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Genetic and environmental influences on pupil performances

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The results presented in this paper are part of a current comparative study of genetic and environmental influences in three educational settings: Stockholm, Jerusalem and the Israeli kibbutz. We specifically wanted to investigate whether a more restrictive educational setting would decrease genetic influences. Here we report on comparisons of cognitive performance measures at several time points for twins/controls, boys/girls and within-pair similarity in MZ, DZ and controls. The tests used were the Raven Progressive Matrices, verbal, reading comprehension and arithmetic. The results show no differences between twins and controls, whilst gender differences seem to be smallest in the Stockholm sample and largest in Jerusalem. A pattern of genetic influences on cognitive performance was also clearly visible in Jerusalem. In Stockholm shared environmental influences at home and at school seemed even stronger than in the kibbutz. No consistent differences were found between tests or occasions.

Keywords: twins, educational setting, follow-up, cognition, school achievement, permissiveness, restrictiveness, cross-cultural influences, heredity/environment

Introduction

This study is part of a comprehensive cross-cultural project designed to investigate hereditary and environmental influences over a time period in three different contexts: (1) urban schools in Stockholm, Sweden (2), urban schools in Jerusalem, Israel, and (3) kibbutz schools in Israel. These contexts were purposely chosen to exemplify variations in restrictiveness, that is availability of choice in the school situation.

Previous research

There has been much debate on the importance of hereditary vs environmental influences on children's emotional and intellectual development. Scarr[1,2] can be said to represent the hereditary point of view, stressing the importance of genetic prerequisites in the choice of environmental experiences. She maintains that these are the primary factors influencing development provided that family environment is within 'the normal range'. Baumrind[3] repudiates this statement, pointing to the importance of parental beliefs in their own capacities to enhance development. Bronfenbrenner and Ceci[4] present a bioecological model, hypothesising how biological/genetic prerequisites interact with environmental influences at both a micro (setting) and a macro (context) level. The authors cite relevant research indicating that both neglectful (laissez-faire) and abusive (authoritarian) socialisation practices are harmful for optimal development. Instead, both permissive and restrictive upbringing can be efficient if it encompasses positive 'proximal processes', that is mutual continuous relationships between the child and the caretaker. Bronfenbrenner and Ceci also argue that environmental influences in the immediate setting are more important for optimal development than contextual factors.

Previous twin research has shown that the impact of hereditary influences on school children's test performance is related to both availability of individual choice and environmental stimulation conducive to optimal development.[5] In this study, monozygotic (MZ) twins, who share all their genes, were compared with dizygotic (DZ) pairs, who share only half of their segregating genes. At puberty logical-abstract thinking was found to be more genetically influenced than verbal ability,[6] whilst school and family environment had a more substantial impact on variation in mathematics achievement. Middle-class families exerted a more powerful influence on pupil achievement than working-class families.[7] On the basis of these results a model of interaction between individual prerequisites and educational influences was developed and has been

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applied to research in many different areas.[8–10] This model hypothesises that a more restrictive environment will reduce the influence of hereditary factors and by contrast a more permissive environment will increase the impact of these factors. Restrictions of individual choice can appear at the societal level, such as the kibbutz system, but it can also be studied in an educational or family setting, where the teacher or parent can be more or less restrictive in the sense that they may allow the child to make his own choices.[11] Whether restrictiveness or permissiveness is preferable in the school or home situation depends of course on the goals and content of the activity as well as on the characteristics of the persons involved. Generally, it can be maintained that if the educational goal is to reduce the impact of individual variation (eg due to home background or intellectual ability), this might be easier to accomplish in a more restrictive environment.

In their kibbutz study of twin/singleton quartets, Nathan and Guttman[12] found that not only twin pairs, but also matched singleton control pairs in the same peer group were similar in their performance on two tests: the Block Design from the WISC and the Raven Progressive Matrices. Within-pair similarity of unrelated control subjects almost equalled that of the DZ twins on scores on these two tests. It was concluded that the shared physical, social and educational environment of the kibbutz influenced similarity in performance of these children on these tasks.

The design of the present research arose from questions emanating from the above studies: whether being raised in a kibbutz, with its apparent limited individual choice, represented a more restrictive environment than urban school environments in Sweden or Israel. A joint Swedish–Israeli study of twins and singletons has been in progress for the past several years.[13–15] Fischbein et al[14] compared perception of restriction by pupils in the fourth and sixth grades in the Israeli kibbutz and in Stockholm compulsory schools and found no systematic differences between the two samples. Pupils in kibbutz schools asserted that they had not much influence on the choice of subjects and activities in the classroom. In expressing disagreement, however, they felt more 'free' towards their teacher than did Swedish children. Comparing teacher-imposed and pupil-perceived restrictions, kibbutz teachers reported only slight restrictions on choice of subjects, whilst their pupils actually felt highly restricted. In Sweden, a difference was found between subjects: pupils felt that they had more individual choice in mathematics than in Swedish (their mother tongue). Their teachers, on the other hand, asserted that they imposed more restrictions in the mathematics than in Swedish. This difference could probably be explained by the fact that the pupils were more 'free' to do their work in mathematics whenever they chose during the week, whilst the teacher generally told them what to do in the Swedish lessons.

The Israeli kibbutz provides a valuable source of comparison with the city, because of the unusually homogeneous environment in which children are raised from birth to maturity.[16,17] Whereas in recent years there have been considerable changes in the social and economic structure of most kibbutzim, at the time the data of this study were collected the Israeli kibbutz was still unique as a comparatively small community in which most property is collectively owned and members share in the work and the governing of the community. Though kibbutz children now sleep in their parents' apartment, the children in our study were raised under the 'classic' kibbutz system of special children's houses. Members of the same peer group shared caretakers, teachers, food and resources during most of the day. The caretaker, metapelet, was still a particularly important and stable figure in the daily life of the child. Thus these kibbutz children had three effective sources of shared environment: family, caretakers and the communal aspects of the kibbutz.[18]

The kibbutz also has a deep ideological commitment to the equality of all its members, including of course gender equality. It therefore offers women the independence necessary for equal possibilities of development.[19] Previous studies have shown smaller sex differences in cognitive performance measures in the kibbutz than in city-born samples. There is also often no increase in this difference after puberty. It is thus reasonable to assume that not only hereditary individual influences but also biological group differences, such as for instance sex and maturation, might be affected by a shared environment specifically fostering equality of the sexes.

