

The Equal Environment Assumption of the Classical Twin Method: A Critical Analysis

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This paper analyzes a key theoretical assumption of the "classical twin method": the so-called "equal environment assumption" (EEA). The purpose of the discussion is to determine whether this assumption, which states that identical and fraternal twins experience similar environments, is valid. Following a brief discussion of the origins of the twin method and the views of its main critics, the arguments of its principal contemporary defenders are examined in detail. This discussion is followed by a critique of several studies which have been cited as evidence in support of the equal environment assumption. It is concluded that the equal environment assumption does not stand up to critical examination, thereby calling into question the claim that the twin method measures genetic effects on human behavior and personality differences.

This paper assesses the theoretical foundation of the so-called "classical twin method." Twin studies are routinely cited in support of the idea that a particular psychiatric condition or psychological trait carries a genetic predisposition or component, but the method has in fact been the topic of considerable controversy. The theoretical issues surrounding schizophrenia twin studies will be emphasized, due to the fact that this diagnosis has been the subject of several well-known studies, and serves as the model for twin studies of human behavior and personality.

Inspired by the writings of Francis Galton (1875), and developed further by Hermann Siemens (1924), the twin method has been promoted since the 1920s as a way of determining whether a particular condition or ability has a genetic component. The method consists of comparing the concordance rates or correlations of identical twins (also known as monozygotic, or MZ

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twins) with the same measures of same-sex fraternal twins (also known as dizygotic, or DZ twins). In the case of psychiatric conditions such as schizophrenia, a significantly higher concordance rate among MZ twins when compared to DZ twins has been cited as evidence for the operation of genetic factors.

Identical twins are the product of a fertilized egg (also known as a "zygote") that splits into two parts. This phenomenon produces human beings genetically identical to each other. Fraternal twins result from the fertilization of two separate eggs by different sperm cells. Therefore, although they are born at the same time, they are genetically no more similar than ordinary siblings. The term "zygosity" refers to the genetic status of a particular pair of twins: MZ or DZ.

As summarized in a behavior genetics textbook (Plomin, DeFries, and McClearn, 1990), the twin method is based on three primary assumptions, all of which must be true in order to be able to claim that the method is measuring genetic influence:

- (1) It is assumed that there are two types of twins, identical and fraternal. Identical twins share 100% of the same genes; fraternal twins share, on average, 50% of their genes.
- (2) Findings relating to twins are generalizable to the entire population.
- (3) MZ and DZ pairs are assumed to share equal environments.

Assumption (3) is commonly known as the "equal environment assumption," and is the subject of the present analysis. If all three assumptions are valid, and if identical twins are found to be significantly more similar than fraternal twins, this would then be considered evidence for a genetic component for a particular condition.

Heritability estimates using the twin method have been calculated as $2(r_{mz} - r_{dz})$, where r_{mz} is equal to the MZ concordance rate, and r_{dz} represents the DZ concordance rate (Falconer, 1965; Smith, 1974). Both Falconer and Smith acknowledged that this calculation is based on the presumed equality of environments between twin types, and that it probably overestimates the degree of genetic determination. Falconer (p. 70) cautioned that conclusions drawn from twins are "not very precise," although their usefulness would be increased if reliable estimates of heritability were obtained from other sources as well.

The first major critique of the schizophrenia twin studies appeared in 1960. Its author was Don Jackson, then Director of the Mental Research Institute in Palo Alto, California. Jackson was a well-known pioneer of family systems theory, and had been a co-author of a widely discussed article outlining the

“double-bind” theory of schizophrenia (Bateson, Jackson, Haley, and Weakland, 1956). Despite Jackson’s belief that genetic factors play a role in the development of schizophrenia, his (1960) critique remains the finest and most original paper in the environmentalist camp. At the time of the report, there were five published schizophrenia twin studies — Kallmann’s (1946) report being the most prominent. (Through 1997, seven more schizophrenia twin studies were published, for a total of twelve.) Jackson’s basic argument was that the methodologies of the five twin studies were flawed, and that the results of these studies contained trends which were difficult to explain from a genetic perspective. He put forward the idea that the unique psychological bond experienced by identical twins could explain MZ–DZ concordance rate differences.

Jackson’s paper had a tremendous impact on the debate over the causes of schizophrenia, and threw the schizophrenia twin-studying world into disarray. His critique raised serious doubt that the twin method measured anything other than the close association and “ego fusion” of twins. With the exception of one or two points, his arguments have never been answered satisfactorily, and for a long time twin researchers carefully considered his observations and attempted to improve the methodology of their studies. But most failed to understand that the implication of Jackson’s critique was not that the twin method was in need of improvement, but rather, that its logic was erroneous at the core level.

The twin method, at least as it relates to schizophrenia, was rehabilitated on the basis of a greater acceptance of genetic theories in general, as opposed to any demonstration of theoretical soundness. Had it not been for the acceptance of the conclusions of the schizophrenia adoption studies (Kety, Rosenthal, Wender, and Schulsinger, 1968; Kety, Rosenthal, Wender, Schulsinger, and Jacobsen, 1975; Rosenthal, Wender, Kety, Welner, and Schulsinger, 1971), it is unlikely that the method would be held in the regard that it is today. In a sense, the twin method was given a last-minute reprieve before its theoretical weaknesses could be fully revealed and acknowledged.

Jackson (1960) noted that female MZ twins were consistently more concordant for schizophrenia than MZ male pairs; that female DZ twins were more concordant than male DZs; that DZ twins were more concordant than ordinary siblings (who bear the same genetic relationship to each other as DZ twins); and that same-sex DZ twins were more concordant than opposite-sex DZ twins. By pooling schizophrenia twin studies carried out both before and after Jackson’s critique, one finds that the differences examined in these four comparisons are significantly imbalanced in the direction of greater concordance on the basis of closer identification and more similar environment (Joseph, 1998). From the environmentalist perspective, argued Jackson, female twins would be expected to be more concordant than male twins:

The heavy incidence of female pairs would point to there being a "closeness" in sisters, especially fraternal twin sisters, which might be accounted for, in part, by some of the following facts. Culturally, girls are more restricted in activities outside the home than are boys. This was especially true in the years nearer the Victorian era, the time at which the patients in these various studies were going through childhood and adolescence Under these conditions, the boys probably work away from home, whereas the girls help around the house or work as domestic servants, with little opportunities for social contacts. Close ties between sisters do not carry the opprobrium that they might with brothers. "Sissy" and "homosexual" implications would be more likely to attach to brothers than to sisters in our culture, especially in terms of kissing, hugging, handholding, and so on Sisters even more than brothers may experience considerable guilt and fear about establishing sexual relationships, and in turn would be driven back to each other as an outlet for feelings they dare not acknowledge. (Jackson, 1960, pp. 67-68)

Two examples of how identification factors may have been evidenced in individual studies should be mentioned: (1) Kallmann's (1946) DZ same-sex twins were significantly more concordant for schizophrenia than his DZ opposite-sex twins (34/296 vs. 13/221, $p = .019$, Fisher's Exact Test, one-tailed). (2) In Slater's (1953) study, the female DZ concordance rate was reported as 9/40 (22.5%), while the schizophrenia rate for siblings of schizophrenic twins was listed as 26/568 (4.6%). The probability that this difference occurred by chance is .0002 (Fisher's Exact Test, one-tailed). Strikingly, the ratio of these concordance rates (4.9:1) is actually greater than Slater's MZ/DZ concordance rate ratio (68% MZ vs. 18% DZ, ratio equals 3.8:1).

The Equal Environment Assumption

As mentioned, the claim that the MZ-DZ concordance rate difference proves the existence of the operation of genetic factors is based on the assumption that MZ and DZ twins share similar environments. The equal environment assumption (or "EEA"), in the words of leading twin method advocates, is a "critical assumption" (Scarr and Carter-Saltzman, 1979). According to Kendler,

The EEA is crucial because, if the EEA is incorrect, excess resemblance of MZ twins compared with DZ twins ascribed to genetic factors could be partly or entirely due to environmental effects. (1993, p. 906)

Put another way, the entire theoretical basis for twin studies that look at genetic components of human behavior and psychiatric conditions *stands or falls on the veracity of this assumption*. For this reason, it will be necessary to investigate the equal environment assumption at some length. Although many commentators have noted that identical twins experience more similar environments than fraternal, the present review is aware of only one critique

that looked specifically at the equal environment assumption (Pam, Kemker, Ross, and Golden, 1996). These authors concluded that the equal environment assumption was not viable, and that the twin method is therefore of "dubious scientific value" (p. 349).

Kendler has made the defense of the equal environment assumption a major aspect of the argument in favor of the validity of the twin method. He began this task in 1983 and has continued to defend the equal environment assumption up to the recent period (Hettema, Neale, and Kendler, 1995). In one sense, Kendler's view of the equal environment assumption is consistent with the original premise upon which the twin method was founded: that the environments of MZ and DZ twins do not play a role in concordance rate differences between the two types of twins. Kendler not only maintains that concordance rates are unaffected by environmental differences, but that the environment cannot have such an effect in order for the twin method to be able to say anything about the heritability of the condition under study.

