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Similarities in Test Scores and Profiles of Kibbutz Twins and Singletons

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Abstract. Resemblances on five cognitive tests were compared in fifty quartets of school children. Each quartet consisted of a twin pair (MZ or DZ) and a matched singleton pair from the same kibbutz peer group. Similarities of MZs and DZs on test scores essentially replicate those reported previously in other studies. The median correlation for singleton control pairs is 0.29, as compared with that of 0.26 reported in the Texas Adoption Study for unrelated children raised in the same home. In the two spatial tests, control pairs were as similar as the DZ pairs. This suggests a more powerful influence on shared environment in aspects of perceptual performance. A new structural analysis (POSAC) of individual profiles of test scores is presented. Comparison of space diagrams of MZ, DZ, and singleton pair profiles shows systematic differences in structure among the three groups, in accordance with the predicted levels of genetic influences. Such structural differences transcend mere differences in size of correlation, and may give more stringent evidence for the respective roles of genetics and environment.

Key words: Intelligence, Special environment, Kibbutz, WISC tests, Spatial ability

INTRODUCTION

A central problem in the use of twins to explore hereditary and environmental contributions to complex characters – such as cognitive abilities – is the effect of their shared environment on the level of resemblance.

The kibbutz society in Israel presents a unique opportunity for comparing the effects of shared environment on twins and on unrelated peers. There are over two hundred kibbutzim in Israel. Though they differ in size, economic status, and political outlook, they are similar in social structure and essential socialization practices [4,6,16]. The kibbutz is a relatively small voluntary community with a collective economy and a collective system of child rearing. Children spend most of their time in special children's houses, where members of the same peer group share care-takers, kindergarten teachers, and have the same ecological experiences. In spite of the collective upbringing, the parents and family in the kibbutz have a strong impact on the developing child. (For a study on infant attachment in the kibbutz, see Fox [5].)

The effect of a shared environment on cognitive functioning in unrelated children is generally studied by means of adoption research, in families where adopted and biological children are raised together [8]. The present study combines some of the special features of adoption studies with those of twin research. The potential contribution of the study of the kibbutz environment has been pointed out by Scarr [12: p 81]: "Educational programs ... seldom continue across a child's development ... and they seldom offer as intensive or extensive an intervention as a family environment. Only studies of kibbutzim and adoptive families offer these advantages".

MATERIALS AND METHODS

The Sample

Our sample consisted of 25 monozygotic (MZ) and 25 dizygotic (DZ) pairs of twins, and of 100 age - and sex-matched singleton controls from the same peer group (educational and living unit) in each kibbutz. Since the parents of each quartet are members of the same kibbutz, they were matched for income and living conditions. Thus, each experimental group consisted of one twin pair and one singleton pair from the same peer group. These 50 quartets came from 46 different kibbutzim. In the vast majority (44 out of 50) of the quartets, the children's sleeping arrangements were in communal children's houses from birth to the time of testing. The children were aged 8-13 years at the time of testing. Eleven of the 25 DZ pairs were opposite-sexed. Their data have been combined with the same-sexed pairs, since it has been shown, both in our data as well as by Wilson [19] and by Plomin and DeFries [10], that level of resemblance in these two types of DZ twin pairs in similar.

Zygosity diagnosis was carried out in two steps. First, a questionnaire adapted from Cohen et al [3,4] was given to each twin separately. In addition, physical characteristics such as hair color and texture, complexion, nose and lip shape were compared by two independent observers. The advantage of this procedure has been pointed out by Plomin and Rowe [11]. The second step consisted of blood analyses of those eight pairs whose zygosity was not otherwise clear.

The Tests

Each child was given a series of tests which included the following subtests from the Wechsler Intelligence Scale for Children (WISC): Information, Arithmetic, Vocabulary, and Block Design. Each child was also administered the full version of the Raven Progressive Matrices. Israeli age norms were used for the WISC tests, while the scores on the Raven Matrices were age-adjusted.

RESULTS

Comparison of Scores of Twins and Singletons

Table 1 shows that mean performances of MZs and singletons were similar on most of the tests, while DZ twins performed somewhat more poorly. A similar relationship between intellectual performance of MZ vs DZ twins was reported in a large study by Husén [9] and has been interpreted by Vogel and Motulsky [17] to be the result of lower SES of DZ parents. In our study we found the number of years of education to be higher for mothers of MZ twins: 48% of DZ mothers, 20% MZ mothers, and 28% mothers of singletons had less than twelve years of schooling.