All the Swedish children in this study came from areas within or in the vicinity of Stockholm. The schools in the different parts of the city vary with regard to number of immigrants, social welfare expenditure, stability of teachers and peers in the classes etc. Swedish children start school at 7 years of age. During the first six years of school, they generally have only one teacher for all subjects, except sometimes in sports, art, music or foreign language (English). In grades 7, 8 and 9 pupils often change school and have different teachers in varying subjects such as natural sciences, social sciences, foreign languages, Swedish and literature. At the time of this study the children did not receive marks until the 8th grade and typically the contact between parents and teacher consisted of a 15 minute meeting every half year when they discussed the progress of the child. Sweden is still a fairly homogeneous

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country in spite of recent increases in immigration rates. There is also a long tradition of corporativism and socialistic government and the school system offers few opportunities of individual choice. The ideology of equality is very strong in Swedish society and this sometimes also implies equal treatment, reducing the possibilities for students to influence their own school situation.[20,21]

The Jerusalem and kibbutz children begin school at age six and all through elementary school follow the same curriculum. Variation among the urban schools tends to be greater than that in the kibbutz schools, because of differences in social and economic circumstances. Very often city children both in Stockholm and Jerusalem meet their classmates primarily during school hours and may have different friends after school. In the kibbutz, on the other hand, peer groups spend most of their day together.

Actual research

The design and the instruments used in the present study are illustrated in Figure 1. This is modified from a model developed by Fischbein[8] on the basis of results from previous longitudinal twin research. Availability of individual choice (permissiveness) is hypothesised to affect the interaction of individual prerequisites and environmental influences at different levels in educational settings. In a more permissive environment hereditary influences would be expected to be greater. On the other hand, a more restrictive environment would decrease such influences and increase the magnitude of shared environmental variance.

Stockholm, Jerusalem and the Israeli kibbutz (vertical dimension) exemplify three different educational settings at the societal level. In these settings the children were observed in grades 4–8, three times in Israel and twice in Sweden. The teachers in these grades gave their views on the availability of choice given to the pupils in different subjects and generally at school.

The children in this study (horizontal dimension) come from more heterogeneous home environments (Stockholm and Jerusalem) and more homogeneous (kibbutz). Parents in the Stockholm and Jerusalem samples tend to have varying backgrounds and socio-economic levels, whilst parents in the kibbutz tend to share a communal lifestyle. All the parents of the twins and controls in Israel and of the twins in Sweden were asked about the rules they have in the family and the availability of choice for their children. In all three environments female and male twins and controls were asked their views on how they perceive their home and school environments, with regard to availability of individual choice in different aspects of their daily lives.

The tests given in this study are ability measurements (Raven Progressive Matrices, verbal test) and

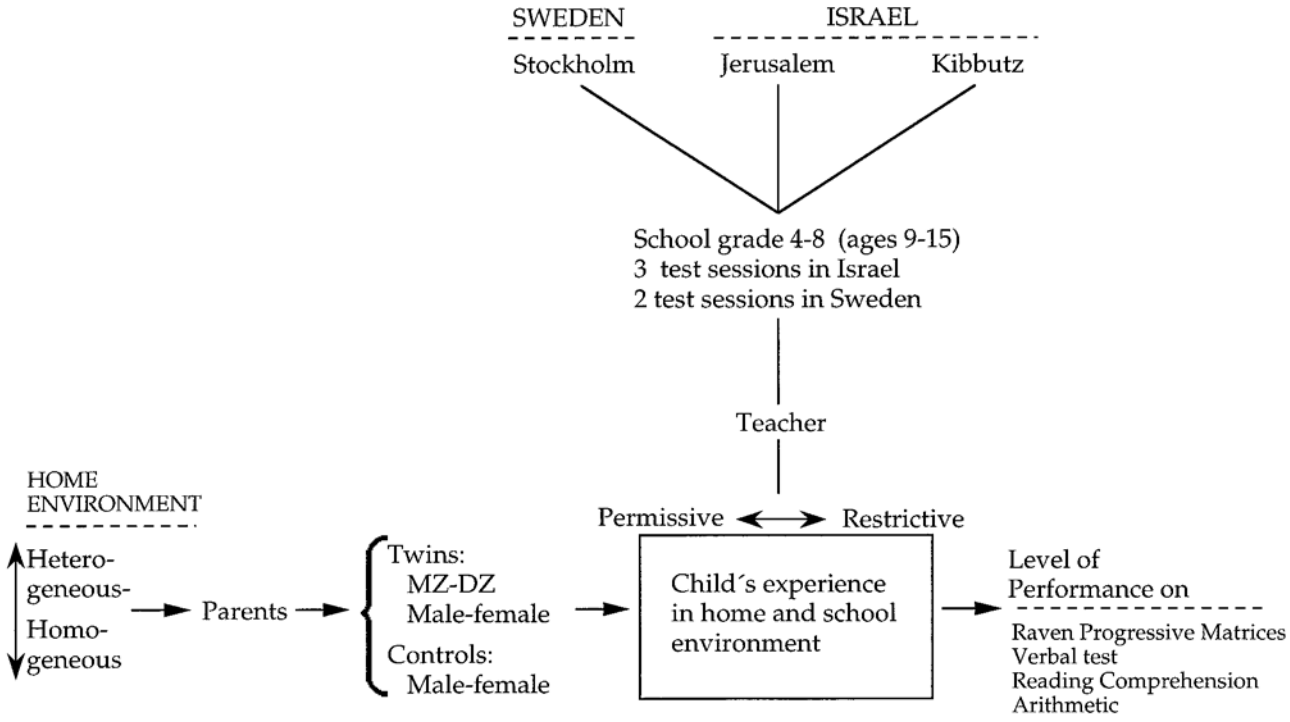

Figure 1 The cross-cultural educational design

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specific achievement measures linked to the school curriculum (reading comprehension, arithmetic). The results presented in this paper concern performances on these tests for groups of twins and controls, females and males, as well as for twin and control pairs.

The conceptual framework for observations on children's educational environment was constructed with the aid of a mapping sentence, given in Guttman et al[13] and in Fischbein et al.[14] It relates to the range of restrictions imposed on, or perceived by the children, teachers, parents and caretakers. Whilst the questionnaires and tests used in Sweden and Israel were similar but not identical, the same facets (eg assessing success in various materials at school) are investigated in both countries taking into consideration the specific cultural context.

Aim of the study

The general hypothesis in this study is that a restrictive environment will decrease the impact of biological (sex differences) and genetic (twin pair comparisons) on outcome variation (ability and achievement) and that a permissive environment will increase this impact.

The first question posed in this study is whether shared environmental influences will be of the same magnitude for boys and girls in restrictive compared with permissive environments. The environments being compared are urban environments in different countries (Sweden and Israel) and kibbutz compared with city in the same country (kibbutz and Jerusalem in Israel).

