



Received 15 December 1982

Twins Living Apart Test: *Progress Report*

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A new approach is proposed in twin research based on the study of twins who, though reared together, have subsequently lived apart for a period of at least five years. With respect to the more powerful study of twins reared apart, the twins living apart test has the advantages of being more realistic and affording easier access to sufficiently large samples. In this pilot study, the test has been applied to a sample of 92 monozygotic pairs now aged 35-45; 15 pairs were still living together and 77 had lived apart for over five years. As a first approach, comparisons have been made, in the cotwins of the two subsamples, with respect to the following traits: height, weight, presbyopia, presbycusis, alcohol consumption, tobacco consumption, blood pressure (systolic and diastolic), dental caries, and hours of sleep.

Key words: Separated twins, Aging pathology, Chronogenetics, Anthropometry, Substance exposure, Blood pressure, Dental caries, Environment, Ecology

INTRODUCTION

The study of monozygotic twins separated at birth and then reared apart is well recognized as a very powerful tool in human genetic and especially behavioral genetic research. Starting with Newman et al. in the 1930s [4] and up to the current project by Bouchard and his group in Minnesota [1], a number of authors have spent considerable time and energy in an effort to collect and analyze sizable samples of monozygotic twins reared apart. However, in a period of about 50 years, only slightly more than 100 such pairs have been studied, 95 of these having recently been found suitable for reanalysis, with only 45 of them representing cases of complete separation [2].

We reasoned that part of the usefulness of the study of twins reared apart might be retained if we would just study twins who, though reared together, had subsequently lived apart for a considerable part of their lives. Such a method, which we would like to refer to as the "twins living apart" test, would benefit from the possibility of having relatively simple access to sufficiently large samples, which would therefore allow us to perform statistical analyses that are sometimes unwarranted in the case of twins reared

This work was partly supported by the National Research Council of Italy (CNR) through grant 79.03225.04.

apart because of the small sample size. Moreover, rather than being limited to a genetic perspective, this test can eventually be useful in clarifying the role of environmental factors.

With these ideas in mind, we decided to undertake a pilot study aimed at locating a first sample of “living apart” twins and making some preliminary observations.

MATERIALS AND METHODS

In order to develop our approach, we first needed to locate pairs of adult twins who had lived for a sizable part of their lives in different environments. Then we could proceed to evaluate their similarities and differences with respect to some basic traits, in comparison with findings in studies of comparable pairs of twins who had lived together.

To this end, we addressed ourselves to a sample of twins we had come in contact with in the 1950s, selecting those that were at the time in the age range 10–20, so that the cotwins, who lived together at that time, would now be likely to have lived separately (because of marriage or other reasons) for a considerable number of years.

We have been able, so far, to trace back 271 pairs, 101 of which we determined to be monozygotic (MZ) by questionnaire procedures. For the time being, we have focused our attention on the latter, retaining, for proper comparison, the 15 pairs of twins who did not marry and still live together. Of the 86 pairs of twins living apart, nine were excluded as having been separated for less than five years. The final sample thus consists of 92 monozygotic pairs, 15 still living together (MZt) and 77 who have lived apart for over five years (MZa).

As a first approach, a number of simple traits, derived from individual answers to our mailed questionnaire, have been compared in the cotwins of the two subgroups. These include height, weight, presbyopia, presbycusis, alcohol consumption, tobacco consumption, blood pressure (systolic and diastolic), dental caries, and hours of sleep.

For each trait, and separately for the two subgroups of twins, within-pair comparisons have been made and correlation coefficients (r) or percentage of concordance (C) have been calculated. Moreover, in order to evaluate the effect of separation in increasing within-pair dissimilarities for each individual trait, the following separation index (SI) has been adopted:

$$SI = \frac{r(MZt) - r(MZa)}{r(MZt)} \quad \text{or} \quad \frac{C(MZt) - C(MZa)}{C(MZt)}$$

The questionnaire mailed to female twins (44 pairs) included an item concerning age at menarche. The latter was found to show very similar intrapair correlations in the two subsamples ($r = 0.86$ in the seven MZt pairs and $r = 0.91$ in the 37 MZa pairs)—an indication of the homogeneity and comparability of the two subgroups.

RESULTS

The results are summarized in Table 1 and in the Figure. For each of the ten traits, and separately for the two subgroups of twins, Table 1 gives the number of pairs (N), the intrapair correlation coefficient (r) for quantitative traits, and the percentage of concordance (C) for qualitative traits.

