live out the script that is written in our genes."[1] The potential impact of these messages on social relations and political policies is enormous.

I have dedicated much of the past two decades to critically examining behavioral genetic and psychiatric genetic theories, which hold that genetic factors play an important role in causing human behavioral differences. Given the lack of gene discoveries, these theories continue to be based on the results of family, twin, and adoption studies. A sizable portion of my 2015 book *The Trouble with Twin Studies: A Reassessment of Twin Research in the Social and Behavioral Sciences* looked into the potentially invalidating problems of so-called "separated" or "twins reared apart" (TRA) studies, with a special focus on the famous "Minnesota Study of Twins Reared Apart" (MISTRA). I concluded that, like "twin method" studies of reared-together twins, the MISTRA and other TRA studies had failed to produce scientifically acceptable evidence that genetic factors play a role in causing differences in human cognitive ability (or "intelligence," supposedly measured by IQ tests), "personality," and human behavior in general. I summarized the main problems in TRA research in a 2014 online article. Estimating the "heritability of IQ" has been a major area of TRA study focus, with personality and other behavioral characteristics playing a secondary role.

TRA researchers and their supporters claim that studies of reared-apart twins provide a definitive method of separating potential genetic and environmental (nature and nurture) influences on behavior, and that the results from these studies have validated twin method comparisons of reared-together twins.[2] TRA studies are few in number (six) and are very difficult to perform because twins are rarely separated in early life, and because it is difficult to identify, recruit, reunite, and study such pairs. *In theory*, because twins are genetically identical but grew up apart, TRA researchers were able to cleanly separate the potential influences of genes and environments on IQ and other types of behavior. The reality, as we will see, was something very different.

The MISTRA was headed by University of Minnesota psychologist Thomas J. Bouchard, Jr., with Bouchard's colleagues Nancy L. Segal, David T. Lykken, Matt McGue, and Auke Tellegen playing important roles. The volunteer-based MISTRA is by far the most cited and discussed of the six TRA studies that have appeared since 1937. The study was largely financed

(about 60% or $1.42 million, roughly $3 million in 2018 U.S. dollars) by the Pioneer Fund, an organization created in the late 1930s to support eugenics and racial differences research.[3]

MZA, MZT, and DZA Twin Pairs

Twins reared apart (TRA) researchers calculate mean (average) psychological test-score correlations (for example IQ, personality) in a group of MZ (monozygotic, identical) twin pairs, who supposedly were separated near birth and grew up apart in different homes. These twins share 100% of their segregating genes, and are known as "monozygotic twins reared apart," or "MZA" pairs. Identical twins reared together in the same home are known as "monozygotic twins reared together," or "MZT" pairs. In the MISTRA, MZA and MZT group test-score correlations were compared in order to assess the role of what behavioral geneticists call "shared" environmental experiences. I will explain shortly how the researchers arrived at their conclusions in favor of genetic influences, and how they estimated heritability.

The MISTRA also collected a sizable sample of reared-apart DZ twins (dizygotic, fraternal), who are known as "dizygotic twins reared apart," or "DZA" pairs. These pairs also were supposedly separated near birth and grew up apart in different homes, but like ordinary siblings they share on average only 50% of their segregating genes in common. As I will discuss later, from the beginning Bouchard designated DZA pairs as the MISTRA control group, which he planned to compare to the MZA experimental group. The study was conducted between 1979 and 2000, continuing to add newly recruited pairs as the study progressed. The final 2000 sample consisted of 81 MZA and 56 DZA pairs.

The Famous 1990 MISTRA *Science* Article

The most famous and most cited of the many MISTRA publications was a 1990 article published in *Science*, one of the world's leading scientific journals. In her 2012 book about the MISTRA, *Born Together—Reared Apart: The Landmark Minnesota Twin Study*, MISTRA researcher Nancy Segal observed that the "results from the *Science* paper appeared in hundreds of newspapers, magazines, and broadcasts across the country and around the world." The *Science* article was highlighted in the book *Forty Studies That Changed Psychology*, and is frequently cited and discussed in psychology textbooks.

The 1990 MISTRA sample consisted of 56 MZA and 30 DZA pairs. The *Science* article reported MZA correlations for three IQ measures ranging from .69 to .78. MZA correlations for the two reported "special mental abilities" tests (verbal, perceptual, spatial, and memory tasks) were .45 and .48, and for the two reported personality tests (inventories) they were .48 and .50. Although the 1990 *Science* article reported what Segal called the "long awaited IQ data," no DZA correlations of any kind were reported in this article (more on this below).

Because the researchers based their conclusions on the claim that the MZA correlation "directly estimates heritability," the 1990 *Science* article heritability estimates were similar to the MZA correlations. This placed the estimated IQ heritability at about 70%, while personality heritability was about 50%. Bouchard and colleagues concluded that "general intelligence or IQ is strongly affected by genetic factors," and that in general, genetic factors "exert a pronounced and pervasive influence on behavioral variability."[4]

However, as I show here and in much more detail in the full version of this article, the study was subject to numerous problems and biases that are rarely mentioned in mainstream accounts. I listed many of these problem areas very briefly in a 2018 tribute to the pioneering critic of TRA studies, the psychologist Leon J. Kamin (1927-2017).