The second question is whether intra-pair similarity for MZ and DZ twins and controls will vary according to environmental restrictions.

The third question is whether restrictions at school will be more influential on achievement compared with ability measures.

The fourth question is whether a longer exposure to the same environmental influences (eg at school) will increase the impact of such influences.

In our study comparisons of cognitive performance measures at several time points are made for

- twins and singleton controls (henceforth called 'controls')
- boys and girls
- within-pair similarity in MZ, DZ and controls (Co)

in

- urban environments in Sweden and Israel (Stockholm and Jerusalem)
- urban and kibbutz environments in Israel.

The expectations are that correlations between the different tests at each time point and over time will be fairly high due to a common underlying g-factor. Differences between twin and control groups will be of the same magnitude irrespective of environmental variation. Sex differences are expected to be smaller in the Swedish than the Israeli urban environment and larger in the urban than the kibbutz environment in Israel. Finally, the differences between MZ, DZ and Co in within-pair similarity are expected to be smaller in the Swedish than the Israeli urban environment and larger in the urban than the kibbutz environment in Israel.

Material and method

In the Stockholm area 36 identical (MZ) and 37 fraternal (DZ) twin pairs of the same sex and all their singleton class mates were included in the study. The corresponding numbers for kibbutzim were 31 MZ and 24 DZ and for Jerusalem 14 MZ and 47 DZ pairs. In total, 27 kibbutzim from the north to the south of Israel participated. Singleton pairs in the same classes were matched to the twins, forming a quartet. We tested 852 boys and 826 girls in Stockholm, 119 boys and 93 girls in the kibbutz and 116 boys and 121 girls in Jerusalem.

At the beginning of the project all the twins and controls were between 9 and 13 years old and attended grades 4 to 6. The Israeli children were on average one year younger than their Swedish counterparts, due to the fact that children begin school at 6 years of age in Israel and at 7 in Sweden. The Swedish twins were contacted again in grade 8 when they were approximately 15 years old. Data were collected for both the twins and their classmates, but since they normally changed schools, the controls are not comparable from the first to the second occasion. In Israel, the Cross Sequential Design of Schaie and Baltes[22] was used: Group 1 was tested in grades 4, 5, 6 in succession, Group 2 in grades 5, 6, 7, and Group 3 in grades 6, 7 and 8. This design provides both three-year follow-up data for each child, and cross-sectional replications for ages 10, 11 and 12 (grades 5, 6 and 7).

Zygosity was established with the help of parents' statements. They were asked to rate the similarity of their children.[23] In Jerusalem and the kibbutz, photographs were also taken of the twins and in case of uncertainty a blood test was made to establish the zygosity.

All twins and controls were contacted at school and were given a questionnaire concerning their relations with teachers and parents, particularly with regard to perceived restrictions. They were given the cognitive performance tests shown in

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Table 1. In Israel these tests were administered individually to the children, whilst in Sweden whole classes took the same tests simultaneously. In grade 8 the standardised achievement test scores in Swedish and mathematics regularly used were collected. These scores have been transformed to stanine values in order to make comparisons between different streams (general and advanced) within grades.

The Raven Progressive Matrices (parts A–E) were used as a test of analytic spatial ability with previous evidence of hereditary influence, and considered fairly robust in different cultural settings.[24] This is the only test which was exactly the same in all three samples. In Israel, parts of the WISC were administered to both kibbutz and Jerusalem children. In the Jerusalem sample the arithmetic part of this test was omitted. Language proficiency was tapped in Sweden by responding with the opposite to a given word and by a reading comprehension test. In Israel, the vocabulary part of the WISC and a reading comprehension test were administered. At the first of the two test sessions in Sweden, the reading comprehension test consisted of pictures with written alternatives from which the children needed to choose the correct alternative. At the second session a standardised achievement test in Swedish was used. The Israeli children were given a reading comprehension test produced by the Israel Ministry of Education. The first arithmetic test administered in Sweden was constructed to fit the curriculum of this age group (grades 4, 5 and 6), whereas on the second occasion, scores from the standardised mathematics achievement test regularly used in grade 8 were collected. In the kibbutz sample, the arithmetic part of the WISC was included.

Results

Test intercorrelations

The only test that was identical for all three samples (Stockholm, Jerusalem and kibbutz) on all occasions was the Raven Progressive Matrices. The other tests measured verbal performance, reading comprehension and arithmetic. The first two were identical only for the Jerusalem and kibbutz samples. It is therefore of interest to study the intercorrelations between the test scores for the three samples at different test sessions. Table 2 illustrates these intercorrelations with the first occasion above and the second occasion below the diagonal. Both twins and their classmates are included in most analyses.

At the first test session, where the twins and controls were approximately 12 years of age in Stockholm and 9–11 years in Jerusalem and the kibbutz, correlations between the Raven scores and the other test scores were fairly high in all three samples. At the second session (age 15 in Stockholm and 10–12 on average in Jerusalem and kibbutz) intercorrelations between test scores in the Stockholm sample were of the same magnitude as on the first occasion. The lowest correlation was found for the verbal and arithmetic tests ($r = 0.31$).

The intercorrelations between test scores of the twins and controls in the kibbutz are generally quite high (from $r = 0.40$ to $r = 0.70$). The correlations were of the same magnitude on the second occasion. Intercorrelations for the third occasion are not presented but they are equal to the other sessions and vary between 0.44 for vocabulary and Raven to 0.71 for vocabulary and Hebrew. The last-mentioned relationship was the strongest on all three occasions. The test intercorrelations in the Jerusalem sample

Table 1 Tests administered to children in Stockholm, Jerusalem, Kibbutz

Sweden	Israel	
Stockholm	Jerusalem	Kibbutz
1st test session		
RPM[a] A–D	RPM[a] A–D	RPM[a] A–D
Opposites	WISC – Vocabulary	WISC – Vocabulary
Reading comprehension (Swedish)	Reading comprehension (Hebrew)	Reading comprehension (Hebrew)
Mathematics test	WISC – Arithmetic	WISC – Arithmetic
2nd test session		
RPM[a] A–E	RPM[a] A–D	RPM[a] A–D
Opposites	WISC – Vocabulary	WISC – Vocabulary
Standardised achievement test (Swedish)	Reading comprehension (Hebrew)	Reading comprehension (Hebrew)
Standardised achievement test (Mathematics)	–	WISC – Arithmetic
3rd test session		
–	RPM[a] A–D	RPM[a] A–D
–	WISC – Vocabulary	WISC – Vocabulary
–	Reading comprehension (Hebrew)	Reading comprehension (Hebrew)
–	–	WISC – Arithmetic

[a]RPM = Raven Progressive Matrices

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are of the same magnitude as in that of the kibbutz, and again the highest correlations are found between Hebrew and verbal ability (r = 0.75) on each of the three test occasions.