Kendler does not discuss the evidence from schizophrenia twin studies suggesting that factors of identification and closeness related to sex roles affected concordance (e.g., the critiques of Jackson, 1960; and Lewontin, Rose, and Kamin, 1984). In response to Jackson's objections to the logic and claims of the method, which challenged a generation of twin researchers before him, Kendler remains silent. He has not acknowledged nor attempted to explain the fact that MZ female twins are consistently and significantly more concordant for schizophrenia than MZ males. The same could be said for the fact that DZ opposite-sex twins are less concordant than DZ same-sex twins, and so on. For Kendler, these issues are apparently unworthy of discussion.

Reading Kendler, one would have little idea that the validity of the method, centered around the question of environmental similarity, had been discussed before 1983. And in fact, before the appearance of Jackson's critique, the equal environment assumption was rarely challenged. It was simply taken for granted by twin researchers, and was not even named until the 1970s. By naming the assumption, as opposed to the previous practice of simply describing it, Kendler and his fellow behavior and psychiatric geneticists attempted to settle the question of its legitimacy once and for all. However, they also placed the twin method in a more vulnerable position — for by giving the assumption a name, they provided a more concrete concept for critically minded reviewers to examine and evaluate.

Because MZ concordance rates fall well short of 100%, virtually all genetic researchers acknowledge that "the environment" plays a role in schizophrenia. When they speak of a person's environment, they are thinking of factors such as family experience, intrauterine or birth trauma, and viruses. Some twin researchers discuss the effects of parental treatment, but rarely do they mention the reality of parental mistreatment. They may speak of nature *and*

nurture as being important but, with a few exceptions, their fixation on genes leads them to disregard the realities of childhood trauma and abuse.

For most twin researchers, a twin-pair's environment is analogous to a journey on a passenger train: twin-pairs are seen as experiencing similar environments simply because they board the train at the same time, and presumably get off at the same time. Based on this information, it is assumed that they must have had similar trips. They may inquire about sleeping arrangements, and whether the twins sat together during the journey, but their treatment by the conductor and by the other passengers — not to mention the twins' mutually interactive experience of the voyage — remains a mystery. Most twin researchers see the environment "as being rather like decor — something that is there and reacted to, rather than a complex series of interactions" (Boyle, 1990, p. 137).

It is necessary to discuss exactly what is meant by the term "equal environment assumption." The following definitions are derived from important defenders of the twin method.

The basic underlying assumption of the classical twin method is, of course, that environmental conditions of monozygotic twins do not differ from those of dizygotic twins. (Kringlen, 1967, p. 20)

The validity of comparisons between MZ and DZ twins depends on the assumptions that the two types of twins are not essentially different from the single-born population or from one another, and that intrapair environmental differences are the same for the two types of twins. (Rosenthal, 1970, p. 268)

[The MZ–DZ concordance rate difference] proves the importance of genotype unless it can be shown that . . . the environments of MZ twins are systematically more alike than those of DZ twins in respects which can be shown to be of etiological significance for schizophrenia. (Gottesman and Shields, 1972, p. 25)

The method assumes that the degree of environmental similarity is about the same for the two types of twins [MZ and DZ]. (Plomin et al., 1990, p. 315)

The traditional twin method, as well as more recent biometrical models for twin analysis, are predicated on the equal-environment assumption (EEA) — that monozygotic (MZ) and dizygotic (DZ) twins are equally correlated for their exposure to environmental influences that are of etiologic relevance to the trait under study. (Kendler, Neale, Kessler, Heath, and Eaves, 1993, p. 21)

The reader should note that the definitions put forward by Gottesman and Shields and Kendler et al. differ from the others in one important respect: these authors add the qualification that the environments are assumed to be similar *regarding the environmental factors that contribute to the etiology of schizophrenia*. There is a problem with this line of reasoning, since there is widespread disagreement over what these environmental factors might be.

These theorists had to change the traditional definition of the equal environment assumption when some studies (such as Smith, 1965) showed that MZ twins were treated more alike and spent more time together than DZ twins. Most present-day defenders of the equal environment assumption concede this point; hence the necessity of redefining the assumption — or of abandoning the twin method itself.

However, in redefining the assumption, Gottesman and Shields have set a theoretical trap for themselves (and for Kendler). In their most important book on schizophrenia they concluded,

Despite high hopes, the study of discordant MZ pairs has not yet led to a big payoff in the identification of crucial environmental factors in schizophrenia. The problem is simply more difficult than we can cope with . . . the culprits may be nonspecific, time limited in their effectiveness, and idiosyncratic. (1982, p. 120)

In other words, they define the equal environment assumption as assuming an equal environment “in respects which can be shown to be of etiological significance for schizophrenia,” but they have no idea what these environmental factors might be. As Jackson noted, “until there exists a valid theory of psychogenic causation for schizophrenia, we cannot state what constitutes psychic trauma for the schizophrenic-to-be” (1960, p. 38). It can be further argued that one cannot state that the environments between twin-pairs are equal without being able to define what criteria are used in the definition of “equal environments.”

Later in the same book, Gottesman and Shields affirmed that “the evidence reviewed so far in this book exonerates parents from having caused their child’s schizophrenia by their methods of rearing” (p. 200). What is not explained is how parents can be so easily “exonerated” when it is acknowledged that the environmental contributors to schizophrenia remain unknown.

In Gottesman and Shields’ voluminous writings on the subject of schizophrenia and genetics, one finds few references to the idea that psychodynamic factors related to childhood mistreatment might be a part of the mysterious “environmental factor” in schizophrenia. In fact, Gottesman, in a more recent book co-authored with Torrey, has stated that, “We believe that the psychodynamic and family interaction theories of schizophrenia have been completely discredited and are no longer worthy of study” (Torrey, Bowler, Taylor, and Gottesman, 1994, p. 10). Gottesman, therefore, would not consider family interaction to be of “etiological significance” in the environments of MZ and DZ twins. But this is a major factor put forward by advocates of an environmental causation of schizophrenia, as well as by many supporters of the “diathesis/stress” model.

Because Gottesman and Shields, along with Kendler, cannot tell us what environmental influences contribute to the etiology of schizophrenia, their

definitions of the equal environment assumption are unworkable, and are therefore unacceptable. Their condition that the two types of twins are assumed to share similar environments "in respects which can be shown to be of etiological significance for schizophrenia" must therefore be rejected. This leaves us with the traditional definition of the Plomin et al. type (1990): "The method assumes that the degree of environmental similarity is about the same for the two types of twins [MZ and DZ]" (p. 315). However, we have already seen that most twin method supporters concede the point that MZ and DZ twins experience different environments. For example, Scarr and Carter-Saltzman (1979) have written that "the evidence of greater environmental similarity for MZ than DZ twins is overwhelming" (p. 528). Therefore, the traditional definition of the equal environment assumption must also be rejected. Since by their own indirect admission, definitions of the equal environment assumption put forward by twin method supporters are untenable or simply untrue, where does this leave us?

Recently, a pair of behavior geneticists attempted to extricate the twin method from the corner into which its defenders had painted it, by seemingly redefining the equal environment assumption to match the new way it was being viewed. It has now become the "equal trait-relevant environments assumption":

A central assumption of the twin method is that MZ twins are not treated more similarly than DZ twins or, if they are, that the difference in treatment is not relevant to the phenotype under study. (Carey and DiLalla, 1994, p. 33)

This definition is simply a restatement of the Gottesman and Shields/Kendler formulation in different terms, and therefore must also be rejected. Because the environmental factors of schizophrenia remain unknown, there are few "treatments" which can be ruled irrelevant in its etiology.

The question really comes down to the idea that treatment does not affect behavior, or as noted by Pam et al., "the 'equal trait-relevant environments assumption' could just as reasonably be called the 'unequal-environments-don't matter assumption'" (1996, p. 354). The implicit claim of contemporary defenders of the equal environment assumption is that *childhood treatment does not affect childhood or adult behavior*. The equal environment assumption and the twin method attempt to hang on by this theoretical thread — for it is the only thread left.

The present assessment has taken the liberty of recognizing this definition for the simple reason that, as we have seen, twin researchers have virtually defined the equal environment assumption out of existence — yet what they seem to be defending is captured by the definition stated above. Virtually all of the pro-equal environment assumption studies cited by Kendler attempt to show that although identical twins experience more similar environments

than fraternal, this greater environmental similarity does not lead to more similar behavior.

