

THE INHERITANCE OF EXTRAVERSION-INTROVERSION

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1. INTRODUCTION

The data reported in this paper formed part of an investigation conducted under the writer's direction by Dr. H. McLeod and Dr. D. Blewett from 1951—1953. This investigation was in part made possible by a grant from the Eugenics Society. Some of the results have been reported in Ph. D. theses (2, 16) and in article form (3).

The investigation as a whole was designed to answer a number of different questions, some of which only will be discussed in this paper. In essence we shall be concerned with two closely related problems. The first of these is the factorial definition and measurement of the personality dimension or continuum known as extraversion-introversion; the other is the discovery of the degree to which heredity plays a part in determining a person's position on this continuum. Most of the work on extraversion-introversion has been done with adult subjects; in this study we shall be concerned with school children, mostly of an age between 145 and 185 months.

A number of questions arose in the course of the investigation, or were from the outset considered to determine the design of the experiment. These additional questions, such as, for instance, the relationship between extraversion-introversion and Rorschach's concept of the extratensive/introvertive type of personality, will be discussed as they arise in the course of this paper.

2. THE PROBLEM OF MEASUREMENT

A considerable amount of experimental material relevant to the measurement of extraversion-introversion has been discussed in previous publications by the present writer (5, 6, 10). By and large the results reported there have shown that there is experimental evidence in favour of the existence of some such personality continuum as Jung postulated,

at least among adults; that this dimension can be found, both among normal and among neurotic subjects; and that a variety of different tests could be constructed to measure this dimension with different degrees of reliability and validity. It was further found that, as Jung had postulated, extraverted neurotics tended to develop hysterical or psychopathic symptoms, whereas introverted neurotics tended to develop dysthymic symptoms, such as anxiety, reactive depression, or obsessional features. None of the studies carried out in this laboratory, or available in the literature, had concerned themselves with measurement of extraversion-introversion in children. Consequently it appeared worth-while to test the hypothesis that behavioural relationships similar to those found among adults could also be found among children to define an extravert-introvert continuum.

Among the types of measures used with adults had been objective behaviour tests, ratings, and self-ratings, and it seemed desirable to include these divergent types of measures in the children's study also. In addition, however, it was decided to include a rather different type of test, namely, the Rorschach. Although the writer has been somewhat critical of its use as a "global" measure of personality, some attempts made by members of the department had indicated that when scores on this test are used in the usual psychometric manner, meaningful relations can be established, although (or possibly because) the test thus loses its subjective and interpretive character (4). The main reason for introducing the Rorschach into the experiment was, of course, the fact that Rorschach's theory contains the concept of the opposed types of the "extratensive" and the "introvertive" person. Although Rorschach workers often deny that these terms are co-extensive with Jung's typology, nevertheless it seemed a reasonable hypothesis to expect a considerable degree of similarity. Curiously enough no test of this hypothesis had ever been carried out previously to our knowledge, and consequently a number of Rorschach scores were included in our battery.

In addition to the variables discussed so far, we also included a battery of intelligence tests and a battery of autonomic measures. There are two main reasons for the inclusion of the battery of intelligence tests. In the first place, some at least of the tests used for the measurement of extraversion were known to be also measures of intelligence. Without the inclusion of reliable and valid measures of intelligence, therefore, contamination between the effects of extraversion and those of intelligence might easily have taken place. This is particularly obvious in the case of some of the Rorschach variables. Thus, for instance, a high movement score on the

Rorschach, according to Klopfer, indicates high intelligence. It also, however, indicates introversion. Assuming, for the moment, both these hypotheses to be true, before using the $M\%$ score as a measure of extraversion, we would have to partial out that part of the variance assignable to intelligence.

The second reason for including tests of intelligence in our battery was as follows. Most of the work on the inheritance of intelligence has made use of a single test. This does not seem permissible as Eysenck and Prell (11) have argued in a recent paper, because the fact that the score on a given test has a high h^2 when a comparison is made between the scores of identical and fraternal twins, is indeterminate as long as we have no way of assigning the hereditary component indicated in this way to a specific part of the factor variance.¹ Thus, for example, if the Binet test were found to give much higher intra-class correlations for identical than for fraternal twins, we would still not know whether the hereditary influence thus indicated affected the general intellectual ability measured by the test, or the verbal ability also measured, or the numerical ability, or any of the other factors contributing to the total variance. The conclusion reached by Eysenck and Prell was that it is not test scores which should be submitted to such analysis but factor scores, and accordingly a number of intelligence tests were included here to make possible such an analysis of factor scores.

