SCHOOL ACHIEVEMENT, INTELLIGENCE, AND PERSONALITY IN TWINS

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A sample of 47 MZ and 49 DZ pairs of Brazilian twins was investigated in relation to school achievement in six specific areas of study, as well as performance in the test of Dominoes, the Differential Aptitude Tests (DAT) and Griéger's Characterological Questionnaire. Significant F-*ratios (variance within DZ/variance within MZ) were observed for the school grades obtained in five of the six areas considered, as well as for their general average; the same being true for the results on the indicated measure of general intelligence, six of the eight DAT tests, and two of the characterological elements. There is a clear positive relationship between the grades earned by the twins and their performance in the Dominoes test. Achievement in Portuguese and foreign language correlates positively with DAT's Sentences; and achievement in mathematics correlates positively with DAT's Numerical Ability, Abstract Reasoning, and Clerical Speed and Accuracy. The results show an agreement with previous estimates of the genetic determination of these variables, which is to a certain extent surprising if we consider the differences in sample sizes, age, and degree of schooling of the subjects, environmental differences, and the dissimilarities which exist between the homes and school systems of USA, Europe, and Brazil.*

The first studies on school achievement in twins date back to the beginning of this century (Thorndike 1905). Since then, more than 20 other investigations dealing with this subject have been carried out. But there is wide variation in these studies as to sample sizes, the tests used, and the degree to which the data were statistically analyzed. Most of these observations have been made in the United States or Europe. Attempts to correlate these findings with measures of general intelligence or specific abilities, personality traits, or selected aspects of the twins' families, are scarce. We therefore decided to study these variables in a sample of Brazilian twins extensively investigated in relation to other characteristics (Da Rocha et al. 1972, Callegari et al. 1972*a* and 1972*b*, Peña et al. 1973).

MATERIALS AND METHODS

The twins were identified mainly through inquiries at high schools. Further information from the twins themselves and other persons were also utilized. For a twin pair to be included in the sample, it was necessary that at least one member of the pair had completed or was finishing junior high school (four years after the five of primary school). With the exception of two dizygotic (DZ) pairs who came from the nearby cities of Esteio and Canoas, all the others were living in Porto Alegre, Brazil, at the time of the investigation.

The mean age of the 21 male and 26 female monozygotic (MZ) twin pairs was 20 years (range:

13-35) and that of the 20 male and 29 female DZ pairs was 19 years (range: 13-39). Three pairs (1 MZ and 2 DZ) were Mulattoes, all the others being White. Zygosity diagnosis was made using blood groups A_1A_2BO, Rh (tests with anti-C, -C^w, -c, -D, -E, -e), MNSs, P, Duffy, and Kell; ABH secretion; and serum haptoglobins. A pair was considered DZ if it showed any difference in the above mentioned genetic markers. The average probability of dizygosity in the twins concordant for all of them was calculated as 3 % (range 2 %-6 %), following the procedures outlined by Maynard-Smith et al. (1961).

For the intelligence and personality studies, members of the pairs were studied simultaneously in three sessions of two hours each; afterwards, individual interviews of one hour duration were done with the twins and their mothers. Therefore, the study of each pair involved about 9 hours of work distributed over 4 days. The tests utilized were Brazilian versions of the Dominoes (Anstey 1967), the Differential Aptitude Tests (DAT) of Bennett et al. (1959) and Griéger's (1952) Characterological Test. The latter is based on G. Heymann's personality theory which postulates three basic bipolar dimensions: degree of emotionality, degree of activity, and relative predominance of primary or secondary function (repercussion of the impressions). Emotionality is defined as the ready expression of emotions and the intensity of feelings; activity as the vital energy displayed in the overall life pattern of meaningful behavior. When the primary function predominates, a person is more influenced by the impressions of the moment, while the predominance of the secondary function leads to a greater influence of the residue of past experiences. Eysenck (1953) has suggested that the primary-secondary function dimension is identical with the extroversion-introversion dichotomy. Other attempts to relate these dimensions to the systems of other authors have been made by Vandenberg (1967*a*).

In the achievement studies, the grades earned by the twins were obtained from the school files and the different subjects taught grouped in six areas: Portuguese, foreign language, mathematics, social studies, sciences, and arts. The great majority of these grades were numerical (ranging from 0 to 10). Averages were calculated for each area including all the school period of each twin. The number of grades considered was always the same for both members of a pair. In some cases the grades consisted of letters; these were converted into numbers by assigning to them the midpoint value of the numerical interval to which the letter corresponded (for instance, if the grade was A and the corresponding interval 8-10, the number assigned would be 9). In almost all cases the correspondence between the letters and the numerical intervals would be given in the official document of the school; in relation to four pairs for which this information was not furnished we used for the conversion the intervals which appeared most frequently in our sample.