The two tests that were identical at the first and second test session in Sweden (Raven and Opposites) correlated quite substantially from one occasion to the next. The figures have been estimated only for the twins since the controls were not the same on the two occasions.

Test correlations over time in the Jerusalem sample were substantial for the Raven between sessions. This was also true of reading comprehension and of the vocabulary test.

The correlations over time in the kibbutz sample were highest for reading comprehension and for the verbal test and a little lower for arithmetic and the Raven.

Summarising the results in Table2 we find that scores on the Raven Matrices have fairly high intercorrelations with other tests in all three samples (0.40–0.55). For the cognitive performance measures that are comparable over time the fairly high intercorrelations between the test sessions suggest satisfactory reliability.

Comparison of twins and controls in the Stockholm, Jerusalem and kibbutz samples

Table3 shows the average test results for twins and controls in the Stockholm, Jerusalem and kibbutz samples on each occasion.

A coefficient of discrimination (Disco) is shown for comparison between the twin and control samples in the varying environments on different occasions. This value has been developed by Guttman[25] to assess the efficacy of differences among means in terms of overlap of the respective distributions. 'Disco' equals zero if there is a complete overlap and 1 if there is no overlap at all between the distributions. Intermediate values between 0 and 1 indicate intermediate amounts of overlap. Thus differences in size of efficacy coefficients are consistent estimates of differences in the population. For comparison F values are also given in the Table.

Table 2 a, b, c Intercorrelations between test scores in the Stockholm, Jerusalem and kibbutz samples (first session above, and second session below diagonal)

a) Stockholm	Raven A-E	Verbal test	Swedish	Arithmetic
Raven A-D	–	0.42	0.41	0.52
Verbal test[a]	0.50	–	0.37	0.49
Swedish	0.46[b]	0.66[b]	–	0.37
Arithmetic	0.45[b]	0.31[b]	0.55[b]	–
b) Jerusalem	Raven A-D	Verbal test	Hebrew	
Raven A-D	–	0.45	0.45	
Verbal test[a]	0.46	–	0.75	
Hebrew	0.55	0.75	–	
c) Kibbutz	Raven A-D	Verbal test	Hebrew	Arithmetic
Raven A-D	–	0.45	0.40	0.45
Verbal test[a]	0.41	–	0.70	0.58
Hebrew	0.51	0.69	–	0.57
Arithmetic	0.46	0.62	0.52	–

[a](Stockholm = opposites; Jerusalem, kibbutz = vocabulary)
[b]Twins only

Mean performances on the Raven tend to be of the same magnitude for twins and controls in the different samples on each occasion. The mean values for the Swedish and Israeli samples cannot be compared since the pupils differ in ages.

The kibbutz sample, however, tends to show somewhat higher mean values than the Jerusalem sample on each occasion. However, Discos, are low for all comparisons, indicating little difference in performance between kibbutz and Jerusalem pupils for all subjects.

There are very small differences on the verbal test between twins and controls in the different samples at each occasion. Kibbutz sample mean performances are higher than the Jerusalem means, particularly for the controls. For the achievement tests in reading comprehension the differences between twins and controls are even smaller than for the ability tests. The kibbutz children again had higher mean performances than the Jerusalem subjects.

For arithmetic comparisons can only be made in the Stockholm and kibbutz samples. They both show very small differences between twins and controls on all occasions.

In summary, we find very small differences in performance between twins and controls for all the tests on varying occasions. No advantage was found for the controls in comparison to the twins. This is evident in urban areas in two different countries (Sweden and Israel) and in the kibbutz environment in Israel. Both twin and control children in the kibbutz tended to perform somewhat better than the Jerusalem children on the same test.

Comparison of sex differences over time in the Stockholm, Jerusalem and kibbutz samples

In addition to comparisons of test results for twins and controls, it is of interest to investigate sex differences in the three samples over time, especially since the kibbutz environment was originally designed to lessen such differences. Table4 thus presents test results for boys and girls in the Stockholm, Jerusalem and kibbutz samples.

In both the Stockholm and kibbutz samples the differences between boys and girls on the Raven are very small. In the Jerusalem sample, however, these differences are substantially in favour of the boys, and they increase over time. On the second and third occasions the Disco values are above 0.30 which

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indicates non-overlapping distributions, and the F-values are 5.73 and 5.51 respectively.

In the verbal test there is a difference between the Stockholm and the Jerusalem and kibbutz samples. In Sweden the girls show slightly higher mean values, particularly at the second test, whilst the boys score higher in the Israeli samples.

In the tests in Swedish and Hebrew respectively, the Stockholm girls again tend to score higher than the boys and particularly on the second occasion in grade 8. However, it has only been possible to compare mean performances for the twins. The comparison between the Jerusalem and kibbutz samples show no consistent differences between boys and girls in the kibbutz, whilst the advantage of the boys in the Jerusalem sample tends to increase over time.

A comparison of the arithmetic test results for the Stockholm and kibbutz samples show negligible sex differences in the Swedish sample (only twins on the second occasion), whilst the boys have higher mean values in the kibbutz sample. The advantage for the boys in the latter sample is fairly significant on the first occasion, then diminishes, but finally shows a substantial increase on the third occasion.

Summarising the results from the comparison of male and female performances, we find the smallest differences between boys and girls in the Stockholm sample. The comparison between the kibbutz and Jerusalem samples show larger gender differences in favour of the boys in the urban sample, particularly on the third occasion (grade 6, 7, 8).

Within-pair similarities of twins and controls in the Stockholm, Jerusalem and kibbutz samples

Intra-class correlation coefficients (R) were calculated to compare within-pair similarity for MZ and DZ twins and controls in the same classes in the different samples. They are shown in Figure 2–5 for Raven, verbal test, reading comprehension and arithmetic. For the Stockholm sample there are two points in time and for the kibbutz and Jerusalem samples three. Arithmetic tests were not given to the

Table 3 a, b, c, d Comparisons of mean performances by twins and singleton control pupils