Impact of the Study

The MISTRA has been referred to as "arguably, the most famous social science project in the last quarter of the twentieth century."[5] According to Segal, the study "forever changed the way people think about the roots of human behavior."[6] The public's knowledge of the MISTRA is based largely on textbook descriptions and the works of authoritative experts, television reports, numerous popular books, and countless print and online articles that have appeared since 1979. A major theme of these reports and publications has been that the researchers discovered, often to their amazement, that genetic factors play a major role in most aspects of human behavior and abilities.

Regardless of the original investigators' intentions and beliefs, twin studies have been cited by various commentators as supplying "scientific evidence" in defense of economic inequality and the social status quo, in support of racism and other forms of oppression, as an explanation for socially disapproved behavior (such as criminality), and in support of cutting back or eliminating needed social programs. The MISTRA findings have been cited in support of genetic (biological) determinism, which predates twin research and refers to the belief that genetic factors play a predominant role in causing differences in human behavior and mental abilities, and that environmental factors play only a minor role, if any. According to this view, which historically has been promoted by the economically and politically powerful in support of their interests, social problems, poverty, and psychiatric conditions are mainly the result of bad heredity.

MISTRA "Model-Fitting" Procedures

Since the 1970s, behavioral genetics has embraced "biometrical model fitting" statistical analyses. Model fitting, according to the leaders of the field, is a "technique for testing the fit between a model of genetic and environmental relatedness against the observed data. Different models can be compared, and the best-fitting model is used to estimate genetic and environmental parameters."[7] Model-fitting analyses attempt to partition (A) genetic, (C) "shared environment," and (E) "non-shared environment" contributions to behavioral variation in a population. Heritability estimates are based on the genetic "A" contribution.

Segal described the MISTRA basic model, which was based on the assumptions that "shared genes underlie similarity between relatives, mating occurs at random (is not assortative), genetic effects are additive, genetic and environmental effects are independent from each other, and genetic and environmental effects combine additively."[8] The model's assumption that "shared genes underlie similarity between relatives" is another way of saying that the model assumes that shared environmental factors *do not* underlie similarity between relatives.

Contrary to model-fitting assumptions, critics have argued convincingly that genetic and environmental effects *are not* independent from each other, and that gene-environment interactions reduce or even invalidate heritability estimates produced by model-fitting analyses.

Furthermore, we will soon see that there are many non-familial environmental influences that contribute to above-zero MZA behavioral correlations. The MISTRA model, however, is based on the assumption that no such influences exist.

DZA Pairs as the MISTRA Designated Control Group

Bouchard designated DZA pairs as the MISTRA control group at the beginning of the study. According to Segal, "Bouchard's decision to use DZA twins as controls was made in a very early memo [dated March 5th, 1979] to the 'Twin Research Team.' This was an important methodological improvement over past projects."[9]

In a 1986 publication, Bouchard, Segal, and colleagues wrote, "Our study is the first to have included a control group of dizygotic twins reared apart (DZA)." They emphasized that by using a DZA control group, they would be able to test genetic versus non-genetic explanations of above-zero MZA psychological test-score correlations:

> "DZA twins allow us to test the two most common competing hypotheses proposed as alternatives to the genetic hypothesis as an explanation of the similarity between MZA twins: placement bias and recruitment bias."[10]

However, the MISTRA model-fitting procedure, which the researchers used for the first time two years later in their first major publication, a 1988 personality study by Tellegen, Bouchard, Segal and colleagues, was based on the assumption that "shared genes underlie similarity between relatives." The study was now based on the built-in model-fitting assumption that placement and recruitment biases *did not* influence MZA behavioral resemblance. This meant that instead of following their 1986 plan to use DZA pairs to *test* the above-mentioned "competing hypotheses," by 1988 the researchers simply *assumed* that the "genetic hypothesis" of MZA behavioral resemblance was correct, and they assumed that placement, recruitment, and all other environmental hypotheses were *in*correct.

How the Researchers Concluded that Genetic Factors Play an Important Role

It is very important to understand and to examine closely the methods, steps, and the stated and unstated assumptions that social and behavioral science investigators use to arrive at their conclusions.

It is often mistakenly reported in the media, in textbooks, in popular works, and even at the University of Minnesota's "Minnesota Center for Twin and Family Research" website that the MISTRA genetic findings were based on MZA versus MZT group comparisons. (I made the same mistake myself in some earlier publications.)[11] Instead, as described throughout Segal's *Born Together—Reared Apart*, the MISTRA team compared MZA and MZT correlations in order to assess the influence of *environmental* factors, using the questionable behavioral genetic distinction between "shared" and "non-shared" environments. In their 1990 *Science* article, Bouchard and colleagues found that "adult MZ twins are about equally similar on most physiological and psychological traits regardless of rearing status [MZA or MZT]," but concluded from this only that "common rearing enhances familial resemblance during adulthood only slightly and on relatively few behavioral dimensions."[12] Even if this conclusion were true—

and common sense assures us that it is not true—environmental factors unrelated to common rearing could still account for MZA behavioral resemblance. (Below I will list and discuss many of these *non-familial* behavior-shaping influences.)

This leads us to the crucial question of how the MISTRA researchers *did* reach their conclusions in favor of "pronounced and pervasive" genetic influences on IQ and other human behavioral characteristics. In the four steps described below, and in the accompanying Figure 1, I discuss and show how they arrived at these conclusions. Because they did not explain this process clearly and consistently in their publications, I have constructed these steps on the basis of information extracted from the original MISTRA publications, in addition to basic principles of twin research, psychological testing, and statistics. Because in different publications the researchers chose different methods of arriving at heritability estimates at Step 3, these two "either/or" methods are described/shown as Step 3A and Step 3B.