In order to fully appreciate Kendler's argument in favor of the equal environment assumption, it will be necessary to quote a passage from a book chapter that he wrote in the mid-1980s. The passage will be quoted in its entirety in order to illustrate the theoretical continuity in his thinking:

Twin studies are based on the assumptions that (a) monozygotic (MZ) and dizygotic (DZ) twins share their environment to approximately the same degree, but (b) MZ twins are genetically identical whereas DZ twins, like normal siblings, have on average only half of their genes identical by descent. Although the second of these assumptions is beyond question, the first, or "equal environment" assumption, has been a focus of considerable controversy. Several studies have shown that measures of the social environment (e.g., sharing the same friends, attitudes of parents and teachers, etc.) are more highly correlated among young MZ than among young same-sex DZ twins (Kendler, 1983). These results first appear to suggest that the equal environment assumption is false. However, reflections suggest another possible interpretation. Although the similarity in environment might make MZ twins more similar, the similarity in behavior of MZ twins might *create* for themselves more similar environments. As recently reviewed (Kendler, 1983), these two alternative hypotheses have been subject to empirical test in at least nine different studies. Consistently, these studies suggest that the environmental similarity of MZ twins is the *result* and not the cause of their behavioral similarity. Whereas most of these studies examined such traits as intelligence and personality, one specifically examined schizophrenia and found no evidence that concordance for schizophrenia was produced in MZ twins as a result of the similarity of their treatment by the environment (Kendler, 1983). Current evidence supports the general validity of the equal environment assumption of twin studies. (1987, p. 706)

This quotation captures the essence of the errors and distortions of the majority of Kendler's written work on the subject of the twin method and the equal environment assumption.

Kendler begins with a definition of the equal environment assumption that he has rarely used before or since — i.e., the traditional definition of the equal environment assumption that "twins share their environment to approximately the same degree." Missing is Kendler's usual condition that only environmental factors contributing to the trait in question are to be considered. He then correctly points out that the equal environment assumption has been beset by controversy, although as usual, he fails to discuss the names, dates, and ideas associated with this controversy. He goes on to concede that evidence shows that his equal environment assumption definition is false, after which he offers a "possible" genetically derived interpretation for these different environments. Nine separate studies are put forward in support of his hypothesis, including one examining schizophrenia. Kendler cites his 1983 "Overview" article as the source of this study. However, his 1983 article was just that — an overview of pro-equal environment assumption literature presented in support of schizophrenia twin studies. It included

no report of a study which “specifically examined schizophrenia and found no evidence that concordance for schizophrenia was produced in MZ twins as a result of the similarity of their treatment by the environment.” Kendler is most likely referring to the summary of his and Robinette’s unpublished 1982 study on the relationship between physical similarity and concordance for schizophrenia. The conclusion of this study, which as of 1997 remains unpublished, was that “no correlation between degree of physical similarity and concordance rate for schizophrenia” was found (Kendler, 1983, p. 1415). This study, then, only *assumed* environmental treatment based on appearance. But the reader of Kendler’s chapter would never know this without going back to the 1983 article.

Finally, in spite of agreeing with the idea that MZ twins are treated more similarly than DZ twins, Kendler concludes that the equal environment assumption is valid based on the current evidence *without changing his equal environment assumption definition*. He is claiming the following:

- (a) The equal environment assumption is based on the idea that MZ and DZ twins share similar environments.
- (b) MZ twins’ environments are more highly correlated than the environments of DZ twins.
- (c) The equal environment assumption is valid.

Logic dictates that he would have to change his definition of the equal environment assumption for claim (c) to follow from premises (a) and (b). But Kendler does not do this. We are supposed to believe something is valid after he has just finished telling us that it is not.¹ The conclusions of twin studies have influenced decisions resulting in the allocation of millions of dollars of research money in the direction of genetic research and away from environmental causes of human problems. Pseudoscientific theories of racial and class inequality have been based, in part, on the study of twins. In other words, there is a lot at stake. If the principal theoretical defender of the twin method and the equal environment assumption cannot adequately define what he is supposed to be defending, then this alone raises questions about the assumption.

¹This is not a question of splitting hairs. The lives of millions of people are affected by the acceptance of the conclusions of the twin method, and this method is predicated upon the validity of the equal environment assumption.

The Validity of the Equal Environment Assumption in the Words of Schizophrenia Twin Researchers

As we have seen, in order for the equal environment assumption to be valid it must be shown that the greater similarity in treatment and the closer psychological bond experienced by MZ twins do not contribute to the commonly found MZ–DZ concordance rate differences reported for various psychiatric diagnoses. The position of the present review is that *there is no reason to accept that higher concordance rates found among MZ twin-pairs are explained by anything other than environmental factors*. As we have seen, Kendler argues from the opposite position, that “behavioral similarity of monozygotic versus dizygotic twins cannot be ascribed to differences in treatment of the twins by the social environment” (1983, p. 1416).

It would be helpful at this point to review the opinions of several prominent schizophrenia twin researchers. Many have been quite candid concerning their doubts about the truth of the assumption; others have written of observed phenomena without understanding that what they were writing, if true, casts doubt on the validity of the twin method — because they implied that part or all of the MZ–DZ concordance rate difference could be attributed to environmental factors. If the present review and Kendler are in agreement about one thing, it is that if environmental factors are found to affect concordance rates, that this would mean the end of the twin method. Yet Kendler has not acknowledged or explained the views of these researchers. The time period from which these quotations are taken reflects the fact that eight of the twelve schizophrenia twin studies were published between 1940 and 1970. The quotations are listed in chronological order, and all italics have been added by the present author:

In only two of the 36 uniovular [MZ] pairs has a marked parental preference for one of the twins been obvious, and in each case *this has had an effect on their psychological development*. In one pair the mother talks of “my Clem” but never of “my Winston.”. . . Winston is in [behavioral] Severity Group 1, Clem in 3 . . . The second of these cases of parental discrimination is a pair of girls [Nancy and Norah] whom I saw at home being treated very differently by their mother . . . Relatives have remarked to her that she always complains of the one twin, never of the other. . . . Nancy is an unhappy-looking, resentful girl Norah is a much more normal personality. (Shields, 1954, p. 229)

The above findings do not rule out the possibility of other psychological hypotheses which might account for higher familial incidence, higher concordance in MZ than DZ twins, and no higher frequency of the illness in twins than in nontwins. *An hypothesis like “identification” might account for the higher concordance rate of illness in MZ twins. . . . One could imagine a co-twin being drawn toward schizophrenic behavior if his twin had become schizophrenic and if he felt himself to be so much like his twin that he was completely convinced that the fate which had befallen his twin would befall him as well. He might be unable to resist this conviction, and presumably could behave in accordance with it.* (Rosenthal, 1960, p. 303)

Even though the bodies of data presented have suggestive value in an accounting of the sex-concordance ratios found in studies of schizophrenia, the role of genetic factors cannot be excluded. However, if the found sex-concordance ratios are valid, *it seems reasonable to conclude that some psychological factors are influencing these ratios in good part.* (Rosenthal, 1962, p. 419)

Quite obviously, then, the logical evidence furnished by the classical twin method is not unambiguous, as originally believed. *A greater concordance in monozygotics must not invariably depend on their genetic identity,* since also their environment may have been more similar. (Essen-Möller, 1963, p. 69)

It is doubtful, moreover, whether the difference in concordance rates between identical and fraternal groups of twins can, as such, be ascribed to hereditary factors. In all likelihood, the environment, too, is more similar in the case of identical than in the case of fraternal twins Furthermore, it is obvious that the intensity of the mutual relationship of identical twins is considerably greater than that of siblings in general and, also, of fraternal twins *It is apparent that differences in concordance rates between groups of identical and fraternal twins, as well as between female and male pairs, are partly attributable to environmental (psychological) effects.* (Tienari, 1963, pp. 119-121)

The question is what will be the possible cause of concordance of neurosis in these twins. Theoretically there are several possible causes. *First is an environmental influence identically shared by two members of a twin pair. This mechanism was seen in one female monozygotic pair in dissociative reaction type.* In this pair the direct etiologies of the neurosis of both twins were diverse psychogenic factors and the common primitive cultural background, which coincidentally influenced the emotion of the twin subjects. The second possible cause of concordance is a susceptibility to neurosis in both twin members resulting from a particular situation to twins. This possibility was pointed out by not a few psychoanalysts *We pointed out the significance of mutual relationship between two members of each pair, and concluded that the particular situation is a probable cause of ego immaturity, which in turn is the probable cause of concordance of the neurosis or neurotic personality.* (Inouye, 1965, p. 1172)

Higher female concordances in two particular studies (Rosanoff and Slater) could be an artifact of sampling; or it could be associated with more environmental variability for males or with some aspect of the process of identification. (Gottesman and Shields, 1966a, p. 815)

Rosenthal considers that a psychological hypothesis such as identification might be used to explain differential concordance rates in MZ and DZ twins without implying a higher incidence of illness in MZ twins. *This would appear to be so provided that the same proportion of potential schizophrenics are held back from overt illness by identifying with a normal twin as those who became ill by identifying with an abnormal one.* (Gottesman and Shields, 1966b, p. 55)