The MZ and DZ twins studied here do not differ in a significant way in the following variables: (1) Averages and variances of the scores obtained; (2) Degree of schooling; (3) Type of school attended (traditional or professional; public or private); (4) Simultaneity of the studies (whether they attended the same or different classrooms, the same or different schools); (5) Education and profession of their parents (most of them had at least completed secondary school, and about 40 % had professions which would classify them at a high socioeconomic level); (6) An extensive series of factors related to their home conditions and the intrapair relationship. A detailed list of the comparisons made is available on request.

RESULTS

Estimates of the degree of genetic determination for school achievement in the six areas for which data were available are presented in Table 1 (since the results of males and females did not differ significantly they were pooled). H varied from 0.00 (Number of nopromotions) to 0.60 (Social Studies), the corresponding *F*s being 0.66 and 2.53. The variance ratio is almost always statistically significant. The general averages, taking into consideration all subjects, yield an F of 1.85 ($P < 0.01$). The results obtained by Stocks and Karn (1933), Newman et al. (1937), Husén (1959) and Nichols (1965) considering such general averages are not very different from ours; those of Burt (1958, 1966), however, deviate markedly, showing higher correlation coefficients for the MZ and especially for the DZ twins. If we examine now the numbers in the specific areas of study, comparing our data with those from the series listed

by Breland and Nichols (1973), we note that the sequence for the relative magnitude of gene determination of social studies > languages > sciences was also encountered by them. There is a curious difference in our data between Portuguese and foreign language, which may be due to chance.

The value observed for the general measure of intelligence ($H = 0.46$; $F = 1.85$ — see Table 1) is consistent with previous investigations using such types of twins (see Erlenmeyer-Kimling and Jarvik 1963), and specifically with a small sample studied by Shields (1962)

TABLE 1

ESTIMATES OF THE DEGREE OF GENETIC DETERMINATION OF SCHOOL ACHIEVEMENT, INTELLIGENCE AND PERSONALITY SCORES

Scores in	MZ pairs		DZ pairs		H	F	Significance
	N	r	N	r			
School Achievement							
Portuguese	45	0.79	46	0.55	0.38	1.60	< 0.05
Foreign language	44	0.79	42	0.42	0.58	2.41	< 0.001
Total languages	44	0.83	42	0.46	0.53	2.14	< 0.01
Mathematics	45	0.73	46	0.34	0.40	1.65	< 0.05
Social studies	45	0.76	46	0.44	0.60	2.53	< 0.001
Sciences	43	0.78	43	0.52	0.40	1.68	< 0.05
Arts	43	0.76	38	0.72	0.12	1.14	NS
Number of failures*	39	0.80	39	0.74	0.00	0.66	NS
General average, all subjects	45	0.82	46	0.58	0.46	1.85	< 0.01
Differential Aptitude Tests							
Verbal Reasoning	42	0.78	42	0.54	0.62	2.67	< 0.001
Numerical Ability	42	0.59	41	0.25	0.42	1.71	< 0.05
Abstract Reasoning	41	0.78	41	0.39	0.59	2.42	< 0.001
Space Relations	42	0.82	42	0.48	0.52	2.08	< 0.01
Mechanical Reasoning	42	0.67	40	0.59	0.27	1.36	NS
Clerical Speed and Accuracy	42	0.78	42	0.55	0.16	1.19	NS
Spelling	42	0.66	40	0.41	0.51	2.02	< 0.01
Sentences	42	0.61	41	0.35	0.35	1.54	< 0.05
Dominoes	42	0.71	40	0.36	0.46	1.85	< 0.01
Griéger's Characterological Test							
Emotivity	31	0.53	36	0.20	0.48	1.93	< 0.05
Activity	31	0.45	36	0.13	0.34	1.51	NS
Repercussion of the Impressions	31	0.35	36	— 0.08	0.47	1.90	< 0.05

* No promotion to the next level of instruction.

r = intraclass correlation coefficient. $H = \frac{Vw\,DZ - Vw\,MZ}{Vw\,DZ,}$, where Vw = variance within pairs (Holzinger 1929). $F = \frac{Vw\,DZ}{Vw\,MZ}$. NS = Nonsignificant.