Step 1 is usually achieved in TRA studies, and therefore has not been a major area of dispute between twin researchers and their critics. The main issue that *has* been disputed is the question of what factor or factors *cause* above-zero MZA group psychological test-score correlations: genetic factors, non-genetic factors, or a combination of both. In addressing this key question, I will show that there are major problems with Steps 2, 3A, and 3B, which led the researchers to arrive at the mistaken Step 4 conclusion that genetic factors are an important cause of human behavioral variation.

The four main steps that the MISTRA researchers used to arrive at their conclusions in favor of genetics are described below. As we will see, MZT correlations were not part of the process that led them to these conclusions (other than possibly being included in model-fitting analyses). In Figure 1 and in the discussion that follows, we will see that the researchers bypassed Step 2 and Step 3A when assessing their IQ (general cognitive ability) results. The quotations found in some of the step descriptions are taken from leading MISTRA publications.

Step 1: MZA correlation > zero

The mean (average) MZA group psychological test-score correlation (e.g., IQ, personality) must be higher than zero (0.0) at a level that falls below the conventional .05 level of statistical significance. If not, the study finds no genetic influence on the behavior in question because, statistically speaking, the MZA group correlation is zero (there is no relationship between the twins' test scores).

Step 2: MZA > DZA

Because MZAs are more genetically alike than are DZAs (100% vs. an average 50%), the significantly above-zero MZA group correlation found in Step 1 must also be higher than the corresponding DZA control group correlation at a statistically significant level. If not, the study finds no genetic influence on the behavioral characteristic in question, which suggests that *non*-genetic influences alone were responsible for raising both the MZA and

the DZA group correlations above zero. "The simple comparison of the MZ (or MZA) and DZ (or DZA) intraclass correlations is an important first step in behavioral-genetic analysis because this demonstrates *whether or not* there is genetic influence on the trait" (italics added).[13]

Step 3A: Model-fitting heritability (most non-IQ MISTRA studies)

Based on the assumption that "all resemblance between reared apart relatives is because of shared genetic factors," in addition to many other assumptions, statistical "model-fitting" analyses use MZA, DZA and other data to produce sizable heritability estimates.[14] If environmental effects are found to influence MZA group psychological test-score correlations, these are counted as *genetic* effects based on the claim that twins create more similar environments for themselves because they behave more similarly for genetic reasons: "The immediate causes of most psychological variations are probably environmental in nature. However, the environments of individuals are significantly fashioned by their genotypes that selectively guide them toward certain people, places, and experiences and away from others."[15] The researchers assume that the heritability estimate (ranging from 0% to 100%) indicates the proportion of the population variance explained by genetic factors for the behavioral characteristic in question, and they assume that such estimates also indicate the degree to which the characteristic is influenced by genetic factors.

OR

Step 3B: The MZA correlation directly estimates heritability (IQ, 1990 *Science* article)

The MZA group correlation is assumed to "directly estimate heritability," because it is assumed that MZA pairs share only their genes in common: "The MZA intraclass correlation directly estimates broad heritability because MZA twins share all their genes but do not share their rearing environment. In other words, MZA co-twins have only their genes in common, so their observed similarities reflect their shared genes."[16] Like model-fitting procedures, environmental influences on MZA correlations are counted as genetic influences. Because heritability is estimated directly and solely from the MZA group correlation, DZA control group correlations are ignored, omitted, or both.

Step 4: Conclusion

After finding "evidence for the strong heritability of most psychological traits," it is concluded that genetic factors "exert a pronounced and pervasive influence on behavioral variability."[17]

I will refer to these steps throughout this article. The researchers' decision-making process is shown in Figure 1.