[T]here is clearly brought out by the data a trend toward higher concordance rates for females, both in monozygotic and dizygotic same-sexed twins It is difficult to explain this tendency With an increasing female emancipation this sex difference in upbringing and attitudes toward boys and girls has diminished. This could offer an explanation of the disappearance of the higher female concordance rates in more recent studies. This phenomenon might also be related to national culture. *One would then expect higher female concordance to be particularly pronounced in cultures where girls and women are most restricted in their activities, whereas the phenomenon would vanish in cultures where females enjoy equal rights with males.* (Kringlen, 1967, pp. 91-92)

[C]oncordance rates are higher in pairs of female twins than in pairs of male twins. If this is confirmed, one might well conclude that the environmental contribution to causation could be responsible Anything which tends to diminish environmental

variance will tend to magnify the apparent contribution made by heredity, and this will show up in twin concordance rates just as much as in other measures. (Slater, 1968, pp. 23–24)

[I]t is established that the MZ co-twins of schizophrenics are at least twice as often and, in many types of samples, 4 or 5 times as often schizophrenic as DZ co-twins of the same sex. This difference will be accounted for by influences from two sources: by the effects of the greater genetic similarity of MZ twins, and by *greater similarity in environmental factors relevant to schizophrenia shared by MZ twins and not by DZ twins.* (Shields, 1968, p. 100)

An hypothesis like “identification” might account for the higher concordance rate in monozygotic twins without implying a higher incidence of schizophrenia in monozygotic twins. . . . Because there are not only genetic but also environmental differences between the monozygotic group and the dizygotic group, *differences in concordance rates may be explained by environmental as well as by genetic hypotheses.* (Hoffer and Pollin, 1970, p. 476)

The assumption that a number of environmental factors are similar in MZ and DZ pairs may be correct only to some degree. (Fischer, 1973, p. 10)

The result that there is a significant difference between concordance for schizophrenia in same sexed DZ pairs and same sexed sibling pairs might be an expression of a real difference, but it might be kept in mind that a statistically significant difference only expresses the likelihood of an event, *in this case the low likelihood that no difference exists.* (Fischer, 1973, p. 69)

The total difference in concordance rate between MZ and DZ twins cannot be ascribed to genetic factors only. A series of studies of both normal and abnormal twins show that the environment of the MZ twin pair is more similar than the environment of the DZ twin pair. (Kringlen, 1976, p. 431)

These quotations show that, in addition to Rosenthal,² who “provided a blueprint for improving the state of the art of schizophrenia twin studies” (Gottesman, 1991, p. 109), *the authors or co-authors of at least nine of the twelve schizophrenia twin studies have written that environmental factors have affected concordance rate differences found between male and female or identical and fraternal twins.* These observations stand counterposed to Kendler’s assertion that behavioral similarity of MZ twins versus dizygotic twins is unrelated to differences in treatment of the twins by the social environment, or to the closer bond that they share. Even among the schizophrenia twin researchers themselves, Kendler is truly the “odd man out.”

Of note is the fact that the majority of these quotations come from the ten-year period beginning immediately after Jackson’s (1960) critique and ending around 1970. After this period, most important schizophrenia twin researchers stopped making statements such as these. Boosted by the “findings”

²Rosenthal finally decided that the twin method was unable to separate possible genetic and environmental influences. By 1979, he would conclude that “in both family and twin studies, the possible genetic and environmental factors are confounded, and one can draw conclusions about them only at considerable risk” (p. 25).

of the schizophrenia adoption studies, the role of genes was now more widely accepted and many of those whose observations are chronicled above simply denied or ignored what they had written in the previous decade.

The reasoning of the above-quoted schizophrenia twin researchers illustrates a critical point which most apparently overlooked: according to twin method theory, there can be no finding of an inherited factor for a particular psychiatric condition if environmental effects are found to influence concordance rates calculated using the method. The twin method can only make genetic claims for a particular condition if the environments of MZ and DZ twins do not affect concordance rates. The belief that a greater level of identification and more similar environments lead to higher concordance rates must, according to the logic of the twin method, lead to only one conclusion — that the method itself is invalid. This is because any genetic conclusion drawn from the concordance rate difference between MZ and DZ twin-pairs is based on the assumption that *only* genetic similarities can explain this difference. If environmental factors are acknowledged, it would be possible that these factors could *completely* explain the concordance rate differences between MZ and DZ twins. Therefore, the present review's position is that *in heritability estimates based on twin method theory* environmental and genetic factors discovered to be influencing twin concordance rates are not additive; they are mutually exclusive.

However, the assertion that the finding of environmental and genetic effects on concordance rates cannot coexist in the conclusions of studies utilizing the twin method is not the same thing as saying that a given trait or condition cannot have both genetic and environmental components. These are two completely different statements. In the first, the conclusion that genetic factors have been found cannot be made because the found environmental effect violates the assumption upon which the genetic claim is based. This does not rule out the theoretical possibility that both genetic and environmental factors could be necessary for a given condition, but it does imply that other methods would be required in order to arrive at such a conclusion. The logic of the twin method is based on there being no environmental effect on *the difference between MZ and DZ twin concordance rates*, not necessarily on the trait or condition itself.

The "Twins Create Their Environment Theory"

Shields (1954) was one of the first twin researchers to put forward the idea that the supposedly inborn personalities of twins were responsible for the similarity of their treatment, as opposed to the idea that their treatment made them more similar:

In so far as [DZ] twins are treated differently from one another and more differently than [MZ] twins, this is likely to be due, not so much to causes outside the twins as to innate differences in the needs of the [DZ] twins themselves, manifested by different patterns of behavior. (pp. 239-240)

The theory lay dormant for over a decade, until it was rediscovered by Scarr (1968) and others as they attempted to refurbish the then-tarnished image of the twin method.

The defense of the equal environment assumption by twin method advocates has retreated from one position to another. First, they defined it as the assumption of similar environments between the two types of twin-pairs. When empirical studies confirmed what common sense already knew — that MZ twins are treated more alike than DZ twins — they retreated to the position that equality of environment need only relate to factors relevant to the etiology of the particular trait in question. It has been shown that this is not a viable alternative definition; twin method defenders cannot provide us with the environmental factors for the traits and behaviors in question. Then, an old theory was revived: that the inherited “similarity in behavior of MZ twins might *create* for themselves more similar environments” (Kendler, 1987, p. 706). As Kendler implied, this idea must be viewed as the theoretical “last stand” of the validity of the twin method. This concept — which shall be called here the “twins create their environment theory” — at first glance appears to be a place of refuge for the equal environment assumption and the twin method. As we shall see, it is a recurring theme in many of the studies we are about to look at. On the face of it, this seemingly implausible theory would nevertheless appear difficult for environmentalist researchers and theorists to refute — for how can such a “chicken or egg” type of question ever be resolved adequately? However, the theory is easily countered if one realizes that, by considering its implications, the “twins create their environment theory” is based on a fundamental error of thought, and the logical error of “special pleading.”

The theory is based on the belief that children are born with a genetic predisposition to manifest certain personality and behavior types; Loehlin and Nichols (1976) put the heritability factor at roughly 50%, and other behavior geneticists have calculated higher figures than this for particular traits. It follows, by this line of reasoning, that the personalities and behaviors of identical twins are similar due to their identical genetic makeup. Therefore, since MZ twins exhibit a genetically predisposed similarity of behavior, their parents and others in their social environment are induced to treat them more similarly. DZ twins, since they are more genetically dissimilar, inherit less similar personalities; hence they are treated more differently. The theory concludes that this inherited similarity of personality traits causes more equal

treatment, not the other way around. But, what is conveniently forgotten is this: according to this theory, *the twins' parents must also be genetically predisposed to manifest a particular personality and set of response modes.*

Advocates of the "twins create their environment theory" would have us believe that the postulated genetically predisposed personalities of children are able to greatly impact the necessarily similarly predisposed personalities and response modes of their parents. MZ and DZ twins are portrayed as genetically programmed to act in rough proportion to the number of genes they share in common, but their parents are seen as readily able to change their behavior and treatment of the twins on the basis of environmentally caused factors, i.e., the twins' personalities. Children are characterized by their inborn propensity to display inherited personality; parents are characterized by their plasticity in reacting to these personalities. If parents can change their behavior on the basis of environmental influences, as this theory explicitly maintains, it should follow that children (including twins) would *also* be able to adjust their behavior and personalities in response to environmental stimuli. If anything, genetic influences or not, we would expect adults to have personalities far less malleable than that of five-year-old children. Yet children are portrayed as having a greater ability to change the genetically predisposed personality of adults than adults have to create, through their treatment, similar behavior in MZ twins.