Within-Pair Correlations of Twins and Singletons

Table 2 gives within-pair correlations for the two twin types and for the singleton control pairs in the same peer group.

Correlations for MZ and DZ are comparable with other studies [especially 18] except for the DZ correlation on the information test. Of special interest are the correlations of

TABLE 1 - Mean Test Scores of Monozygotic and Dizygotic Twins and Singletons[1]

Test	MZ		DZ		C	
	X	SD	X	SD	X	SD
Information	13.0	3.0	12.7	2.0	13.6	2.4
Vocabulary	14.3	2.0	13.1	2.7	14.3	2.4
Arithmetic	10.9	3.1	10.2	2.6	11.2	2.9
Block Design	14.4	2.8	12.8	2.6	14.4	2.4
Raven Progressive Matrices (age adjusted)	29.6	8.7	25.7	8.4	29.1	7.3

[1] Based on individual scores: 50 MZ, 50 DZ, 100 Singletons.

TABLE 2 - Within-Pair Correlations for Monozygotic and Dizygotic Twins and for Singleton Control Pairs

Test	MZ	DZ	C
Information	0.83	0.12	0.26
Arithmetic	0.76	0.59	0.29
Vocabulary	0.80	0.59	0.27
Block Design	0.86	0.33	0.34
Raven Progressive Matrices (age adjusted)	0.70	0.38	0.33
Median r	0.80	0.38	0.29
N (pairs)	25	25	50

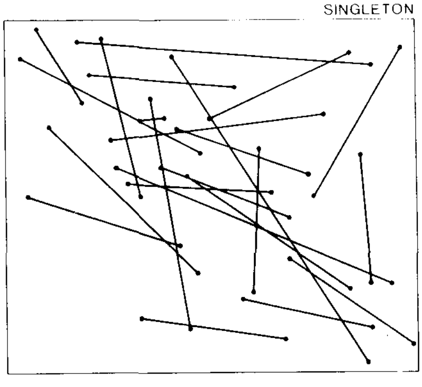
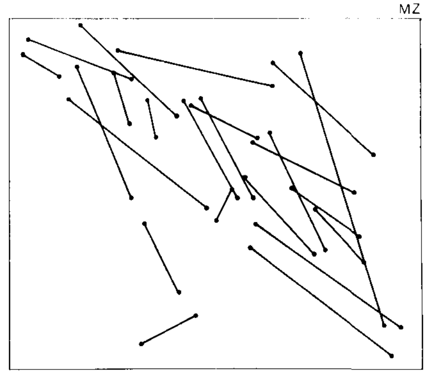


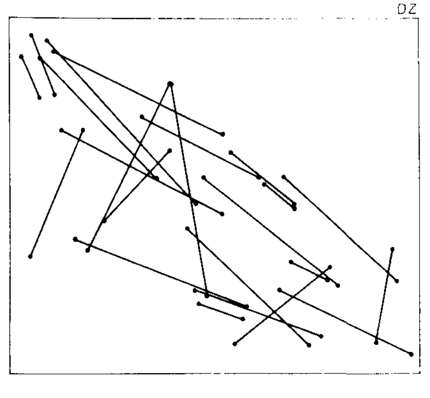
Figure - Space Diagrams of Partial Order Scalogram Analysis (POSAC)
MZ Twin Pairs
DZ Twin Pairs
Singleton Control Pairs.

Note. The POSAC-1 program is available from the Hebrew University Computer Center, Jerusalem, Israel, or from the Laboratory for Research Methodology in Child Development, Department of Psychiatry, University of Chicago.

TABLE 3 - Mean Absolute Differences Within Pairs on Five Tests

Test	MZ	DZ	C
Information	1.28	1.96	2.26
Arithmetic	1.88	1.84	2.90
Vocabulary	1.56	2.08	2.58
Block Design	1.24	2.40	2.50
Raven Progressive Matrices	4.84	7.20	7.24





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the singleton control pairs: the median correlation for the five tests is 0.29. This is almost identical to the IQ correlation for unrelated children reared from birth in the same adoptive family reported for the Texas Adoption project by Horn et al [8]. The similarity between the control pairs is the result of the shared kibbutz environment, but *without* the shared parental involvement and interactions present in adoptive families or in the MZ and DZ twins in their families. High correlations between unrelated pairs of children were reported in an early study by Sims [15], who found a correlation of 0.39 in IQs of children aged 13-15 in the same school, matched for nearest age and home backgroud.