Figure 1

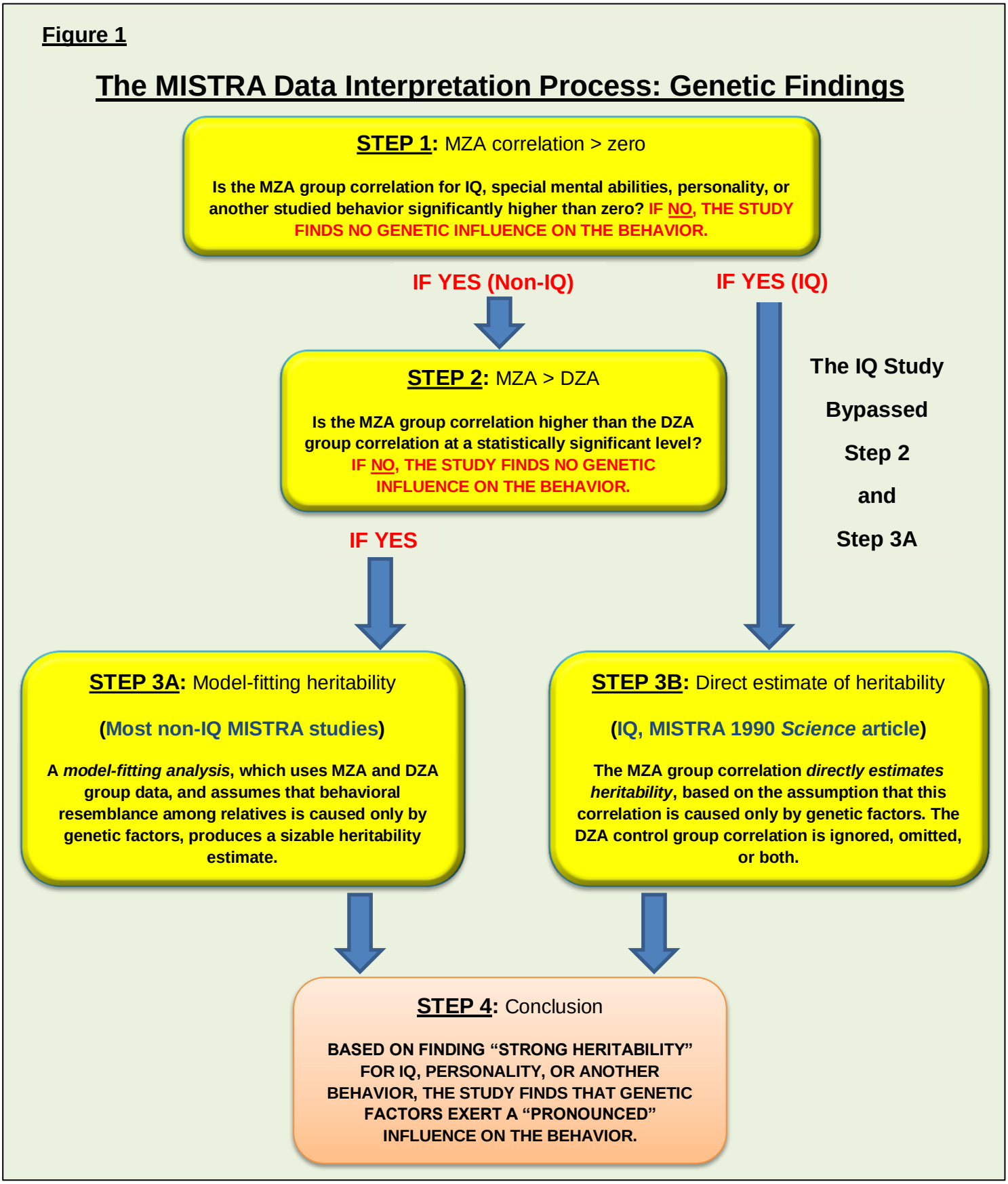
The MISTRA Data Interpretation Process: Genetic Findings
STEP 1: MZA correlation > zero
Is the MZA group correlation for IQ, special mental abilities, personality, or another studied behavior significantly higher than zero? IF NO, THE STUDY FINDS NO GENETIC INFLUENCE ON THE BEHAVIOR.
IF YES (Non-IQ)
IF YES (IQ)
STEP 2: MZA > DZA
Is the MZA group correlation higher than the DZA group correlation at a statistically significant level? IF NO, THE STUDY FINDS NO GENETIC INFLUENCE ON THE BEHAVIOR.
The IQ Study Bypassed Step 2 and Step 3A
IF YES
STEP 3A: Model-fitting heritability
(Most non-IQ MISTRA studies)
A model-fitting analysis, which uses MZA and DZA group data, and assumes that behavioral resemblance among relatives is caused only by genetic factors, produces a sizable heritability estimate.
STEP 3B: Direct estimate of heritability
(IQ, MISTRA 1990 Science article)
The MZA group correlation directly estimates heritability, based on the assumption that this correlation is caused only by genetic factors. The DZA control group correlation is ignored, omitted, or both.
STEP 4: Conclusion
BASED ON FINDING "STRONG HERITABILITY" FOR IQ, PERSONALITY, OR ANOTHER BEHAVIOR, THE STUDY FINDS THAT GENETIC FACTORS EXERT A "PRONOUNCED" INFLUENCE ON THE BEHAVIOR.

Figure 1 provides a roadmap of the decision-making process that the researchers themselves did not provide. The logic that they used to arrive at their conclusions in favor of genetics was inconsistent and difficult to follow. The summary (abstract) of the 1990 *Science* article could be interpreted as saying that the study's 70% IQ heritability estimate was based on MZA-MZT comparisons, but in the body of the article this estimate was based only on the "MZA correlation directly estimates heritability" claim (Step 3B). Turning to non-IQ behaviors such as personality and vocational interests, in most MISTRA publications the genetic findings were based on Step 3A model-fitting results, yet in the 1990 *Science* article, genetic findings were based only on Step 3B. Furthermore, the *Science* IQ heritability estimate was arrived at "under the assumption of no [MZA] environmental similarity," yet later in the article the researchers concluded that "MZA twins are so similar in psychological traits because their identical genomes make it probable that their effective environments are similar." Apparently, MZA twins *did* experience environmental similarity.

The 1990 *Science* article began with the statement, "Monozygotic and dizygotic twins who were separated early in life and reared apart (MZA and DZA twin pairs) are a fascinating experiment of nature. They also provide the simplest and most powerful method for disentangling the influence of environmental and genetic factors on human characteristics." However, this "fascinating" and "most powerful" "experiment of nature" did not appear in the article, and all DZA findings and correlations were omitted! The summary stated that the study tested "more than 100 sets of reared-apart twins or triplets," but the article reported correlations for less than half of these sets. It is simply amazing that this confusing (and confused) article based on the obviously false MZA "no environmental similarity" assumption (see below), where the DZA *control group* correlations were omitted, made it through the supposedly rigorous peer-review process of one of the world's leading scientific journals, and continues to be cited favorably in leading psychology textbooks and elsewhere as a "landmark study."