		Twins			Controls				
	Test session	N	M	SD	N	M	SD	Disco	F
a) Raven[a]									
Stockholm	1	147	38.72	5.05	1517	38.38	6.05	0.06	0.44
	2	104	47.96	4.82	1293	46.82	6.52	0.18	3.08
Jerusalem	1	118	33.71	7.90	117	33.63	7.86	0.01	0.01
	2	118	36.47	7.83	115	37.84	6.00	0.19	2.26
	3	103	39.19	6.00	96	39.93	5.41	0.12	0.81
Kibbutz	1	108	34.60	8.36	103	34.87	7.98	0.03	0.06
	2	110	37.01	7.65	101	38.75	5.44	0.26	3.58
	3	109	40.39	5.13	96	41.08	3.85	0.15	1.16
b) Verbal[b]									
Stockholm	1	146	22.67	6.13	1540	22.32	6.01	0.05	0.45
	2	104	27.76	5.31	1279	27.38	5.36	0.06	0.49
Jerusalem	1	118	27.86	6.66	118	28.52	6.42	0.09	0.60
	2	118	30.05	6.48	115	29.75	6.80	0.04	0.12
	3	103	33.51	5.02	97	32.64	6.23	0.14	1.21
Kibbutz	1	108	28.58	7.02	103	29.30	6.48	0.09	0.59
	2	110	31.29	6.89	101	32.58	5.74	0.18	2.17
	3	110	33.42	6.57	96	35.01	5.08	0.24	3.70
c) Reading comprehension[c]									
Stockholm	1	146	24.89	2.44	1538	24.74	2.42	0.06	0.52
	2[d]	97	4.87	1.89	1104	5.17	1.98	0.05	0.26
Jerusalem	1	118	37.02	8.09	118	38.20	7.27	0.14	1.38
	2	118	40.52	7.38	115	41.24	7.16	0.09	0.58
	3	103	44.49	6.27	97	44.49	6.31	0.00	0.00
Kibbutz	1	110	37.73	8.79	103	38.52	7.69	0.09	0.49
	2	110	41.50	7.75	101	43.70	6.34	0.27	5.06
	3	110	45.51	6.60	96	45.78	5.35	0.04	0.10
d) Arithmetic									
Stockholm	1	146	12.62	3.27	1536	12.77	3.22	0.04	0.29
	2[d]	97	4.87	1.89	1104	5.17	1.98	0.14	2.06
Kibbutz	1	108	13.36	2.34	103	13.45	2.42	0.03	0.07
	2	110	14.18	2.34	101	14.61	2.12	0.17	1.97
	3	110	14.80	2.19	96	15.10	1.90	0.13	1.12

[a]Raven A-D (max 48 p) except test session 2 in Stockholm: Raven A-E (max 60 p); [b](Stockholm = opposites; Jerusalem, kibbutz = vocabulary); [c]Stockholm = Swedish; Jerusalem, kibbutz = Hebrew); [d]Standardized achievement test

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Jerusalem sample, thus this comparison is of the Stockholm and kibbutz samples only.

In the presence of genetic influences on cognitive performances, higher intra-class correlations for MZ than for DZ twin pairs and lower for the controls would be expected. This classic pattern is found in the Jerusalem sample for all the tests at each session, except the Raven at the second session where twins and controls show similar intra-class correlations. In the kibbutz the vocabulary and the reading comprehension tests follow this pattern as well. In the Stockholm sample the only result that is in agreement with this pattern is the arithmetic test. This can be said without going into size of correlation or calculating heritabilities.[3]

For the Raven test in both Stockholm and kibbutz, DZ twins show either equal levels of similarities to the MZ or even higher correlations at some test sessions. This is also true for the results on the verbal and reading comprehension tests in Stockholm. For the arithmetic test in the kibbutz, MZ and DZ twin similarities were the same at the first test session, whilst MZ twins had higher intra-class correlations on the other two occasions.

Intra-pair similarities were always found to be lower in the controls than in the twins, irrespective of test or point in time. Intra-class correlations vary around 0.20–0.30, indicating higher than random similarities.

In summary, the results for the Jerusalem sample are generally in accordance with the expected pattern in the presence of genetic influences on cognitive performances. Both the Stockholm and the kibbutz samples deviate from this in the sense that MZ twin pairs show lower than expected correlations on the Raven in the kibbutz and DZ twins higher than expected correlations on the Raven, verbal and Swedish tests in the Stockholm sample. Control pairs often show higher than expected correlations.

Table 4 a, b, c, d Mean comparisons of test performances by gender

		Boys			Girls				
	Test session	N	M	SD	N	M	SD	Disco	F
a) Raven[a]									
Stockholm	1	852	38.34	5.77	811	38.48	6.18	0.02	0.24
	2	795	46.88	6.69	766	46.71	6.32	0.02	0.25
Jerusalem	1	116	33.90	7.73	119	33.45	8.01	0.05	0.19
	2	112	38.28	5.67	121	36.10	7.93	0.31	5.73
	3	94	40.54	4.46	105	38.66	6.55	0.32	5.51
Kibbutz	1	118	34.96	7.66	93	34.45	8.77	0.06	0.20
	2	119	37.64	7.24	92	38.11	6.01	0.07	0.25
	3	118	40.80	4.75	87	40.61	4.37	0.04	0.08
b) Verbal[b]									
Stockholm	1	859	22.27	5.80	826	22.45	6.24	0.03	0.39
	2	791	26.92	5.22	759	27.71	5.45	0.13	8.55
Jerusalem	1	116	29.20	6.94	120	27.21	5.99	0.27	5.57
	2	112	30.38	7.70	121	29.46	5.44	0.13	1.10
	3	95	33.84	6.34	105	32.41	4.85	0.23	3.26
Kibbutz	1	118	29.48	6.94	93	28.24	6.47	0.16	1.78
	2	119	32.67	6.52	92	30.92	6.10	0.24	3.95
	3	118	34.84	6.00	88	33.25	5.82	0.24	3.62
c) Reading comprehension[c]									
Stockholm	1	855	24.68	2.53	828	24.83	2.30	0.06	1.52
	2[d]	59[d]	4.69	1.98	46[d]	5.67	1.63	0.44	7.32
Jerusalem	1	116	37.79	8.41	120	37.43	6.97	0.04	0.13
	2	112	41.66	7.57	121	40.15	6.92	0.18	2.53
	3	95	45.28	6.62	105	43.77	5.89	0.21	2.92
Kibbutz	1	120	37.88	8.73	93	38.42	7.66	0.06	0.23
	2	119	42.54	7.41	92	42.58	6.91	0.00	0.00
	3	118	45.41	6.51	88	45.94	5.35	0.08	0.40
d) Arithmetic									
Stockholm	1	851	12.80	3.43	830	12.72	3.00	0.02	0.21
	2[d]	61[d]	4.69	2.00	48[d]	4.92	1.71	0.11	0.40
Kibbutz	1	118	13.76	2.45	93	12.95	2.20	0.31	6.30
	2	119	14.57	2.38	92	14.15	2.04	0.17	1.82
	3	118	15.27	2.17	88	14.50	1.83	0.33	7.29