with the same test (Dominoes). Significant genetic components seem to be influencing six of the eight Differential Aptitude Tests, with Fs ranging from 1.54 (Sentences) to 2.67 (Verbal Reasoning), but not Mechanical Reasoning, or Clerical Speed and Accuracy. Previous DAT studies in two series of twins were reported by Vandenberg (1969). His results in a general way are similar to ours, but differences were observed in relation to Abstract Reasoning

(nonsignificant *F*s found in the US investigations) and Clerical Speed and Accuracy (*F*s equal to 2.54 and 2.96 respectively in those studies).

Following Vandenberg (1967*b*), who performed a similar analysis using the subtests of the Wechsler Intelligence Scale for Children, we searched for correlations between the DAT scores and the following variables: sex, age, sibship size, birth order, socioeconomic level, education of father, education of mother, type of school attended by the twins, intrapair interdependence, and occurrence of psychiatric problems in the twins' families. Only 3 of the 80 correlation coefficients obtained (4%) showed significant values; it seems, therefore, that these factors are not very important in influencing the results on these tests. A variance components analysis of the DAT scores was also done and compared with similar calculations performed by Bock and Vandenberg (1968) in another series. Since they had subdivided their sample by sex, we had to do the same; this reduced the numbers compared in each category. Some differences appeared between the US and Brazilian twins, but, since they were not systematic and the sample sizes involved small, we decided to omit these results from this report.

Table 1 also shows the data for Griéger's Characterological Test. Genetic factors seem to be of relative importance for two of the three elements measured (Emotivity, $F = 1.93$; Repercussion of the Impressions, $F = 1.90$). As far as we know, this is the first report of the application of this test to a twin sample.

Table 2 presents the correlation coefficients calculated between the scores obtained in school achievement and several other variables. Four of the six correlations which considered par-

TABLE 2

CORRELATION COEFFICIENTS BETWEEN SOME OF THE VARIABLES STUDIED

Characteristics compared	MZ pairs		DZ pairs	
	N	*r*	N	*r*
Grades' averages × Parents' professions	78	0.07	74	0.35**
Grades' averages × Parents' education	76	0.11	68	0.16
Grades' averages × Sibship size	86	−0.01	84	−0.31**
Grades' averages × Dominoes	80	0.45***	75	0.35**
Achiev. in Portuguese × DAT's Spelling	80	0.25*	75	0.18
Achiev. in Portuguese × DAT's Verbal Reasoning	80	0.16	79	0.33**
Achiev. in Portuguese × DAT's Sentences	80	0.26*	76	0.35**
Achiev. in Foreign Lang. × DAT's Spelling	78	0.23*	72	0.14
Achiev. in Foreign Lang. × DAT's Verbal Reasoning	78	0.09	76	0.26*
Achiev. in Foreign Lang. × DAT's Sentences	78	0.29*	73	0.36**
Achiev. in Mathematics × DAT's Numerical Ability	80	0.54***	76	0.39***
Achiev. in Mathematics × DAT's Abstract Reasoning	79	0.33**	77	0.34**
Achiev. in Mathematics × DAT's Clerical Speed and Accuracy	80	0.24*	78	0.27*
Achiev. in Mathematics × DAT's Space Relations	80	0.33*	78	0.10
Achiev. in Sciences × DAT's Mechanical Reasoning	77	0.01	72	0.05
Achiev. in Sciences × DAT's Clerical Speed and Accuracy	76	0.17	73	0.27*
Achiev. in Arts × DAT's Space Relations	76	0.35**	65	0.03
Grades' averages × Griéger's Characterological Test	60	0.26	68	0.24

DAT: Differential Aptitude Tests.
* Significant at the 0.05 level; ** Significant at the 0.01 level; *** Significant at the 0.001 level.

ents' professions and education, as well as sibship size, yielded nonsignificant results. As expected, there is a clear relationship between the grades obtained by the twins and estimates of their « general intelligence » as measured by the Dominoes test. Achievement in Portuguese and foreign language correlates positively with DAT's Sentences and achievement in mathematics with Numerical Ability, Abstract Reasoning, and Clerical Speed and Accuracy. No significant relationships were observed between the school grades and the results in Griéger's Characterological Test.