The Disappearing DZA Group IQ Correlations

We have seen that, depending on which behavior they were studying, the researchers used different methods to arrive at their major conclusions. Apart from the 1990 *Science* article, for most *non-IQ* MISTRA-studied behaviors they appear to have followed Steps 1, 2, 3A, and 4, assuming that the Step 2 MZA-DZA group correlation comparisons were incorporated into the model-fitting analyses.

We have also seen that when analyzing their *IQ data* in the 1990 *Science* article and elsewhere, the researchers did not compare MZA and DZA correlations, and they did not use model-fitting analyses. Instead, as seen in Figure 1, they bypassed Step 2 and Step 3A, and based their conclusions on the Step 3B assumption that the MZA group correlation directly estimates heritability because MZAs share only their genes in common, and that environmental influences count as genetic influences. By using this maneuver, Bouchard and colleagues ***completely removed the DZA control group data from the process they used to arrive at their conclusions in favor of "pronounced" genetic influences on IQ.***

To this day, the MISTRA researchers have not published their full-sample DZA control group IQ correlations. Perhaps this is because, as the *near* full-sample DZA IQ correlations published in 2007 and 2012 strongly suggest, the full-sample MISTRA MZA group IQ

correlations were not higher than the corresponding DZA group correlations at a statistically significant level, and therefore failed to meet the Step 2 requirement of finding a significantly higher MZA versus DZA correlation.[18]

Because, with the data in hand, the researchers decided to bypass Steps 2 and 3A in their IQ study—and to thereby ignore their DZA control group IQ correlations—their conclusions in this area rested on the assumption that all factors influencing significantly above-zero MZA group correlations should be counted as genetic factors, and on the accompanying assumption that the MZA correlation "directly estimates heritability" (Step 3A). As we will soon see, and as I argued in *The Trouble with Twin Studies*, the numerous biases built into the study, in addition to the many non-familial environmental influences shared by MZA pairs, show that these assumptions are utterly false.

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The all-important question to be answered in a TRA study is the following one:

> ***Assuming that the tests and the behavioral categories in question are valid, what is the cause, or what are the causes, of statistically significant above-zero MZA group psychological test-score correlations?***

In this article I present the critics' case against genetic interpretations of the MISTRA MZA correlations, in the form of 22 reasons (either standing alone or in combination with other reasons) why such interpretations should be rejected. Similar to other behavioral genetic research methods and previous TRA studies, I will show that the MISTRA was unable to disentangle the potential influences of genes and environments (nature and nurture) on human behavior. Here I will simply list the 22 reasons and elaborate on some of them. For a complete analysis of these issues, please see the full version of this article.

Twenty-Two Reasons to Reject the MISTRA Researchers' Conclusions in Favor of "Pronounced and Pervasive" Genetic Influences on Human Behavioral Differences

1. TRA studies based on volunteer twins recruited through media appeals, such as the MISTRA, produce samples that favor the inclusion of behaviorally similar twin pairs.

2. The validity and usefulness of the "heritability" concept is controversial, and it has rightfully been called one of the "most misleading [terms] in the history of science."

3. The researchers refused to share their raw data and information with independent reviewers and potential critics.

4. The researchers' conclusions were based on assuming the validity of what are in fact disputed psychometric tests and concepts, with "IQ" being the most well-known example.

5. The researchers' conclusions were influenced by their strong biases in favor of genetic explanations of their data.

6. The researchers published only minimal information on the twins they studied.

7. Most MZA twins were abandoned children, and most suffered because of this. Their unique status as abandoned twins, in addition to other factors, casts doubt upon the researchers' claim that the MISTRA results can be generalized (applied) to the non-twin population.

8. Twins were not placed randomly, which contributed to the creation of an MZA sample that was biased in favor of behavioral similarity. Two sources of similarity bias introduced by non-random placements are the "selective placement" of adopted-away twins on the basis of their biological parents' socioeconomic status (SES) and perceived genetic background, and the restricted SES range of adoptive family homes.

9. As I showed in *The Trouble with Twin Studies*, the evidence suggests that most studied MZA pairs were only *partially* reared apart. As one example, MISTRA MZA pair Gladys Lloyd and Goldie Michael were 57 years old when they arrived in Minneapolis circa 1980, presumably after responding to a MISTRA media appeal:

> "In 1964, Gladys was married to a businessman who, behind her back, also wanted her twin as his mistress. He asked Goldie if he could buy a house for her, and a car, in return for her secret favours….Gladys found out and divorced the man. Since then the relationship between the sisters has been off and on. When they were both pregnant, they were close. They were also so alike then that Gladys's husband (another one) kissed Goldie by mistake as he came into the house one day from the office."[19]

According to the MISTRA criteria, Gladys and Goldie, in addition to another pair who "had been close friends for over thirty years,"[20] qualified as a pair of "reared-apart" MZ twins. Presumably (critics are not permitted access to the raw data), there are many more "separated" twins of this type in the MISTRA MZA sample.