Table 2 shows, furthermore, that the correlations for DZs and control pairs on the two figural tests (Block Design and Raven Matrices) are about equal, while correlations for the MZs are comparable to those reported by Wilson in six-year-old twins in WISC subtests [18]. This implies a particularly potent effect of the kibbutz environment on spatial ability. This finding will be elaborated on in the Discussion Section.

In order to make a direct comparison between the test scores – without adjusting to the means as does a correlation coefficient – we have computed the *mean absolute score difference* within twin pairs and within unrelated pairs. These are given in Table 3.

This table gives comparisons for the three kinds of pairs: MZ, DZ, and unrelated singletons.

The results in Table 3 reinforce the findings from Table 2. As in the correlation presentation, the similarity of unrelated pairs on the spatial tests essentially equals that of the resemblance of the DZ pairs.

Structural Analysis of Test Score Profiles

The data presented in Tables 2 and 3 raise several questions, particularly with regard to the source of the resemblance within the DZ pairs in this study – whether it represents shared environment, genetic endowment, or both.

The following is an attempt to distinguish between these sources of resemblance in a structural analysis of the test profiles by means of *Partial Order Structuple (Scalogram) Analysis* (POSA) using the POSAC-I computer program [13: pp 165-279; 14].

POSAC studies the profiles of individuals from a battery of variables – such as test scores – where the ranges of the variables are ordered in the same direction. In the case of this study, all test scores are ordered from low to high "intelligence test performance".

The range of each of the five test scores was converted into four categories, from lowest performance (1) to highest (4). Every child thus obtained a profile (structuple) of five numbers. The profiles range from the lowest score on all items (11111) to the highest (44444), with all other possible permutations of item categories. Any two given profiles (structuples) are defined to be *comparable* if, and only if, each item score in one profile is greater than or equal to the corresponding item score in the other. For instance, the two profiles 12333 and 13443 are comparable. In fact, 13443 is greater than 12333: in the first and last items they are equal, while in the other items the first profile is greater than the latter. The two profiles 43112 and 34112 are *noncomparable.* While the total scores of these two structuples are equal (= 11), there exists at least one pair of variables in one of which one profile has a higher and in the other a lower category.

POSAC-1 presents a spatial representation of individual profiles (structuples), each as a point in a two-dimensional space. The POSAC-1 program prints a "space diagram"; three such space diagrams are given in the Figure: (A) of MZ, (B) of DZ, and (C) of singleton structuples (profiles).

Each point represents an individual structuple (profile) of five tests; a subroutine makes it possible to identify each child to whom the profile belongs. The two points for each pair of children have been connected by us by a straight line. The space is partly ordered by the two axes so that the maximal point (the highest profile score) is the upper right-hand corner, and the minimal point is lower left-hand corner. Thus the singleton point in the upper right-hand corner in Figure C probably has the highest compound score of the group.

A comparison of space diagrams A, B, and C shows differences in the *direction* of the lines connecting pairs of children, particularly with regard to the space diagram of the singletons (C). This is according to our prediction which relates to the systematic nature of the profile pairs as it arises from their direction.

Our hypothesis is that MZ profile pairs should be *basically* identical, showing only ideosyncratic deviations created by environment. If the environment affects the individual test scores, but not in a completely systematic way, this will convert identical profiles into noncomparable ones. Hence the two points for an MZ pair will not coincide but will tend to lie on a counter-diagonal line (a line with negative slope). Inspection of Figure A shows the 46 individual profiles (who had answers on all tests) for 23 MZ pairs. All but two profile pairs are ordered in the counter-diagonal direction.

In the DZ pairs (B) differences are genotypic as well as environmental. Hence, differences within DZ pairs should be more systematic in test performance than within MZ pairs, for which all differences are not genotypic, and are thus random. The DZ differences should therefore lead to more comparability. Indeed, 6 out of 23 profile pairs are comparable. In the singleton pairs (C) we find, as expected, a variety of directions including a variety of comparable and noncomparable profiles. Thus the evidence clearly shows a descending order of frequency of comparable profile pairs from singletons to MZ pairs, as would be predicted by their level of genetic similarity.

DISCUSSION

This study has focused on the impact of the kibbutz environment on similarity in performance of children raised in the same peer group. While the number of pairs tested is not large, it represents a major proportion of the cohort of kibbutz twins aged 8-13 at the time of testing.

We found that the peer group environment produced similarities in unrelated kibbutz children of a level similar to that found by Horn et al [8] in unrelated children who were raised in the same home by the same set of parents. In the kibbutz study, each control child had a separate set of parents.