The thrust of this argument has been put forward in a slightly different form by Zerbin-Rüdin:

Twin studies, in particular, suggest the presence of a hereditary factor. The large difference between the concordance figures for MZ and DZ twins cannot be explained exclusively by the more similar environment of MZ twins. If MZ twins create a similar environment through their greater similarity, they do so because of the greater inherited similarity in their appearance and response modes. Thus, in a roundabout way, we still come back to the importance of heredity. (Zerbin-Rüdin, 1972, p. 48)

Like Kendler, Zerbin-Rüdin asserts that response modes are genetic — in order to *prove* that behavioral differences are genetic. But her argument goes beyond mere logical error; Zerbin-Rüdin's reference to the phenomenon of the striking physical similarity of MZ twins must be addressed. No one on either side of the twin method debate would claim that similarity of appearance by itself would cause a pair of twins to show high concordance rates for a particular psychiatric diagnosis. Therefore, Zerbin-Rüdin's assertion that "the greater inherited similarity in their appearance" would lead to more similar treatment of MZ twins is in complete accordance with the environmentalist position, which acknowledges that a greater *physical* similarity contributes to more similar treatment by the social environment, and therefore plays a part in the closer bond between members of the MZ twin-pair.

Furthermore, the great similarity of appearance among MZ twins is the result of the splitting of a fertilized egg; *it is not an inherited characteristic*. Rather, it is a biological phenomenon occurring in a zygote. For the reader who may view this claim with skepticism, a reminder is offered that what is being referred to is the similarity of identical twins' appearance *to each other*, not to their parents. A randomly selected fertilized egg, taken from a Petri dish and inserted into the uterus of a mother-to-be, would, should it split, produce MZ twins as identical in appearance as those produced by a split zygote conceived within the biological mother's own body. On the other hand, the degree of phenotypic similarity between DZ twins *is* inherited, because in this case we are dealing with two separately fertilized eggs, which require common genes in order to produce physical similarity. But Zerbin-Rüdin misses this point entirely.

Although not discussed by Kendler, an interesting aspect of the idea that identical twins create more similar environments for themselves by virtue of their more similar inherited personalities is that *even if this theory were true*, the twin method could still be measuring nothing more than environmental effects. Suppose for the moment that (1) the "twins create their environment theory" is correct, and (2) that it is discovered that schizophrenia is caused by brain damage due to the ingestion of a dangerous environmental toxin — mercury for example. Even if it were true that identical twins' environments were more alike because of their more similar inherited personalities, identical twins — by virtue of the universally acknowledged fact that they spend more time together, eat more similar foods, etc. — would correlate higher for exposure to mercury than fraternal twins, who spend less time together. It is therefore likely that identical twins would be more concordant for schizophrenia than fraternal twins — yet schizophrenia would still be completely environmental in origin.

Or take the example of skin cancer. Suppose that the love of the outdoors and the desire to sunbathe were inherited personality traits. Naturally, both members of a genetically identical MZ twin-pair would be likely to spend a lot more time at the beach than a DZ pair consisting of a sun worshiper and a co-twin who received a healthy dose of couch potato genes. Suppose a sun-worshipping twin from each pair is diagnosed with skin cancer. It is more likely that the co-twin of the MZ skin cancer patient would also have skin cancer than the remote-control wielding co-twin of the sun-worshipping DZ skin cancer patient, yet it would be erroneous to conclude that the higher MZ skin cancer concordance rate was suggestive of a genetic predisposition for skin cancer. Theoretically, twins' personality traits and behaviors could be under complete genetic control, yet the more similar behavior of MZ twins could still lead to higher levels of exposure to pathological *environmental* conditions. Therefore, regardless of whether identical twins are more alike

because they are treated more alike (conventional wisdom), or because they create more similar environments on the basis of more similar inherited personalities (Shields/Scarr/Kendler), the acknowledgment that identical twins spend more time together implies that the equal environment assumption is false.³

Kendler's support of the idea that the genetically predisposed personalities of twins create their more similar environments has been logically extended to the idea that *everyone* creates their environment. In a paper looking into the concept of "social support," Kendler (1997) concluded that adults' inherited personalities contribute to the quality of the supportive environment around them, thus, "Heritabilities of the stable component of social support ranged from 43% to 75% . . . [T]hrough genetically influenced traits such as temperament, individuals play a substantial role in creating their own social environments" (p. 1398).

In conclusion, the "twins create their environment theory" must be rejected as self-contradictory and lacking in empirical evidence. It is a classic example of "trying to have it both ways." Furthermore, it has been demonstrated that the correctness of this theory would in no way exclude the possibility that the twin method measures nothing more than environmental differences between twin-pairs of differing zygosity. One wonders how the proponents of this theory view the widespread prevalence of child abuse in Western society. Are the millions of physically and sexually abused children in the world "creating" this abuse for themselves? If so, then masochism must be a highly heritable personality trait — for children obviously would not intentionally bring pain and suffering upon themselves.

Implications of the Twin Method's Rejection of DZ Opposite-Sex Pairs

There is another important aspect of the equal environment assumption of the twin method which deserves attention. This is the question of why the twin method requires that MZ twin concordance rates be compared with

³Like Kendler and associates, Manfred Bleuler (1955) argued that identical twins create their environments on the basis of a genetically produced similarity of personality. Unlike Kendler, he considered this to be evidence against the validity of the twin method:

[A]ccording to the older view, it is axiomatic that identical twins are identical in their inherited predisposition (*Anlage*), while the environment in which the identical twin partners live is on the average as different as the environment of the fraternal twin-partners. In reality, this last assumption is wrong. Identical twins, on the basis of their common inherited predisposition, create for themselves on the average a much more similar environment than is the case with fraternal twins . . . [T]he old idea that the environment of twins varies without regard to their innate predisposition (*Anlage*) is quite erroneous; hence all further deductions which used to be based on this premise must be wrong. (p. 13)

concordance rates of DZ *same sex* twins. Earlier, we briefly examined schizophrenia concordance rate differences between DZ same-sex (DZ_{ss}) and DZ opposite-sex (DZ_{os}) pairs in the analysis of the effect of sex differences on twin concordance rates.

“According to the traditional view,” wrote Kendler (1983), “because monozygotic and same-sex dizygotic twins share the same environmental factors to approximately the same extent, differences in concordance between the two twin types must be due to the influence of genetic factors” (pp. 1413–1414). Later in the same paper, Kendler wrote that “behavioral similarity of monozygotic versus dizygotic twins cannot be ascribed to differences in treatment of the twins by the social environment” (p. 1416). The question then becomes: If DZ_{ss} and DZ_{os} twins share, on average, the same genetic makeup (50%), and if treatment by the social environment does not affect the twins’ behavior, why then does the twin method require that only DZ_{ss} twins be compared to MZ twins? By requiring that DZ twins be of the same sex, *the twin method tacitly acknowledges that environmental influences do affect the similarity of behavior among DZ pairs, based on the gender of the twins*. Another way of stating this is that, *based on gender*, the acknowledgment that differential treatment of DZ twins leads to different behavior is built into the theory of the twin method — at least as it pertains to non sex-linked conditions such as schizophrenia.

“In most studies,” wrote Gottesman (1991) “same-sex fraternal pairs are used to eliminate possible variations due to sex differences within a pair” (p. 104). In this case, the expression “possible variations” implies that DZ_{os} twins would be expected to have different concordance rates for schizophrenia. Because both DZ_{os} and DZ_{ss} twins share the same average genetic heritage, a lower DZ_{os} concordance rate could only be accounted for by the fact that opposite-sex pairs experience a less similar environment or a less intimate bond than DZ_{ss} pairs. This means that lower concordance rates found among DZ_{os} twins when compared with DZ_{ss} twins are due entirely to environmental factors — a fact which stands in direct contradiction to the equal environment assumption.

If environmental differences based on gender can lead to different behavior, why are other physiological differences found among DZ twins not considered also, such as, for example, one DZ twin being fat and the other thin; one being tall, the other short; one bearing a striking resemblance to one of their parents, and the other not; or one being physically attractive and the other one not? Why is it denied that these types of differences could also play an important role in different behavior caused by different treatment of DZ twins? The decision that only gender differences among DZ pairs is of importance is an arbitrary one. DZ twins, as do ordinary siblings, can differ in a great many ways. But the twin method will not acknowledge this. Nor can it — for

to do so would mean the repudiation of the most critical assumption of the method.

An objection to this line of argument might be that DZos pairs should be excluded from comparison with MZ pairs because men and women are biologically different and/or behave differently because of learned sex roles. The problem with such an objection is that even if biological or socially learned gender-based differences lead to a greater difference in behavior or personality within a DZos twin-pair, such a finding would nonetheless constitute a violation of the equal environment assumption. Because schizophrenia is not a sex-linked condition, the only factor that could “confound” concordance rates between DZos and DZss pairs would be environmental. And the equal environment assumption, by Kendler’s definition, does not recognize that differential treatment of members of a twin-pair can lead to different behavior.

Speaking again of non sex-linked conditions such as schizophrenia, it is irrelevant from the standpoint of the equal environment assumption whether gender differences are biogenetic, learned, or a combination of these two factors. According to the twin method, twin-pairs are seen as sharing similar environments for two reasons only — because they are born at the same time, and because they are raised in the same family. The first of these two factors, it should be remembered, is the only reason that non-twin same-sex siblings are excluded from consideration as controls to be compared to MZ twins. DZos twins meet the traditional requirements for comparison with MZ twins — yet, tradition has also excluded them.