[a]Raven A-D (max 48 p) except test session 2 in Stockholm: Raven A-E (max 60 p); [b](Stockholm = opposites; Jerusalem, kibbutz = vocabulary); [c]Stockholm = Swedish; Jerusalem, kibbutz = Hebrew); [d]Standardized achievement test/twins only

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Discussion

In this cross-cultural study, we were particularly interested in comparing urban and kibbutz environments in Israel and urban environments in Sweden and Israel. The hypothesis was that the urban environment in Sweden compared with Israel, and the kibbutz compared with the urban environment in Israel, would be more restrictive and accordingly biological and genetic influences would be less conspicuous in these environments. Specifically, group differences (twins/controls, boys/girls) and within-pair similarities (MZ, DZ, Co) were investigated over a time period in three educational environments (Stockholm, Jerusalem, Kibbutz). The kibbutz environment could be considered to be more homogeneous and restrictive in the sense that it offers less individual choice for its inhabitants. Sweden, on the other hand, has been subjected to a deliberate policy of striving towards equality in economy, gender and education during the greater part of the twentieth century; consequently individual striving and endeavour has not been encouraged.

Hereditary influences, illustrated by larger within-pair similarity for MZ than for DZ twins were hypothesised to vary in urban and kibbutz environments as well as between countries. Sweden, for example, can be considered a more homogeneous society than Israel, though immigration recently has increased in Sweden. The similarity of the unrelated controls is an indication of the effects of shared school environments. For the kibbutz children, however, this also includes sharing the life experiences outside school, such as social networks as well as physical environment.

Several studies have found differences in cognitive performance between twins and singletons in favour of the latter. This has been particularly so of verbal ability.[26] In our study, differences between the two groups were generally very small for all the cognitive tests. This was true for both urban and kibbutz environments. There were no systematic changes in this pattern from the fourth to the eighth grade.

As to gender differences, we found that girls generally had higher mean averages in the cognitive performance tests in Sweden, whilst the opposite was often the case in Israel. The differences were most conspicuous in the achievement tests (reading comprehension, arithmetic) and they also increased over time. This could be an effect of the age differences between Sweden and Israel, since the Swedish girls had already passed puberty. On the other hand, the same trend would then be expected in Israel on the third occasion. Instead, the gender

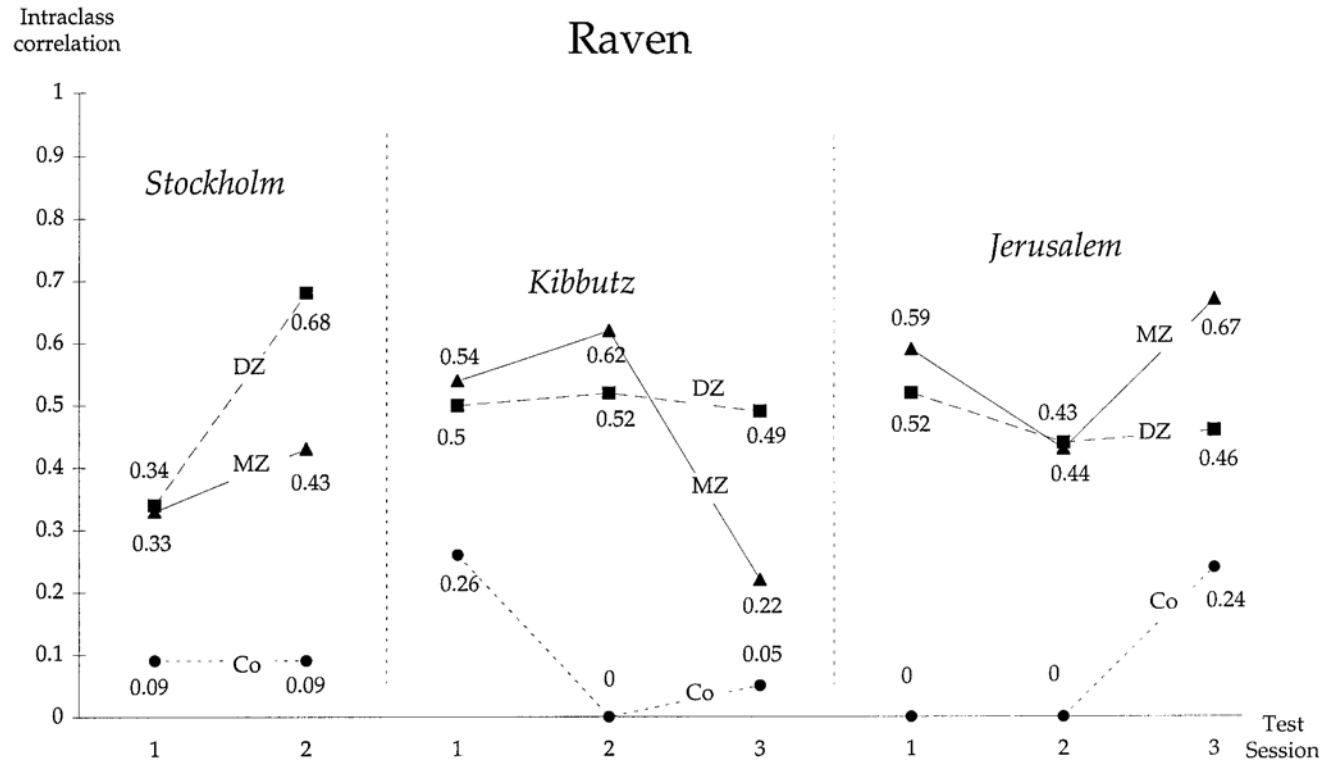

Figure 2 Within-pair correlations over time for MZ, DZ twins and controls (Co) on the Raven in the Stockholm, Jerusalem and kibbutz samples

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differences in the Jerusalem sample showed an increasing advantage in the boys. Other researchers have also found that Swedish girls have higher averages than boys on these types of tests. A tentative explanation might be the effects of a more egalitarian society.[27,28]

A comparison of the urban (Jerusalem) and kibbutz societies in Israel shows the kibbutz girls performing as well as the boys on Raven and reading comprehension. In the Jerusalem sample, on the other hand, boys excelled on all the tests and these differences tended to increase over time. Similar tests were reported by Nathan and Schnabl-Brandes[19] and explained by the equal treatment of boys and girls in the kibbutz environment.