Particular attention should be paid to the equal correlations of singleton pairs and DZ pairs on the two figural tests. This implies a particularly potent impact of the kibbutz environment on spatial performance.

Two further papers also point to an environmental influence on spatial performance. A study by Guttman and Shoham [7] on the structure of conditional correlations between performance of parents and performance of their children under different levels of education, reveals a reduction in parent-offspring correlations from unconditional correlations. Particularly in the Raven Progressive Matrices, the correlation is reduced from $r_{po} = 0.32$ (unconditional) to 0.16, when parent's education is held constant.

Amir's study [1] relates directly to the effect of the kibbutz on spatial ability. Amir found that in tests administered by the IDF (Israel Defence Forces), inductees who had been raised in kibbutzim excelled in several tests including the Raven. He ascribes his finding to the effect of the socialization process in the kibbutz.

The data presented here need to be replicated in a new cohort and extended to different test batteries. Studies should be designed which will define and test the specific factors in the kibbutz environment which influence cognitive development of the kibbutz reared child.

The method of adding to the comparison of the kibbutz twin pairs also matched singleton controls, combined with the structural analysis (POSAC) of the data, should add a further measure of validation to such studies and may give more stringent evidence for the respective roles of heredity and environment in performance on cognitive tests.

REFERENCES

1. Amir Y (1969): The effectiveness of the kibbutz-born soldier in the Israel Defense Forces. Human Relations 22:333-344.
2. Cohen DJ, Dibble E, Grawe JM, Pollin W (1973): Separating identical from fraternal twins. Archives of General Psychiatry 29:465-469.
3. Cohen DJ, Dibble E, Grawe JM, Pollin W (1975): Reliably separating identical from fraternal twins. Archives of General Psychiatry 32:1371-1375.
4. Devereux EC, Shouval R, Bronfenbrenner RR, Rodgers S, Kav-Venaki E, Kiely E, Karson E (1974): Socialization practices of parents, teachers, and peers in Israel: The kibbutz versus the city. Child Development 45:269-281. Reprinted in Krousz E (ed): "The Sociology of the Kibbutz". New York: Transaction Books, pp 305-318.
5. Fox N (1977): Attachment of kibbutz infants to mother and metapelet. Child Development 48:1228-1239.
6. Greenbaum Ch, Kugelmass S (1980): Human development and socialization in cross-cultural perspective: Issues arising from research in Israel. In Warren N (ed): "Studies in Cross-Cultural Psychology Vol.II." New York: Academic Press, pp 95-144.
7. Guttman R, Shoham I (1983): Parent-offspring resemblance and parental education. Behavior Genetics 13:99-105.
8. Horn JM, Loehlin JC, Willerman L (1979): Intellectual resemblance among adoptive and biological relatives: The Texas Adoption Project. Behavior Genetics 9:177-207.
9. Husén T (1960): Abilities of twins. Scandinavian Journal of Psychology 1:125-135.
10. Plomin R, DeFries JC (1980): Genetics and intelligence: recent data. Intelligence 4:15-24.
11. Plomin R, Rowe DC (1977): A twin study of temperament in young children. Journal of Psychology 97:107-113.
12. Scarr S (1975): Commentary 1. In Schaie KW, Anderson VE, McClearn GE, Money J (eds): "Developmental Human Behavior Genetics." Massachusetts: Lexington Books, pp 77-84.
13. Shye S (1978): Partial order scalogram analysis. In Shye S (ed): "Theory Construction and Data Analysis in the Behavioral Sciences." San Francisco: Jossey-Bass Pubs., pp 265-279.
14. Shye S, Elizur D (1976): Worries about deprivation of job rewards following computerization: A partial order scalogram analysis. Human Relations 29:63-71.
15. Sims VM (1931): The influence of blood relationship and common environment on measured intelligence. Journal of Educational Psychology 22:56-65.
16. Talmon Y (1974): "Family and Community in the Kibbutz." Massachusetts: Harvard University Press.
17. Vogel F, Motulsky AG (1979): "Human Genetics: Problems and Approaches." New York: Springer.
18. Wilson RS (1975): Twins: patterns of cognitive development as measured on the Wechsler Preschool and Primary Scale of Intelligence. Developmental Psychology 11:126-134.
19. Wilson RS (1981): Mental development: Concordance for same-sex and opposite-sex dizygotic twins. Developmental Psychology 17:626-629.

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