Also included were a number of autonomic measures, such as systolic and diastolic blood pressure, pulse rate in the resting state and under stress, sub-lingual and finger temperature, and dermatographic latency. The main reason for the inclusion of these measures was as follows. In "The Structure of Human Personality" (8) a number of studies have been summarized suggesting that autonomic lability may be related to neuroticism. If this were true, then it should follow that autonomic measures of this type should correlate with measures known to be good indicators of neuroticism, such as, for instance, body sway suggestibility. Thus, if autonomic measures and a few known tests of neuroticism were included, and if the theory were to be substantiated by our research, then we would expect, in addition to a factor of extraversion-introversion and a factor of intelligence, also to find a factor of neuroticism containing some, if not all, of these autonomic tests. In this way it was hoped to extend the work begun by Eysenck and Prell in 1951 (11).

¹ h^2 is the symbol used by Holzinger to denote a statistic proposed by him as a measure of the degree of hereditary determination of a given trait or ability.

For a critical discussion of it, cf. May (17).

The actual tests and measures included in this study will be described briefly in the third section; a much longer description will be found in the theses by McLeod and Blewett (16, 2). In most cases the rationale for including a test has not been given here because considerations of space make this impracticable. A thorough documentation can be found in the writer's previous summaries of work done on these problems. Quite generally it may be said that a test was included as a possible measure of introversion-extraversion when it either had in the past been found in factorial analyses to have significant projections on this factor among adults, or when it had in the past been found to differentiate significantly between hysterics, the neurotic prototype of the extravert, and dysthymics, the neurotic prototype of the introvert. This would, of course, be reasonable only on the assumption that the behaviour of children and their responses to the test situation are similar to those of adults. This assumption appears to be reasonable and, as will be seen in the section on Results, is, in fact, borne out.

3. THE SAMPLE STUDIED

Little need be said here as in all essentials this study is a duplication of the Eysenck-Prell study. We have relied again on the differences found between identical and fraternal twins to give us evidence regarding the hereditary determination of any particular test score or factor score used in the investigation. The general theory is too well-known to be discussed in any detail: it depends on the fact that differences between identical twins must be due to environment; differences between fraternal twins may be due to either environment or heredity. If, therefore, differences between identical twins and differences between fraternal twins are equal in size, the total variance of the particular test under investigation can be ascribed to environmental influences. The greater the similarity of identical twins as compared with fraternal twins, the greater will be the amount of hereditary influence it is necessary to postulate. A convenient formula to assess the amount of hereditary influence has been given by Holzinger. His statistic, which he calls h^2 , has frequently been criticized. A general discussion of the twin method, the difficulties which it gives rise to, and possible criticisms of it is given elsewhere (11), and a discussion of Holzinger's h^2 statistic will be found in another paper from this department (17).

The exact details of the population of children used in the present study have been published by Blewett (3). Here it is merely necessary to summarize the main points. Our sample was drawn from four metro-

politan boroughs in South London. Our thanks here are due to the co-operation of the London County Council who wrote to headmasters of all the L.C.C. secondary schools in the boroughs of Camberwell, Southwark, Lambeth and Lewisham, requesting a report on any twins on their registers. 102 pairs of twins were located, of whom 56 pairs were subsequently tested. Four of these were later dropped on a random basis to equate numbers of pairs in the four groups: male identical, female identical, male fraternal, and female fraternal, retaining 13 pairs in each group. A thorough check was carried out to avoid various well-known sources of error in the selection of the sample; these are discussed in detail by Blewett.

The criteria used in this study were practically identical with those used by Eysenck and Prell, including rating scales for closeness of similarity of facial features, general habitus, hair colour and distribution, iris pigmentation, shape of ears, and teeth. Height and weight were measured and the ability of the subjects to taste phenyl-thio-carbamide was established. In addition, blood groupings and finger-prints were taken into account. Again, details are given by Blewett (3) and there is little doubt that the final decision regarding the zygoticity of the twin pairs arrived at on the basis of all these criteria is essentially correct. The mean age of the children tested was 166 months, with a standard deviation of 11 months. Age was partialled out from the intercorrelations in the factor analysis as it seemed essential to have data not contaminated by this variable.

4. TESTS USED

The tests used in this investigation will now be briefly described. In connection with each will be given an index which will enable the reader to identify it in the factor analysis. The first two variables included in the factor analysis are zygoticity (index number 1), and sex (index number 2); these are not exactly tests in any sense of the word, but are referred to here, nevertheless, in order to keep all the index numbers together. The scoring in these cases was as follows: zygoticity — $M = 1$, $D = 2$; sex — $M = 1$, $F = 0$.