With regard to within-pair comparisons, the Swedish sample differs from the Israeli in all the tests except arithmetic. It must be taken into consideration, however, that group testing was used in Sweden and that this might affect the results. MZ and DZ twins had equal levels of similarity for the Raven, verbal test and reading comprehension and both MZ and DZ twins became more similar over time. This may also be an effect of restrictive home and school influences. In the arithmetic test MZ twins are more similar than DZ, and MZs become more similar over time. This would be the expected result if genetic influences interacted with a shared school environment to affect test results.

The more homogeneous kibbutz environment does not seem to affect within-pair similarities. Generally, similar patterns were found in the Jerusalem and kibbutz samples with higher within-pair correlations for MZ than for DZ twins and lower for the controls. One of the important findings in this study is, however, the larger than expected similarity of singleton controls. This has been found in other studies[12,29] and can be explained by factors in the school environment, implying the sharing of a common curriculum, textbooks, teacher, peers etc.

There was no evidence of consistent differences between different types of cognitive performance measures nor of a consistent trend of increasing or decreasing genetic influences over time.

The most significant result of this study is the effect of the shared home and school environment in the Swedish sample. The homogeneous kibbutz environment primarily influences decreasing gender differences and increasing similarities for the control pairs. The expected weaker hereditary effects in a shared kibbutz environment could not be found. This perhaps is an illustration of the saying in the kibbutz that 'Where you have a fence you can have a lot of freedom within it'.

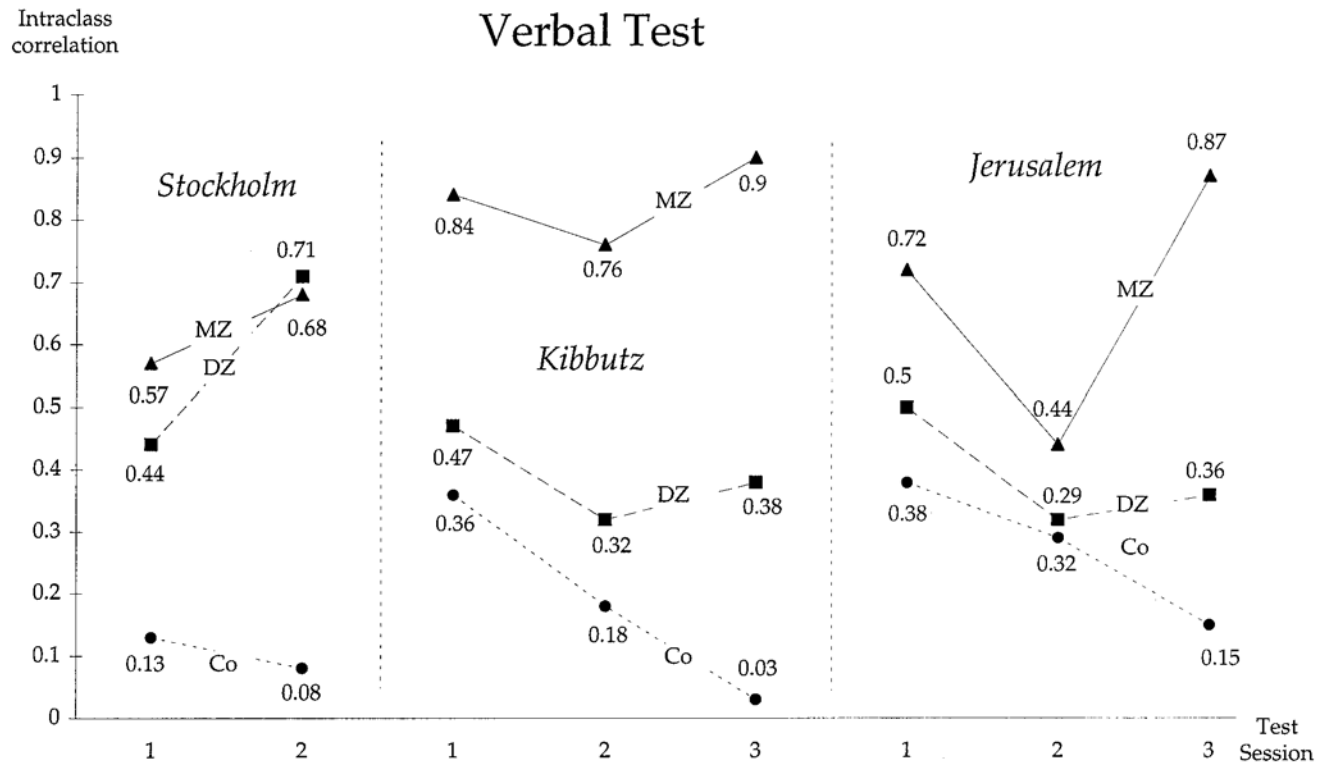

Figure 3 Within-pair correlations over time for MZ, DZ twins and controls (Co) on the verbal test in the Stockholm, Jerusalem and kibbutz samples

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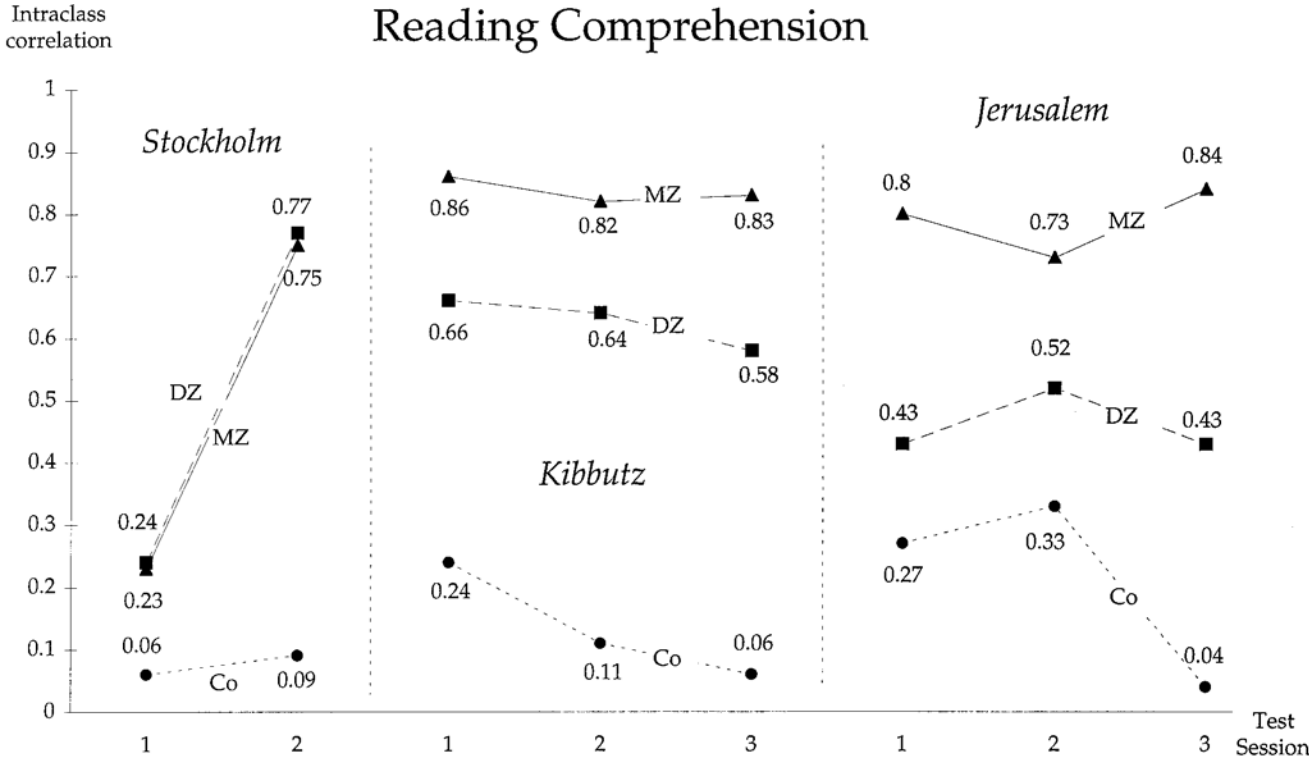