Based solely on the knowledge of twin method theory and procedure, it would be possible to reject the method as illogical. In a sense, the contradictory nature of twin method theory — which states that differential treatment and/or interaction of the twin-pairs does not affect behavior, while at the same time acknowledging that it *does* affect behavior (regarding DZos pairs) — is reason enough to call the validity of the method into question. One could argue that the exclusion of DZos twins from comparison with MZ twins is, by itself, a repudiation of the equal environment assumption — and therefore of the twin method itself.

Kendler’s Theoretical Retreat

Although Kendler has staked everything on the theory that treatment does not affect behavior, he has also come to understand that the idea that twins completely determine their similarity of treatment does not reflect reality. By 1994, Kendler realized that for some parents, the differences in the way they raised their MZ or DZ twins was an “approach” — not simply a reaction to their twins’ behavior (Kendler, Neale, Kessler, Heath, and Eaves, 1994, p. 588). He went on to acknowledge that,

The tendency for parents of MZ twins to treat their offspring more similarly than parents of DZ twins is, therefore, unlikely to result entirely from a greater similarity in behavior as children of MZ v. DZ twins. (p. 588)

Thus Kendler implicitly acknowledged a correlation between the greater similarity of MZ twins' personalities and the rearing *approach* of their parents. It seems as though Kendler and colleagues should have closed up shop at this point, but they maintained that although "these results may seem like prima facie evidence for rejecting the twin method, such a step would be premature":

Differential parental treatment of MZ and DZ twins would invalidate twin studies of psychiatric disorders *only* if the type of parental treatment for which MZ twins were more similarly exposed than DZ twins influenced the risk for the psychiatric disorders under examination. (Kendler et al., 1994, p. 588)

It must be stressed that in the above quoted passage, Kendler is speaking of all psychiatric conditions and not simply schizophrenia with its relatively mysterious etiology. For Kendler, therefore, to invalidate the twin method it must be shown that the greater similarity of treatment of MZ twins could influence their concordance rates for psychiatric diagnoses. According to Kendler (1983, p. 1414), the equal environment assumption predicts that "monozygotic twins would develop similar phenotypes regardless of the similarity of their social environment." But a simple example will demonstrate that this is clearly not the case. Suppose a pair of identical twins were separated at birth and raised in different social environments. One twin is shifted from one foster home to another, is beaten nearly every day, is unloved, neglected, underfed, and abandoned several times during childhood. The other twin is raised in an exceptionally caring home where he or she is loved and treasured, respected, well taken care of, and does not suffer abuse. For Kendler's theory to hold, he must conclude that both twins would be at equal risk for childhood or adult psychiatric diagnosis — in other words, the claim that treatment does not influence behavior. But, as common sense and psychodynamic theory would predict — and the real world would confirm — such individuals would not be at equal risk for psychiatric diagnosis.

A similar hypothetical scenario has been discussed by Kendler himself:

If we selected 100 genetically diverse individuals and took them on a "love-boat" cruise in which all of their needs (e.g. entertainment, food, and love) were met, we would find, I predict, both low levels of anxiety and depression and very little variability. Almost everybody would be happy. Suppose, however, that we then expose these same 100 individuals to a highly stressful experience, such as combat. The average level of anxiety and depression would increase but, more important, so would variability. Some individuals who are good at coping would deal effectively with the adversity and demonstrate few psychiatric symptoms. Others, with poorer coping abilities, would become very symptomatic. (1995, p. 896)

Here, Kendler recognizes that a given individual could be "happy" or "depressed" on the basis of a good or bad environment. There is no disputing this scenario. But Kendler cannot allow that an identical twin sent into combat after taking the cruise would be more likely to become depressed or anxious than his or her genetically identical co-twin who remains on the "love boat," since as we have seen, Kendler insists that identical twins would develop the same phenotype regardless of the similarity of their environments. From the genetic standpoint, however, there is no difference between *an individual* placed in different environments and *identical twins* placed in different environments.

If we consider Kendler's scenario as analogous to a twin-pair's rearing environment, because virtually everyone agrees that identical twins share more common experiences and are treated more alike than fraternal twins, they would be much more likely, for example, to go on a cruise or into combat *together*. Conversely, the more variable environments of fraternal twins would make it much more likely that one twin would be sent into combat, and the other on a cruise. Because Kendler (Kendler et al., 1994) would consider the twin method "invalid" if such environmental differences "influenced the risk for the psychiatric disorders under examination" (p. 94), his position that the same individual would be depressed or not depressed in relation to which environment they found themselves in has seemingly invalidated Kendler's equal environment assumption theory, and therefore all twin studies of psychiatric disorders.

By 1997 Kendler would explicitly recognize that a more similar twin-pair environment could lead to more similar behavior. In a paper discussing possible environmental and genetic effects on religiosity and political affiliation (Kendler, Gardner, and Prescott), he wrote that, "Twin resemblance for personal conservatism could be explained solely on the basis of shared environmental experiences (e.g., community, parental, and peer group influences)" [p. 326]. While continuing to defend the validity of the twin method, Kendler now not only recognizes a partial environmental effect on twin similarity of behavior, but even an *exclusive effect*. One might ask whether twin concordance rates for schizophrenia and other psychiatric conditions could not also be "explained solely on the basis of shared environmental experiences." It could be argued that this concession constituted the last nail in the coffin of Kendler's equal environment assumption theory.

The debate over the equal environment assumption centers on the following question: Is there something special about being an MZ twin, apart from genetic similarity to a co-twin, that would cause MZ twins to manifest more similar behavior and "psychopathology" than DZ twins? Defenders of the twin method such as Kendler answer "no"; most of its critics answer "yes."

Studies Cited by Kendler in Support of the Equal Environment Assumption

Kendler has written that "the EEA has been tested in five different ways" (Hettema, Neale, and Kendler, 1995, p. 327).⁴ It is Kendler's style to compile a seemingly impressive list of studies that presumably demonstrate how the equal environment assumption has been thoroughly tested. Kendler rarely cites anyone who does not have a genetic orientation. The occasional oppositional paper he does mention is typically penned by another behavior geneticist, or a critic "from the right" such as Price (1950), who believed that the twin method *underestimates* the genetic inheritance of human traits. Kendler cites several studies in support of each of the five ways that the equal environment assumption has supposedly been tested. These studies have been analyzed in greater detail elsewhere (Pam et al., 1996; Joseph, 1998), and the most important of these will be reviewed briefly in this section.

The "first method" records "direct observation of twins in a social situation in which the behavior of other individuals is divided into those which are self-initiated and those which occur in response to behavior of the twins" (Hettema, Neale, and Kendler, 1995, p. 327). There is one study cited in which researchers attempted to carry out such observations — that by Lytton (1977).

This study is one of many in the equal environment assumption support literature which, while acknowledging that MZ and DZ twins are treated differently, seeks to deny the importance of different treatment by offering an explanation which goes against conventional wisdom. Lytton's sample of twins consisted of 46 pairs (17 MZ, 29 DZ). All were two-and-a-half-year-old boys. It is questionable what kinds of generalizations about twinship can be made from subjects of this age. From an environmentalist perspective, personality differences between the two types of twins would be expected to increase as they get older, and this idea finds support from longitudinal studies. One study of this type looked at same-sex twin-pairs at ages 2 months, 9 months, 6 years, and 15 years, and concluded that,

MZ pairs get more and more similar in temperament with age, suggesting that environmental factors influence closer identity. Differential similarity over traits in DZ pairs may suggest that some temperamental traits are more influenced by shared environmental factors than others. (Torgersen, 1987, pp. 145-146)

⁴Although Hettema is the lead author of this article, Kendler should be considered the main spokesperson for these ideas, because they have been a reoccurring theme of his work since 1983. This article was chosen because it is one of his more recent defenses of the equal environment assumption.

The purpose of Lytton's study was to see if different treatment of the MZ and DZ twins was initiated by the parents, or whether it was in *response* to the behavior of the twins. Lytton separated out the alleged child-initiated parental responses, which left the behavior he was seeking to measure: "parent-initiated actions." These were defined as parent-actions not preceded by a child-action within the previous 10 seconds. This is a questionable distinction, because the simple passing of 10 seconds cannot determine the direction of an action — and it seems doubtful that the direction of interactive communication between parents and children can be determined at all. According to Lytton's criteria, a parent waiting eleven seconds before reacting to his or her child's behavior is taking a "parent-initiated action." A child may defy its parent on Tuesday morning in response to a spanking he or she received Monday night, and Lytton would classify this as a "child-initiated action." As Pam et al. noted, "We find such an inference dubious since it is based on the supposition that one can discern which behavior is 'imposed' or 'elicited' — but any family therapist will insist that child-parent encounters are interactional" (1996, p. 352).