DISCUSSION

The first question that may be asked is whether school grades represent the true ability of the subjects tested. There is no doubt that a series of factors involving the school, the student, the teacher, and their interactions, should be considered when a given grade is to be interpreted. But the examination of a whole set, obtained over several years, tends to eliminate extraneous, nonrepeatable events. The fact that the general averages obtained by the twins in this sample show a high correlation with their performance in a general intelligence test; as well as the positive correlations obtained by achievement in languages or mathematics with specific abilities measured by the DAT battery, strengthen our belief that the grades are good indicators of the students' capacity to master the subjects considered.

The limitations of the twin method in providing the desired kind of genetic information have been repeatedly emphasized and need not be reiterated here. But we want to stress that all precautions were taken by us to obtain strictly comparable MZ and DZ series. On the other hand, due to the way we collected our sample, couples with large differences in school achievement would not be considered (for instance, if twin A had completed junior high school but twin B had attended primary school only). We came across only one such case, however, and do not think that its exclusion seriously biased our estimates.

Another problem that has been much discussed is the one related to the accurate determination of the ability one wants to measure, as well as to whether it is appropriate to extend concepts of heritability estimates to man (see, for instance, Layzer 1974). In relation to the first point, the advantages of the use of the Differential Aptitude Tests for twin studies was emphasized by Bock and Vandenberg (1968). On the other hand, we are well aware of the limitations of the use of H and F for the estimation of the degree of genetic determination of a given characteristic (see, for instance, Cavalli-Sforza and Bodmer 1971, p. 574). But since previous series used them extensively, we decided that they should be calculated for our sample, in order to make comparisons. A more refined statistical analysis of our data is at present being performed (D.C. Rao and F.M. Salzano, in preparation).

The results presented here show an agreement with previous estimates of the genetic determination of school achievement, as well as general and specific factors influencing intelligence, which is to a certain extent surprising if we consider difference in sample sizes, age, and degree of schooling of the subjects, environmental differences, and the dissimilarities which exist between the homes and school systems of USA, Europe, and Brazil.

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REFERENCES

Anstey E. 1967. Teste de Dominos. Buenos Aires: Ed. Paidós.

Bennett G.K., Seashore H.G., Wesman A.G. 1959. Manual do D.A.T. Rio de Janeiro: Centro Editor de Psicologia Aplicada.

Bock R.D., Vandenberg S.G. 1968. Components of heritable variation in mental test scores. In S.G. Vandenberg (ed.): Progress in Human Behavior Genetics [pp. 233-260]. Baltimore: The Johns Hopkins Press.

Breland N.S., Nichols R.C. 1973. Genetic and environmental components of human trait variation as determined by twin studies. (Manuscript).

Burt C. 1958. The inheritance of mental ability. Am. Psychol., 13: 1-15.

Burt C. 1966. The genetic determination of differences in intelligence: a study of monozygotic twins reared together and apart. Br. J. Psychol., 57: 137-153.

Callegari S.M., Salzano F.M., Peña H.F. 1972*a*. ABO saliva and plasma agglutinins in twins. Acta Genet. Med. Gemellol. (Roma), 21: 287-296.

Callegari S.M., Salzano F.M., Peña H.F. 1972*b*. ABH salivary secretion in twins. Acta Genet. Med. Gemellol. (Roma), 21: 297-304.

Cavalli-Sforza L.L., Bodmer W.F. 1971. The Genetics of Human Populations. San Francisco: W.H. Freeman.

Da Rocha F.J., Salzano F.M., Peña H.F., Callegari S.M. 1972. New studies on the heritability of anthropometric characteriastics as ascertained from twins. Acta Genet. Med. Gemellol. (Roma), 21: 125-134.

Erlenmeyer-Kimling L., Jarvik L.F. 1963. Genetics and intelligence: a review. Science, 142: 1477-1479.

Eysenck H.J. 1953. The Structure of Human Personality. London: Methuen.

Griéger P. 1952. Le Diagnostic Caractérologique. Paris: Ed. Ligel.

Holzinger K.J. 1929. The relative effect of nature and nurture influences on twin differences. J. Educat. Psychol., 20: 245-248.

Husén T. 1959. Psychological Twin Research. A Methodological Study. Stockholm: Almqvist and Wiksell.

Layzer D. 1974. Heritability analyses of IQ scores: science or numerology? Science, 183: 1259-1266.

Maynard-Smith S., Penrose L.S., Smith C.A.B. 1961. Mathematical Tables for Research Workers in Human Genetics. London: J.A. Churchill.