In general, and as expected, twin resemblance, whether expressed by correlation coefficients or by concordance values, appears to be considerably decreased in the subgroup of MZa pairs with respect to MZt pairs. More specifically, the following observations can be made:

Height and Weight

The correlation value appears to be slightly lower in the MZa than the MZt pairs both for height ($r = 0.84$ vs 0.96) and for weight ($r = 0.87$ vs 0.94). This is not surprising in view of the fact that both traits are controlled by multiple genes and are therefore likely to be influenced by environmental factors, although basically fairly stable. The influence

TABLE 1. Questionnaire Survey on Monozygotic Twins Living Apart and Living Together: A Summary of Data

| Variable | Living together | | | Living apart | | |
|---------------------------|-----------------|------|-----|--------------|------|----|
| | N | r | C | N | r | C |
| Height | 13 | 0.96 | | 72 | 0.84 | |
| Weight | 13 | 0.94 | | 72 | 0.87 | |
| Presbyopia | 13 | | 92 | 70 | | 79 |
| Presbyacusia | 12 | | 100 | 70 | | 67 |
| Alcohol consumption | 15 | | 87 | 76 | | 62 |
| Tobacco consumption | 15 | | 87 | 75 | | 67 |
| Blood pressure, systolic | 7 | 0.84 | | 41 | 0.58 | |
| Blood pressure, diastolic | 7 | 0.64 | | 41 | 0.46 | |
| Dental caries | 12 | | 58 | 72 | | 54 |
| Hours of sleep | 13 | 0.49 | | 75 | 0.53 | |

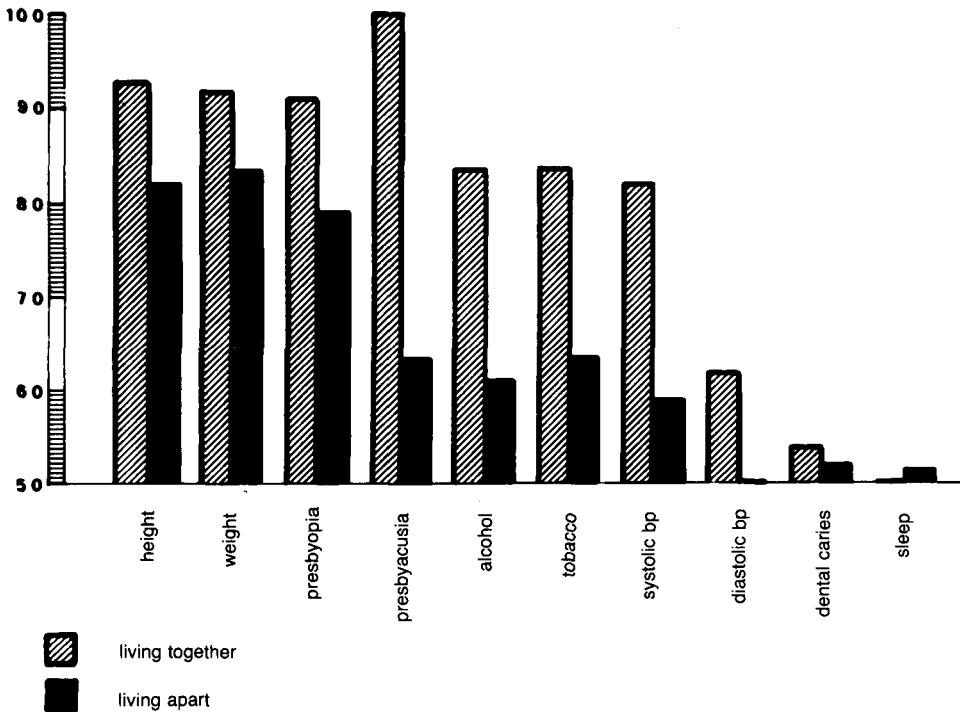


Figure. Within-pair covariance in twins living together and twins living apart.

of environmental factors is confirmed by the comparison, as is possible in 33 male MZa pairs, of the intrapair correlation for weight as it is today, following separation ($r = 0.86$), and as it was 25 years ago, when the cotwins still lived together ($r = 0.94$).

Presbyopia and Presbyacusia

Concordance values for presbyopia appear to be higher in MZt pairs (both cotwins affected in five pairs and unaffected in seven pairs, out of 13 pairs: $C = 92\%$) than in MZa pairs (both cotwins affected in 36 pairs and unaffected in 19 pairs, out of 70 pairs: $C = 78\%$). This points to the possibility that environmental factors (e.g., reading, TV watching,

TABLE 2. Consumption of Alcohol and Consumption of Tobacco in Monozygotic Twins Living Apart and Living Together

| 2nd Twin | Living together: 1st twin | | | Living apart: 1st twin | | |
|----------------------|------------------------------|---|-------------|---------------------------|----|-------------|
| | A | B | C | A | B | C |
| Alcohol ^a | | | | | | |
| A | 5 | | | 16 | 8 | 1 |
| B | 2 | 7 | | 16 | 30 | 1 |
| C | | | 1 | 1 | 2 | 1 |
| Concordance | | | 13/15 = 87% | | | 47/76 = 62% |
| Tobacco ^b | | | | | | |
| A | 6 | | 1 | 33 | 10 | 2 |
| B | | 3 | 1 | 2 | 6 | 5 |
| C | | | 4 | 2 | 4 | 11 |
| Concordance | | | 13/15 = 87% | | | 50/75 = 67% |

^aA = no alcohol; B = up to 1 liter of wine/day; C = over 1 liter wine/day.