Four different parental response categories were measured, with one set of ratings for the mother, and one set for the father. Based on parent-initiated actions, Lytton found that MZ twins were treated significantly more alike in only one of the eight categories, and non-significant results were recorded for the remaining seven categories (an equivocal result, it should be added). He concluded that "parents respond to, rather than create, differences between the twins" (Lytton, 1977, p. 459).

Putting aside for the moment the objection that the twins were too young to tell us much about MZ–DZ twinship differences, and the claim, based on equivocal results, that something significant was found, there is a serious methodological bias in this study. This has to do with the method used to rate the behaviors in question. The observations were made in the families' homes, and the raters' job was to observe parent-child interaction and score behavior counts for the family members. Lytton, who is inclined toward the behavior genetic viewpoint, indicated that there were two raters. These raters' names were not given and their theoretical orientations were not identified. It is difficult to imagine a setting more conducive to investigator rating bias than this one. Two raters, most likely looking for evidence to support their research hypothesis, are sitting in the homes of families with twins for whom in many cases the zygosity of the twins was apparent. It is difficult to believe that their biases did not affect the subjectively rated behavior counts they were making as they observed these families. At the very least, Lytton should have chosen raters with no interest in what the study's results would show. In fact, they should not have even known that the study was looking at anything having to do with zygosity, or even twinship. To summa-

size, the small and very young sample size, the equivocal statistical results, the questionable claim that it is possible to determine the direction of interactions between parents and children, and the high likelihood of rater bias combine to render this study unworthy of the claim that it supports the equal environment assumption.

Before leaving this study, it is necessary to comment on the notes of one of the raters of an MZ twin-pair. It is an all-too-familiar example, commonly found in the genetic literature, of an observation directly contradicting the researcher's claims, but which nevertheless goes unseen. Lytton tells us about one of the MZ pairs in which one of the boys had to be kept in a hospital incubator for several weeks after birth because of a respiratory infection, while the other twin did not. The interviewer's notes on this family read as follows:

Mother doesn't think of them as twins, J. has been behind. Their personalities warrant their being treated differently. The differences that mother makes are those they demand, or that events produce. J. is 10 times worse than D. in climbing on cupboards and tables and is usually spanked. Mother often has to spank J. for things that D. does not have to be spanked for. D. is more sensitive, responds to a look or being sent to his room. Mother spends about half an hour holding and cuddling D. and about 15 minutes with J. or as much time as he'll allow. (Lytton, 1977, p. 458)

The reader should note that the phrase "Their personalities warrant their being treated differently" is a good indication of the interviewer's bias; it is an obvious example of "seeing" what you are hoping to see. Lytton quotes this passage as an example of how a mother treats her MZ twins differently based on their personality, as opposed to her "parent-initiated" treatment. But he did not recognize the importance of the observation that the personalities and behaviors of these twins had changed *because of an environmental occurrence* (the hospital stay). Lytton understood that the hospital stay affected the twins' personalities, but he was unaware of how this observation flies in the face of the hereditarian theory that MZ twins' personalities are similar due to genetic resemblance. According to this view, their personalities should not have been so different. It seems that an environmental factor played a big part in shaping the differing personalities of these genetically identical individuals.

Finally, how can the experience of this pair be reconciled with Kendler's assertion that "monozygotic twins would develop similar phenotypes regardless of the similarity of their social environment" (Kendler, 1983, p. 1414)? Clearly, this case history does not support his idea.

The "second method" takes as its starting point the acknowledgment of reports that MZ twins grow up in more similar environments than DZ twins, but that,

If these environmental experiences influence twin similarity, controlling for zygosity, the degree of similarity in childhood environment or the frequency of contact as adults should predict twin similarity. However, the vast majority of studies using this method

have found no relationship between these measures of environmental similarity and twin similarity for [personality and various psychiatric conditions]. (Kendler, 1993, p. 906)

This method attempts to determine whether differential childhood treatment of MZ and DZ twin-pairs, or differences in adult twin relationships, are related to adult variables such as personality, intelligence, and "psychopathology." Eleven studies looking at these issues were examined. Several attempted to show a lack of association between childhood treatment differences (as measured by questionnaires administered to adults) and differences in adult personality and behavior. The majority of these studies asked questions relating to the twins' childhood that failed to accurately assess for the psychological bond between them.

Few quantitative results for the important questions were provided, and in several studies we were expected to believe on faith that statistical procedures showed that there was no relationship between childhood experience and adult personality. One group of researchers (Morris-Yates, Andrews, Howie, and Henderson 1990) would have concluded that "the equal environments assumption appears to be invalid" (p. 325), had it not been for their adherence to the questionable "twins create their environment theory." By 1994, even Kendler had come to believe that this theory is only partially true. Another study cited by Kendler (Clifford, Hopper, Fulker, and Murray, 1984) noted:

Much controversy has surrounded the basic assumption of the classical twin method: that the effect of shared environment is the same for (like-sexed) identical and fraternal twins. From our analysis this assumption would appear not to be satisfied for these measures . . . (p. 76)

In another Kendler-cited study (Martin, Eaves, Heath, Jardine, Feingold, and Eysenck, 1986), based on a sample of Australian and British twin-pairs, the authors found that, "Fourteen of the 50 items in the Australian study . . . showed significant evidence of both genetic and social components of twin resemblance" (p. 4366). The fourteen social attitudes claimed by the researchers to carry an inherited component included: "Sabbath observance," "Hippies," "Divine law," "Socialism," "Moral training," "Legalized abortion," "Student pranks," "Royalty," "Nudist camps," "Church authority," "Caning," "Mixed marriage," "Casual living," and "Bible truth." This study serves us only to demonstrate the potential absurdity of calculating heritability on the basis of MZ/DZ concordance rate differences.

Kendler cites several studies investigating the relationship between adult contact and concordance for psychiatric diagnoses; however, such studies are of little value in assessing the validity of the equal environment assumption,

other than to *speculate* on the degree of the twins' closeness as children. Studies showing evidence both for and against such an association were reviewed, and the studies in favor provided far more data relating to how the degree of adult contact was measured than did the studies against. It is concluded here that the studies cited in support of Kendler's second method provide no evidence in favor of the equal environment assumption.

Kendler's "third method" for testing the equal environment assumption is described as follows,

[P]arents of MZ twins may treat their twin offspring more similarly than parents of DZ twins. In a study of academically talented adolescent twins, parents of MZ twins indeed reported treating their twins more similarly than parents of DZ twins, but the similarity of parental treatment was unrelated to twin similarity for cognitive abilities, personality, or vocational interests. (Kendler, 1993, pp. 906–907)

The principal study cited as providing evidence in favor of the EEA using this method of analysis is by Loehlin and Nichols (1976).

This widely cited book-length report analyzed data collected from 850 pairs of twins and their parents. The sample (514 MZ–336 DZ) was obtained from high school juniors who took the National Merit Scholarship Qualifying Test (NMSQT) in the Spring of 1962. Approximately 600,000 students took this examination, and each examinee was asked to indicate if he or she had a twin sibling. The research team was able to obtain the names of 1,507 same-sex twin-pairs, who were then mailed questionnaires and asked to participate in the study. The final sample of 850 twins (58.4% female, 41.6% male) was based on twin-pairs who supplied "reasonably complete" data plus a filled-out parent questionnaire (p. 7).

Each member of the twin-pair was mailed a 1,092-question survey asking about the twins' experiences, behaviors, interests, and other aspects of their lives. In addition, each twin was mailed a copy of the California Personality Inventory (CPI). The twins were requested to fill out the questionnaires and mail them back to the researchers. The parent questionnaire consisted of a 289-question mail-in survey which asked about the twins' childhood environment, personalities, and how parents perceived the way that they treated their twins.

Kendler has cited this study because its results are alleged to have shown that, in the words of Loehlin and Nichols, "Differences in the childhood treatment of twins are not very predictive of adolescent personality differences" (1976, p. 92). This conclusion was based on the finding that identical twins correlated higher on personality measures than fraternal twins, but that these differences did not correlate with parental responses to the way parents treated their twins. In fact, parents reported that they treated their MZ twins alike on 99% of the questions, and their DZ twins alike on 97.5% of the

questions (p. 55). Clearly, the results from this retrospective questionnaire are highly suspect, since parents reported treating *both* types of twins the same almost all of the time. And in fact, parental recall questionnaires often reflect an idealized image of how parents think that they *should have* treated their children, as demonstrated by Robbins (1963).

Other twin researchers have encountered the phenomenon of parental idealization of their child-rearing role, without, however, taking parents' descriptions of the family environment at face value. Shields (1954) studied British MZ and DZ twins aged 12–15, and conducted interviews with parents while observing twins' home life firsthand. The following is an account of Shields' impressions of the conversations he had with the mothers of fraternal twins (which he called "B" or binovular twins):

So far as parental discrimination is concerned, an observation which most impressed me was the insistence by mothers that they made no difference between their B twins. *This must often have been untrue* [italics added]; for the twins had different needs and made different demands on their parents. (p. 230)

Loehlin and Nichols, on the other hand, reviewed questionnaires which showed that parents treated their DZ twins alike on over 97% of the responses — yet would not call into question the validity of these results.