Figure 4 Within-pair correlations over time for MZ, DZ twins and controls (Co) on the reading comprehension test in the Stockholm, Jerusalem and kibbutz samples

Conclusions

With regard to the questions posed in the introduction, the following conclusions can be drawn:

- Differences in favour of boys are most conspicuous in the Jerusalem sample and considerably less so in the Swedish and kibbutz samples, except for arithmetic. It thus seems as if a restrictive environment promoting equality has a considerable effect on test results.
- The hypothesis that a more permissive societal environment will enhance biological and genetic influences has been partly corroborated, since such influences seem to be most conspicuous in the Jerusalem sample. It was not expected, however, that the Swedish sample would show smaller differences between boys and girls and between MZ, DZ and Co pairs in within-pair similarities. This could, however, also be an effect of the use of different instruments and test procedures.
- There is no consistent tend towards smaller differences between MZ, DZ and Co pairs in within-pair similarity for achievement compared with ability tests. Instead the arithmetic test seems to show the largest genetic influence.
- There is no consistent trend towards smaller differences between MZ, DZ and Co pairs in within-pair similarity over time which would be expected if shared school environment had a restrictive influence.

In the field of behaviour genetics multivariate methods of analysing twin data have been developed. Unfortunately, these methods demand fairly large samples and it has not been possible to apply them to our samples. In future, however, it would be of interest to collect larger twin samples in different societies with varying restrictions in societal and educational policies. In the Swedish society we had the opportunity to draw such comparisons for an older and younger twin cohort regarding choice of education and occupation. We found that genetic influences were larger for males in the older cohort, whilst the difference in this respect was negligible in the younger sample. This result could be explained by the restrictions on women in the older sample (over 60 years of age) in respect of educational and occupational choice.[30]

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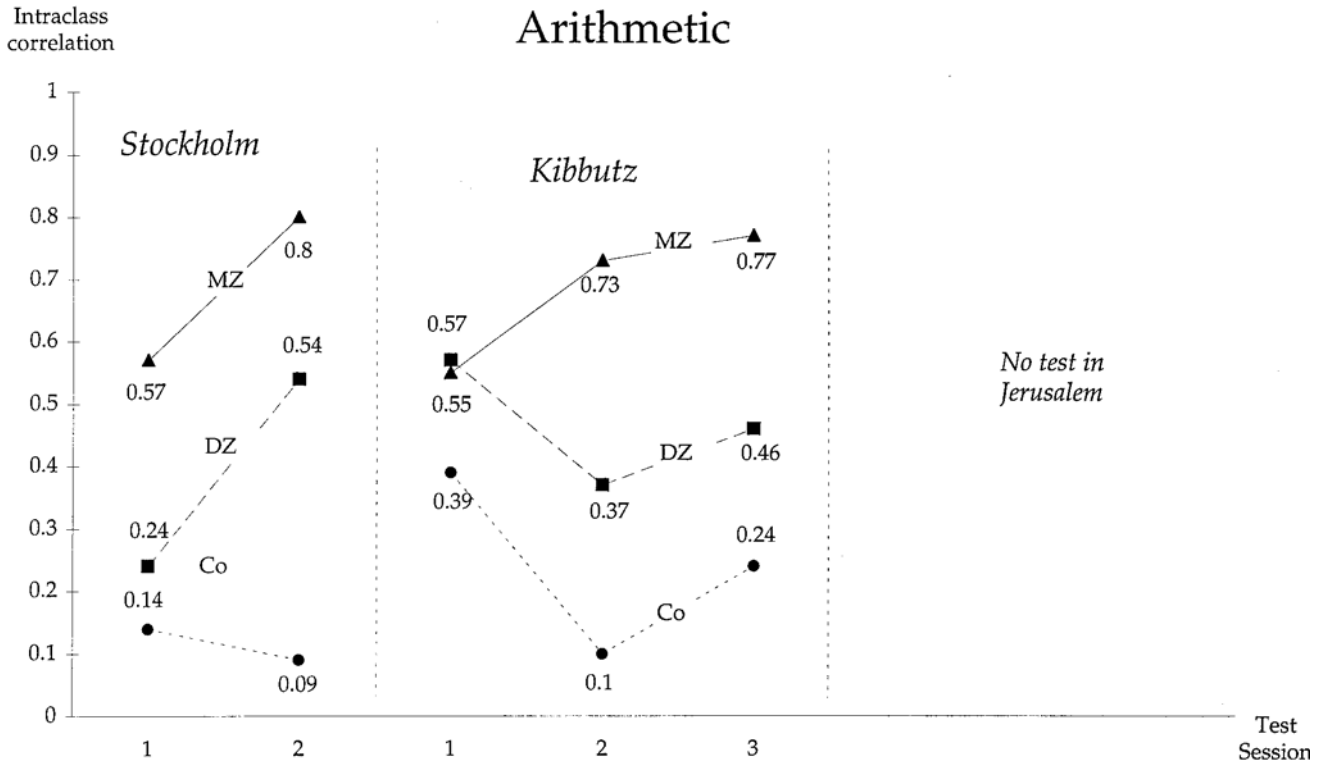

Figure 5 Within-pair correlations over time for MZ, DZ twins and controls (Co) on the arithmetic test in the Stockholm and kibbutz samples

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