^bA = no smoker; B = up to 10 cigarettes/day; C = over 10 cigarettes/day.

etc.) play some role in the onset of presbyopia. Similarly, in the case of presbycusis, concordance values also appear to be higher in MZt pairs (both cotwins affected in one pair and unaffected in 11 pairs, out of 12 pairs: C = 100%) than in MZa pairs (both cotwins affected in two pairs and unaffected in 45 pairs, out of 70 pairs: C = 67%). Again, this seems to point to a role of environmental factors (e.g., noise pollution) in determining hearing loss.

Alcohol and Tobacco

The answers to our questionnaire have been classified into three groups as follows: for alcohol—A = no wine, B = up to 1 liter/day, C = over 1 liter/day; for tobacco—A = nonsmoker, B = up to 10 cigarettes/day, C = over 10 cigarettes/day.

The results, shown in Table 2, indicate higher concordance values in the MZt than the MZa pairs, which clearly underscores the influence of environmental factors. On the other hand, the finding of a still considerably high concordance level in the MZa pairs supports the idea that genetic factors may also play a role.

Blood Pressure

Intrapair correlation appears to be considerably lower in MZa than in MZt pairs. This applied both to the systolic pressure ($r = 0.58$ vs 0.84) and to the diastolic pressure ($r = 0.46$ vs 0.64), correlation values for the latter being considerably lower than for the former in both subsamples.

Dental Caries

The answers to our questionnaire have been classified into the following four groups: A = no caries; B = 1–3 decayed teeth; C = 4–6 decayed teeth; D = 7 or more decayed teeth. The results (Table 3) indicate relatively low concordance values, both in the case of the MZa pairs (C = 54%) and in the case of the MZt pairs (C = 58%), a clear indication of powerful environmental influences.

TABLE 3. Dental Caries* in Monozygotic Twins Living Apart and Living Together

| 2nd twin | Living together: 1st twin | | | | Living apart: 1st twin | | | |
|-------------|------------------------------|------------|---|---|---------------------------|-------------|---|----|
| | A | B | C | D | A | B | C | D |
| A | 3 | 1 | | | 5 | 3 | 1 | 2 |
| B | 2 | | 1 | | | 5 | 4 | 1 |
| C | | | 2 | | 2 | 6 | 6 | 6 |
| D | | | 1 | 2 | 2 | 3 | 3 | 23 |
| Concordance | | 7/12 = 58% | | | | 39/72 = 54% | | |

*A = no caries; B = 1–3 decayed teeth; C = 4–6 decayed teeth; D = 7 or more decayed teeth.

Sleep

The number of hours of sleep appears to be similarly correlated in the two subsamples ($r = 0.49$ in the MZt and 0.53 in the MZa), so that no effect of separation can be detected.

Influence of Separation

As a first step toward an evaluation of the effect of separation, the separation index (SI) previously introduced has been applied to the results obtained for the different traits, yielding the following values of the SI index: height, 13%; weight, 7%; presbyopia, 14%; presbycusis, 33%; alcohol consumption, 29%; tobacco consumption, 23%; systolic blood pressure, 31%; diastolic blood pressure, 28%; caries, 0%; and sleep, 0%.

CONCLUDING REMARKS

Our proposed approach has the advantage, over the classical twin method, of allowing comparisons of cotwins within groups as well as comparisons of groups of twins living together and living apart. With respect to the undoubtedly more powerful approach based on twins reared apart, the twins living apart approach is more realistic and easily affords access to sufficiently large samples.

In this pilot study, we have limited ourselves to the 101 MZ twin pairs that we have so far been able to trace back out of a sample of twins, from various Italian regions, that we had come in contact with 25 years ago. The aim of the present report, however, was only to illustrate our proposed approach and some of the possibilities it offers. These include, in particular, the evaluation of the effect of separation over the phenotypic expression of traits that are partly controlled by genetic factors, and thereby the evaluation of the extent of environmental influences.

This may be particularly relevant in the perspective of chronogenetics, i.e., of the temporal dimension of the hereditary message on which we have previously focused our attention [3]. We consider the life span of the genetic information (chronon) to be directly proportional to the gene's molecular stability or energy (ergon), so that the latter decays with time as a function of information consumption. This is in turn a function of environmental requests, so that the comparison of cotwins who age under similar environmental conditions and that of cotwins who age under different environmental conditions may turn out to offer very useful clues along this line.

The samples can easily be extended. Data from our twin file of now almost 20,000 pairs indicate that about 85% of our MZ twins marry, the age at marriage being 27.5 ± 4.9 for males and 25.5 ± 3.7 for females.

The twins living apart approach obviously allows an extension to dizygotic (DZ) twins and may prove particularly relevant for longitudinal and/or follow-up studies.

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