10. The MISTRA twins had financial and personal incentives to exaggerate, or to even lie about, their degrees of separation and behavioral similarity. An example of the behavioral similarity aspect is seen in the 2018 movie *Three Identical Strangers*, where one of the two surviving MZA triplets confirmed that in the 1980s, he and his brothers emphasized their similarities and downplayed their differences. The triplets attempted to profit from their fame on the basis of these claimed similarities. Although not mentioned in the movie, in a 1981 appearance on the U.S. *Today* show they revealed that they were enrolled in acting classes and hoped to star in a TV situation comedy. When that didn't happen, as seen in the

movie they opened a New York restaurant called "Triplets" that made over $1 million dollars in its first year of operation.

11. The key MISTRA assumption that above-zero MZA group behavioral and psychological test-score correlations are caused by genetic factors, because "MZA pairs share only their genes in common," is false. Because in most societies men and women are socialized from birth to behave, think, and feel in differing gender-specific ways, the members of an MZA pair will behave more similarly for this reason alone. As a simple example, in Western societies *female-female* pairs are much more likely to resemble each other (correlate higher) for "lipstick-wearing behavior" than are *female-male* pairs. Examples of this type are usually overlooked by the popularizers of TRA studies.

    In addition to incomplete separation, volunteer status, sex effects, selective placement bias, and range restriction bias, there are numerous non-genetic non-familial prenatal and postnatal factors that contribute to MZA behavioral resemblance, including cohort effects. The *cohort effect* concept refers to similarities in age-matched people's behavior, preferences, beliefs, physical condition, and other characteristics that are caused not by heredity, but by experiencing stages of life at the same time in the same historical period and cultural milieu.[21]

    In her 2015 autobiography, rock musician and leader of *The Pretenders* Chrissie Hynde (born in 1951) described the huge difference between her views and lifestyle as a young adult, versus those of her parents. Her behavior and beliefs were heavily influenced by the U.S. post-World War II "baby-boom" generation and the counterculture of the 1960s and 70s, whereas her conservative Republican Ohio parents were heavily influenced by the preceding Great Depression/World War II generation. Hynde and her parents were born at different times in different eras, and when growing up were influenced by very different ideas, peer groups, technologies, birth control options, financial conditions, wars, career opportunities for women, and countless other cohort influences.

    Twins are of course born at the same time, and therefore are similarly exposed to cohort effects at the same points of their lives. Today in a typical big-city American coffeehouse, people reading the print edition of the daily newspaper are likely to be over 50 years old, not because of their genes, but because they grew up reading the newspaper this way. As behavioral geneticist Richard Rose pointed out in relation to the impact of cohort effects on MZA behavioral resemblance, "You're comparing individuals who grew up in the same epoch, whether they're related or not. If you asked strangers born on the same day about their political views, food preferences, athletic heroes, [and] clothing choices, you'd find lots of similarities. It has nothing to do with genetics."[22] It has been said that MZAs are "not so much similar to each other as they are similar to people of their eras and SES."[23]

    Even hypothetical MZA pairs (rarely found even in TRA studies) who were separated at birth, who never met each other, and who spent their entire lives not knowing that they had a twin, grow up experiencing many of the following 28 behavior-molding cultural/environmental influences in common:

1. Prenatal (including common prenatal exposure to toxins and other influences)
2. Postnatal healthcare
3. Postnatal nutrition
4. Postnatal exposure to environmental toxins
5. Birth cohort (same age)
6. Gender cohort (same sex)
7. Developmental stage
8. Striking physical resemblance, including facial appearance and height
9. Adoptee status (with accompanying abandonment and attachment issues)
10. National
11. Regional
12. Political
13. Socioeconomic or class status
14. Ethnic/racial
15. Language
16. Religious (defined in part as "a cause, principle, or system of beliefs held to with ardor and faith")
17. Oppression, racism, discrimination, or privilege on the basis of common racial or national background, gender, SES status, language, religious beliefs, etc.
18. Climate/Weather
19. Shifting gender roles and increased career opportunities for women
20. Age at puberty onset or menarche
21. Diet/nutrition
22. Advertising and marketing campaigns
23. Exposure to the mass media, Internet, social media, etc.
24. Legal status of abortion
25. Birth control technology and availability
26. Selective placement status (adoption)
27. Teaching methods and technological advances in education
28. Exposure to similar music and lyrics

Clearly, there are numerous environmental factors unrelated to "common rearing" that contribute to MZA behavioral similarity and psychological test-score correlations. This means that the key MISTRA Step 3A/3B assumption, that genetic factors are the only cause of above-zero MZA group psychological test-score correlations, ***is completely false***.

12. Findings based on MISTRA model-fitting analyses depended on the researchers' acceptance of assumptions that Bouchard admitted "are likely not to hold."[24] In fact, most of these assumptions were either false or questionable.

13. The MISTRA claim/assumption that environmental influences shared by MZA pairs should count as genetic influences is false, and was based on an illogical circular argument in which the researchers both concluded *and assumed* that behavioral resemblance between reared-apart twins is caused only by their shared genes. Because the researchers counted all factors that influenced twins' test-score correlations as genetic factors, they created a

genetic "heads I win, tails you lose" type of study that guaranteed that genetic explanations would prevail.

14. For the following reasons, the MISTRA Step 3B claim/assumption that the "MZA correlation directly estimates heritability" is false:

    - Most studied MZA pairs were only *partially* reared-apart
    - The MZA sample was biased in favor of behaviorally similar pairs
    - Even perfectly separated MZA pairs share many non-familial environmental influences in common
    - Environmental influences should not be counted as genetic influences
    - In the area of IQ, the researchers omitted their DZA group correlations (they bypassed Step 2)
    - There are major problems with the heritability concept itself

15. The researchers have never published their full-sample control group DZA IQ correlations. In other words these potentially conclusion-overturning correlations were, and remain, *suppressed*.