Newman H.H., Freeman F.N., Holzinger K.J. 1937. Twins: A Study of Heredity and Environment. Chicago: University of Chicago Press.

Nichols R.C. 1965. The inheritance of general and specific ability. National Merit Scholarship Corporation Research Reports, 1: 1-16.

Peña H.F., Salzano F.M., Callegari S.M. 1973. Dermatoglyphics in twins. Acta Genet. Med. Gemellol. (Roma), 22: 91-98.

Shields J. 1962. Monozygotic Twins Brought up Apart and Brought up Together. Oxford: Oxford University Press.

Stocks P., Karn M.N. 1933. A biometric investigation of twins and their brothers and sisters. Ann. Eugen., 5: 1-55.

Thorndike E.L. 1905. The Measurement of Twins. New York: Science Press.

Vandeberg S.G. 1967*a*. Hereditary factors in normal personality traits (as measured by inventories). In J. Wortis (ed.). Recent Advances in Biological Psychiatry [Vol. 9, pp. 65-104]. New York: Plenum Press.

Vandenberg S.G. 1967*b*. Hereditary factors in psychological variables in man, with a special emphasis on cognition. In J.N. Spuhler (ed.). Genetic Diversity and Human Behavior [pp. 99-133]. Chicago: Aldine.

Vandenberg S.G. 1969. Human behavior genetics: present status and suggestions for future research. Merrill-Palmer Quart. Behav. Developm., 15: 121-154.

RIASSUNTO

Rendimento Scolastico, Intelligenza e Personalità nei Gemelli

È stato studiato un campione di 47 coppie MZ e 49 DZ di gemelli brasiliani in rapporto al rendimento scolastico in sei specifiche aree di studio, cosí come in rapporto al rendimento in un certo numero di test di intelligenza e personalità. Sono stati osservati dei valori significativi di *F* (rapporto fra varianza nei DZ e varianza nei MZ)

nei voti ottenuti in 5 delle 6 aree considerate, come pure nella media generale. Lo stesso vale per la misura dell'intelligenza generale. I risultati concordano con le precedenti stime della determinazione genetica di queste variabili, il che è in certa misura sorprendente quando si considerino le differenze per dimensioni del campione, età e grado di scolarità dei soggetti, differenze ambientali, nonché le differenze esistenti nei sistemi scolastici negli Stati Uniti, in Europa e in Brasile.

RÉSUMÉ

Résultats Scolaires, Intelligence et Personnalité chez les Jumeaux

Un échantillon de 47 couples MZ et 49 couples DZ de jumeaux brésiliens a été étudié par rapport aux résultats scolaires dans six domaines spécifiques, ainsi que par rapport aux résultats dans un certain nombre de tests d'intelligence et de personnalité. Des valeurs significatives de F (rapport entre variance chez les DZ et variance chez les MZ) ont été observées dans cinq des six domaines d'étude considérés, ainsi que dans l'évaluation de l'intelligence générale. Les résultats sont en accord avec les évaluations précédentes de la détermination génétique de ces variables. Ceci est surprenant si l'on considère les différences par rapport aux dimensions de l'échantillon, l'âge et le niveau scolaire des sujets, les différences de milieu, ainsi que les différences qui existent dans les systèmes scolaires aux Etats Unis, en Europe et au Brésil.

ZUSAMMENFASSUNG

Schulleistungen, Intelligenz und Persönlichkeit bei Zwillingen

Bei einer Reihe brasilianischer Zwillingspaare (47 EZ und 49 ZZ) wurden die Schulleistungen auf sechs spezifischen Fachgebieten sowie die Ergebnisse einer Reihe von Intelligenz- und Persönlichkeitstests untersucht. Bei 5 der 6 untersuchten Fachgebiete sowie in den allgemeinen Durchschnittsleistungen konnten bemerkenswerte Resultate für F (Verhältnis zwischen der Varianz bei ZZ und der bei EZ) beobachtet werden. Das gleiche gilt für die Messung der allgemeinen Intelligenz. Die Ergebnisse stimmen mit vorhergegangenen Schätzungen der Erbbendingtheit dieser Variablen überein. Dies verwundert etwas, wenn man die Unterschiede bedenkt, die einerseits im Ausmass der Versuchsreihe, im Alter und im Schultyp der Kandidaten, andererseits in den Umweltsbedingungen sowie im Schulsystem zwischen USA, Europa und Brasilien bestehen.

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