The problem that their data have created for Loehlin and Nichols is this: virtually every other study cited by Kendler acknowledges that MZ twins are treated differently than DZ twins, but that this difference in treatment does not affect behavior, and/or that this treatment is induced by the greater genetic similarity found in MZ twins. Paradoxically, the results of the Loehlin and Nichols study could be interpreted as showing that Kendler's idea that twins might create different environments for themselves is *false*, since both types of twins have "created" parents who treated them alike nearly 100% of the time! Yet this study is cited favorably by most proponents of "twins create their environment theory," including, of course, Kendler, and Scarr and Carter–Saltzman (1979).

The "fourth method" looks at twins whose zygosity status has been misidentified by their parents or by the twins themselves. (For example, a genetically fraternal pair who thought they were, or were thought to be, identical.) These mislabeled twins are then compared to correctly identified twins in order to test the effects of "true" versus "perceived" zygosity. Perceived zygosity effects, since they are based on beliefs and not biology, can only be derived from environmental factors. Although Scarr (1968) is usually credited with having first proposed this research method, the idea was put forward by Kety as early as 1959, when he proposed "a comparison of the concordance rates in monozygotic twins whose zygosity had been mistakenly

evaluated by the twins themselves and by their parents and associates” (p. 1594). Kendler cites several studies in support of the idea that true, and not perceived zygoty, predicts twins’ traits and abilities.

The main point that needs to be made about the studies cited by Kendler is that the most important ones found evidence of an environmental effect on twin similarity. For example, Goodman and Stevenson (1989, p. 696) discovered “substantial” perceived zygoty effects in twin correlation for hyperactivity. Scarr (1968) discovered that her data “suggest that beliefs about zygoty also have an effect on MZ pairs,” though these differences are “not as potent as the critics charge” (p. 40). In a later study on a large population of twins, Scarr and Carter–Saltzman (1979) concluded that “both true *and perceived zygoty* [italics added] were related to co-twin similarity on personality measures” (p. 532).

In spite of their finding, Scarr and Carter–Saltzman considered the twin method to be a viable tool for estimating heritability percentages for particular traits. In point of fact, the presence of a perceived zygoty effect invalidates the procedure and allows for no estimation of heritability. The reason is that any estimation of genetic factors from twin method results is predicated on the validity of the equal environment assumption. Although overlooked by Scarr and Carter–Saltzman, the crucial point is that *any allowance for or recognition of a “perceived zygoty effect” means that the equal environment assumption is false*. The equal environment assumption cannot allow for the existence of a perceived zygoty effect. Let us remind ourselves of the words, often repeated by Kendler, which were cited at the beginning of this paper,

The EEA is crucial because, if the EEA is incorrect, excess resemblance of MZ twins compared with DZ twins ascribed to genetic factors could be partly or *entirely due to environmental effects* [italics added]. (Kendler, 1993, p. 906)

For this reason, Scarr and Carter–Saltzman and others are mistaken in thinking that heritability estimates can be made if perceived zygoty effects are discovered. In fact, the existence of such effects means that, according to Kendler, some or all of the supposed genetic effects could be ascribed to the environment. And if these effects exist in this study, why could they not also be present in any other twin study of human behavior? Or to put it in a broader context, why not acknowledge that environmental effects are an aspect of the nature of parent/child, parent/twin, and twin/twin interactions?

Before leaving these studies, the question of whether it is possible to run a statistical procedure to test the validity of the equal environment assumption for a particular study should be addressed. A computer program has been developed which supposedly makes such a test. Recall that the supposed ability to statistically test the equal environment assumption was the basis for

Kendler's comment that "psychiatric twin researchers would be well advised to continue to test the EEA rather than to assume its validity" (Kendler et al., 1994, p. 588).

It is not necessary to engage in a detailed discussion of the technical aspects of the methods of the test and how it is performed. The question of the validity of the equal environment assumption seems more theoretical and philosophical. Thus, the equal environment assumption of the twin method is not true or false for any particular set of data; it is a statement about the nature of interactions between human beings and their relationship to their social environment in twentieth-century Western societies. The veracity of the equal environment assumption can only be determined by empirical, theoretical, psychodynamic, and sociological data pertaining to the nature of twinship in general — and cannot be tested for in any particular study.

The "fifth method" examines whether physical resemblance among twin-pair members is correlated with more similar personality or concordance for various psychiatric conditions:

[R]esemblance in twins may be influenced by the similarity with which they are treated by their social environment, which is a result of their degree of physical resemblance. If this is the case, controlling for zygosity, physical similarity of twin pairs should be correlated with trait similarity. Three studies have examined this question . . . and none suggested that twin resemblance was substantially influenced by physical similarity. (Kendler, 1993, p. 906)

This statement could only be made by someone unable to see the larger picture of what the twin method likely demonstrates. In fact, every twin study showing a significantly higher MZ concordance rate could be interpreted as a powerful statement in favor of the idea that "physical similarity of twin pairs should be correlated with trait similarity" — since MZ twins are far more similar in appearance than DZ twins. In fact, we could quite legitimately frame every MZ/DZ comparison in these terms. But Kendler and colleagues cannot see this — instead seeking to "control for zygosity" when such control is only required on the basis of genetic assumptions about human behavior differences.

One of the studies cited by Kendler (1983, 1993) was an unpublished 1982 report by Kendler and Robinette which reviewed 164 MZ twin-pairs in the NAS-NRC twin sample. This study was supposed to have found "no correlation between degree of physical similarity and concordance rates for schizophrenia" among these MZ pairs (Kendler, 1983, p. 1415). In another paper, Kendler and Robinette (1983) summarized their findings:

When the schizophrenic monozygotic twin-pairs are divided on the basis of their degree of physical similarity (based on hair and eye color, height, and weight at induction), concordance for schizophrenia is no higher in those who were versus those who were not very physically similar. (p. 1557)

Kendler and Robinette never saw these twins, but instead ranked them on the basis of information obtained from the records of armed forces induction charts. In fact, several twin researchers (Cohen, Dibble, Grawe, and Pollin, 1975; Newman, Freeman, and Holzinger, 1937) have documented the fact that identical twins' eye and hair color are exactly the same over 90% of the time. Newman et al. also found that the mean pair difference in height was 0.7 inches. Therefore, it is unlikely that Kendler and Robinette could have made any meaningful distinctions between MZ pairs on the basis of these criteria. A far more important demonstration of the effects of physical similarity on concordance would be to compare rates among similar and dissimilar *fraternal twins*. The fact that same-sex DZ twins were significantly more concordant than opposite-sex DZ twins in two major schizophrenia twin studies (Kallmann, 1946; Slater, 1953) speaks strongly for the idea that physical appearance does have an important effect on twin concordance rates.

Summary and Conclusions

Any theoretical model is only as strong as its underlying assumptions. If the equal environment assumption is false, then the twin method becomes an instrument for the measurement of the differing levels of association and environmental similarity between identical and fraternal twins. Kendler has spent over 15 years attempting to defend the validity of the twin method, but he has been unable to show that the equal environment assumption has a sound basis. Among the studies he cites in defense of the equal environment assumption, not one can be considered a solid piece of evidence in favor of its validity. Several studies (Goodman and Stevenson, 1989; Scarr, 1968; Scarr and Carter-Saltzman, 1979) found evidence for environmental effects on twin concordance, a finding which is not compatible with the equal environment assumption. To accept the study of Loehlin and Nichols (1976) as evidence in favor of the equal environment assumption, one would have to consider as valid a parent questionnaire in which parents answered that they treated their same-sex *fraternal* twins alike more than 97% of the time. Most of the lesser-known studies cited by Kendler contain similar flaws and biases as those discussed in the present review. The twin method is based on the equal environment assumption, and for Kendler and associates that assumption is dependent on the validity of the "twins create their environment theory." It has been demonstrated that this theory has no basis in evidence, and that even if true, MZ/DZ concordance rate differences could still reflect nothing more than environmental differences between the two types of twins.

The total weight of evidence from the pro-equal environment assumption studies provides no support for its validity, however the assumption may be

defined. It is therefore the conclusion of the present review that *there is no reason to accept that the classical twin method measures anything other than the greater psychological bond and environmental similarity experienced by identical twins in comparison to fraternal twins*. The authors or co-authors of at least nine of the twelve schizophrenia twin studies have acknowledged that concordance rates are likely affected by environmental similarity and identification factors. However, with few exceptions, these researchers have not drawn the logical conclusions from this finding. The evidence suggests that the classical twin method, as Manfred Bleuler (1978, p. 432) has told us, is indeed "based on a fallacy" — *the fallacy of the equal environment assumption*.

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