16. The published *near* full-sample MZA and DZA group IQ correlations for two of the three MISTRA IQ measures did not differ at statistically significant levels (Wechsler Adult Intelligence Scale, Raven's Progressive Matrices), meaning that the Step 2 requirement was not met (see Note 18). The researchers failed to publish any DZA group correlations for the third IQ measure, the "First Principal Component of Special Mental Abilities." This supports the critics' conclusion that the study found no evidence that genetic factors influence IQ. It also helps explain why the full-sample DZA group IQ correlations were suppressed, and why the researchers omitted all DZA correlations from their widely cited 1990 *Science* article.

17. A computer software program used by the researchers was designed to favor genetic explanations. When the DZA group correlation was too high, the researchers assumed that this was the result of "sampling variability." They used this software program to greatly diminish the impact of the (too high) DZA correlations, and to base genetic estimates mainly on the MZA correlations, which they assumed directly estimate heritability.[25]

18. Personality inventories (tests) and the "personality" concept are controversial. The results of one of the MISTRA-administered inventories, the widely used "Sixteen Personality Factor Questionnaire" (16PF), have never been published.

19. The results of a little-known 1998 behavioral genetic (non-twin) adoption study of personality which, though flawed, was methodologically far superior to the MISTRA and showed no genetic influences on personality, contrasted sharply with the MISTRA personality findings.

20. Single-case anecdotal stories of allegedly very similarly behaving MISTRA MZA pairs or triplets, such as the "Jim Twins," the "Nazi-Jew Pair," the "Fireman Twins," and the

"Three Identical Strangers," provide no scientifically valid evidence in favor of genetic influences on behavior. These cherry-picked stories are used mainly to sell false genetic-determinist theories to the general public. Behaviorally *dis*similar MZA pairs are rarely mentioned in media reports or in textbooks.

21. There is a lack of accountability and pre-registration in psychological research, and in social and behavioral science research in general. In his 2017 book *The Seven Deadly Sins of Psychology: A Manifesto for Reforming the Culture of Scientific Practice*, cognitive neuroscientist Chris Chambers highlighted these and other problem areas in psychological research, some of which are found in the MISTRA.

22. "Genes for behavior" are still "missing." Given the decades of sensationalized yet non-replicated claims of gene discoveries for behavioral traits and psychiatric disorders, the media and public response to recent claims based on genome-wide association studies, or to newer studies based on the "polygenic risk score" method, should be extreme skepticism and caution.

Conclusions

The central fallacy of the Minnesota Study of Twins Reared Apart was that the researchers claimed that above-zero MZA group psychological test-score correlations were caused by shared genetic influences, when these correlations can be explained by cohort effects and other *non*-genetic influences and biases, plus researcher bias and error. Like the TRA and twin method studies that came before it, the MISTRA findings were confounded by environmental influences, and the study therefore was unable to disentangle the potential influences of genes and environments on human behavior.

The researchers claimed that any genetic biases they may have had did not influence how they analyzed the data, or how they arrived at their conclusions. According to Segal, "We were interested in results of any kind on any topic that was studied. We did not decide how the data turned out, *the twins did*" (italics in original).[26] However, the "twins" did not decide to base the study's findings on key assumptions that "are likely not to hold," to omit the DZA control group results and correlations from the IQ study, to count environmental influences as genetic influences, to suppress the full-sample DZA group IQ correlations, to use a genetically biased computer software program to produce genetic findings, and to deny critics access to the raw data—*the researchers did*.

When social and behavioral science investigators refuse to make their raw data available for inspection and analysis by qualified reviewers—especially when the study's results have important social policy implications—we must automatically reject their findings when they are based on samples taken from rare populations that cannot be independently reproduced, such as reared-apart twins. The MISTRA researchers did not allow independent review of their raw data, and then asked us to accept their claim that genetic factors play a major role in causing behavioral differences among billions of human beings—past, present, and future—on the basis of how a few hundred abandoned twins performed on psychological tests. We must decisively

reject this claim, especially in the context of the decades-old failure to make confirmed discoveries of genetic variants that cause differences in IQ scores, personality, and other forms of behavior. This leads to the conclusion that the study's findings in favor of genetic influences on human behavioral differences must be rejected, that textbooks should be rewritten to reflect this conclusion, and that this should be widely reported in the media.

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LINK TO THE FULL VERSION OF THIS ARTICLE

About the Author

Jay Joseph, Psy.D. is a clinical psychologist practicing in the San Francisco Bay Area. Since 1998, he has published peer-reviewed articles and book chapters critically examining genetic theories and research in the social and behavioral sciences. He is the author of *The Gene Illusion: Genetic Research in Psychiatry and Psychology Under the Microscope* (2004), *The Missing Gene: Psychiatry, Heredity, and the Fruitless Search for Genes* (2006), *The Trouble with Twin Studies: A Reassessment of Twin Research in the Social and Behavioral Sciences* (2015), and *Schizophrenia and Genetics: The End of an Illusion* (2017). His blog "The Gene Illusion" can be found at the Mad in America website. A complete list of his publications can be found at his website.

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ENDNOTES

[1] Wright, L., (1997), *Twins: And What They Tell Us About Who We Are*, New York: John Wiley & Sons, pp. 143-144.

[2] Joseph, J., (2015), *The Trouble with Twin Studies: A Reassessment of Twin Research in the Social and Behavioral Sciences*, New York: Routledge.

[3] Segal, N. L., (2012), *Born Together—Reared Apart: The Landmark Minnesota Twin Study*, Cambridge, MA: Harvard University Press, Appendix A.

[4] Bouchard, T. J., Jr., Lykken, D. T., McGue, M., Segal, N., & Tellegen, A., (1990), Sources of Human Psychological Differences: The Minnesota Study of Twins Reared Apart, *Science*, *250*, 223-228, pp. 223, 227.

[5] Tucker, W. H., (2013), [Review of the Book *Born Together—Reared Apart: The Landmark Minnesota Twin Study*, by N. L. Segal], *Journal of the History of the Behavioral Sciences*, *49*, 337–341, p. 337.

[6] Segal, 2012, p. 400.

[7] Plomin et al., (2013), *Behavioral Genetics* (6th ed.), New York: Worth Publishers, p. 412.

[8] Segal, 2012, p. 63.

[9] Segal, 2012, p. 12.

[10] Bouchard et al., (1986), "Development in Twins Reared Apart: A Test of the Chronogenetic Hypothesis," in A. Demirjian (Ed.), *Human Growth: A Multidisciplinary Review* (pp. 299-310), London: Taylor & Francis, p. 300. Although at the beginning of the study Bouchard had designated DZA pairs as the MISTRA control group, and even though he had reaffirmed this in this 1986 publication, in his 2018 "Dunnette Prize Address" he implied (video starting at about 50:38) that the MISTRA control group consisted of *MZT* pairs: "Once we got our study going we realized…that we needed comparison groups, ordinary twins, non-adoptees and so we built a huge twin registry….We immediately built a control comparison group to see if we could replicate our findings." (Retrieved from YouTube 10/23/2018, URL: https://www.youtube.com/watch?v=zAPBHis9GKg).

[11] Although in their research publications Bouchard and colleagues did not base their genetic conclusions on MZA versus MZT comparisons, there are a few instances in later commentaries where they stated or implied that similar MZA-MZT correlations support such conclusions.

[12] Bouchard et al., 1990, p. 227.

[13] Segal, 2012, p. 61.

[14] McGue, M., & Bouchard, T. J., Jr., (1989), "Genetic and Environmental Determinants of Information Processing and Special Mental Abilities: A Twin Analysis," in R. Sternberg (Ed.), *Advances in the Psychology of Human Intelligence* (Vol. 5, pp. 7-45), Hillsdale, NJ: Erlbaum, p. 22.

[15] Segal, 2012, p. 111.

[16] Segal, 2012, p. 61.

[17] Bouchard et al., 1990, p. 223.

[18] The final MISTRA full sample consisted of 81 MZA and 56 DZA pairs. Based on a *near* full sample of 74 MZA and 52 DZA pairs, the MISTRA WAIS (Wechsler Adult Intelligence Scale) full-scale IQ correlations were MZA = .62, versus DZA = .50. The Raven's Progressive Matrices IQ correlations were MZA =.55, versus DZA = .42. The

Raven test was part of the larger MISTRA "Raven's Progressive Matrices /Mill-Hill Vocabulary Scale composite." The WAIS IQ correlations are taken from Segal, 2012, p. 286. The Raven IQ correlations are found in Johnson et al., (2007), Genetic and Environmental Influences on the Verbal-Perceptual-Image Rotation (VPR) Model of the Structure of Mental Abilities in the Minnesota Study of Twins Reared Apart, *Intelligence, 35,* 542-562, p. 552, Table 3, Test #21. Tests of statistical significance, using the VassarStats website, show that both the MISTRA WAIS and the Raven MZA versus DZA correlation comparisons fail to differ below the conventional .05 level of statistical significance (.17 and .18, respectively), meaning that the differences are assumed to have occurred by chance, and that there is no difference between the correlations.

[19] Watson, P., (1981), *Twins: An Investigation into the Strange Coincidences in the Lives of Separated Twins,* London: Hutchinson, p. 58.

[20] Segal, 2012, p. 132.

[21] The MISTRA researchers recognized that "for most psychological, physiological, and medical variables there are substantial age and sex effects." See McGue, M., & Bouchard, T. J., Jr., (1984), Adjustment of Twin Data for the Effects of Age and Sex, *Behavior Genetics, 14,* 325-343, p. 325. They devised a questionable and complicated statistical procedure, which they claimed corrected their psychological test-score correlations for these effects. In any case, age- and sex-effects on test scores are a small component of the many potential reared-apart twin study environmental confounds that I list in the present analysis.

[22] Richard J. Rose, quoted in Cole, K. C., (1995), "Innumeracy," in R. Jacoby & N. Glauberman (Eds.), *The Bell Curve Debate: History, Documents, Opinions* (pp. 73-80), New York: Times Books, p. 75.

[23] Farber, S. L., (1981), *Identical Twins Reared Apart: A Reanalysis*, New York: Basic Books, p. 77.

[24] McGue & Bouchard, 1989, p. 23.

[25] Johnson et al., 2007, p. 551, Footnote 4.

[26] Segal, 2012, p. 244.