Next we have the set of intelligence tests included in this investigation. Most of these were taken from Thurstone's tests of primary mental abilities for ages 11—17. These are so widely used that it would serve no useful purpose to describe them in detail. The directions given in the Revised Manual (1949) were followed in the administration, and Thurstone's scoring methods were used throughout. The particular tests used

were the verbal scale (index number 8), the numbers scale (index number 9), the space scale (index number 16), the reasoning scale (index number 17), the fluency scale (index number 18) and the total score (index number 19), calculated according to Thurstone's formula:

$$V + S + 2N + 2R + W.$$

In addition, we used the Furneaux level and speed tests. These are described in some detail by Eysenck (7) and by Blewett (3).

Our next set of scores is derived from the Rorschach test. Standard methods of administration, enquiry, and testing the limits were employed. We followed the method outlined by Klopfer and Kelly (15). The following scores were used: Popular responses (index number 28), average response time (index number 29), D (index number 31), $To \div de$ ($H \div A \div Hd + Ad$) (index number 32), $FM \div M$ (index number 33), $F \%$ (index number 34), $M \%$ (index number 36), $FM + m - Fc + c + C'$ (index number 37), range of response times (index number 13), and lastly a composite score of pathological indicators devised by Blewett and given in detail in his thesis (index number 30). Most of these variables had odd and abnormal distributions and had to be transformed in various ways, usually by a logarithmic transformation.

Also included with the Rorschach group might be another test, the Rosenzweig Picture Frustration test, as this too is often considered as a projective technique. The only score used here was the extrapunitive one (index number 35).

The autonomic tests employed were as follows: Systolic blood pressure (index number 39) and diastolic blood pressure (index number 40). (Room temperature and humidity were measured at the time this and the other autonomic tests were administered, and wherever a significant relationship was found, temperature and humidity were partialled out.) The other measures used were pulse rate after stress (the stress consisted of pulling a hand dynamometer ten times as hard as possible) and pulse rate after resting (index numbers 41 and 42). Sub-lingual temperature (index number 43) and finger temperature (index number 44) were also taken. Lastly, dermatographic latency (index number 35) was determined using Wenger's method (23).

The next set of variables consisted of ratings and sociometric measures. Questionnaire scales were used, both in the form of self-assessments and teachers' assessments. The scales used were adaptations of Guilford's C and R scales, which have been shown to be good measures of neuroticism and extraversion respectively (8). The detailed scales employed are given in the theses by Blewett and McLeod respectively (2, 16). Based

on these scales, then, we have a teacher's rating of extraversion (index number 4), a teacher's rating of neuroticism (index number 15), self-ratings of extraversion (index number 5), and self-ratings of neuroticism (index number 7). A lie scale based on the well-known M.M.P.I. — but adapted for use with children — was also employed (index number 6).

Two sociability scores were obtained, both derived from a sociometric examination. The subjects were asked simply to write down names of their choice to a series of questions. These questions were of the following kind: "Whom would you like to sit by during class?" "Who do you think would choose you to sit beside them in class?" "Whom would you like to be with after school?" and so forth. The two scores were the total number of names given (index number 53) and the total number of *different* names given (index number 54). The hypothesis underlying this test was, of course, that extraverts, being more sociable, would give a larger number of names in both categories.

The last set of tests to be considered consists of objective behaviour tests. The first of these is the body sway test of suggestibility (index number 11); the second, the finger dexterity test (index number 14). Both these tests are described fully in "The Scientific Study of Personality" (6). Next, we have three tests of rigidity taken from the work of Ferguson and his colleagues (20). These are the opposites test (index number 22), the alphabet test (index number 23), and the arithmetic test (index number 24). These tests are based on the interfering effects of highly habituated culturally induced behaviour patterns in tasks involving largely cognitive processes. Another index of rigidity, called the index of flexibility, is a measure of the amount of change in level of aspiration by actual performance (index number 25). It is taken from a test using the so-called triple tester described in "The Scientific Study of Personality" (6), as is the affective discrepancy score (index number 50) which is the sum of the goal discrepancy and the judgment discrepancy scores. The rationale and meaning of these scores are discussed in "Dimensions of Personality" (5).

Two tests of persistence were included, namely, the leg persistence test (index number 26) and the dynamometer persistence test (index number 27). Both tests have been described in previous publications. As a test of expressive movement two of Mira's (19) tasks were used, namely, the drawing of sagittal lines and the drawing of vertical lines. The score on this test was the total area covered by the lines (index number 38). Two tests of humour were included, one of orectic (index number 46) and one of cognitive (index number 47) humour. The test consisted of 30 cartoons which had to be rated with respect to the amusement derived from them;

the rationale for this test is given in "Dimensions of Personality" (5).

The Porteus Maze test was also given to the children. As Hildebrand (13) and Foulds (12) have shown, certain qualitative performances differentiate hysterics from dysthmics. Included in our study, therefore, were scores "wrong directions" (index number 48) and "lifted pencils" (index number 49). Two scores were also taken from the track tracer described in "Dimensions of Personality" (5). One of these is an accuracy score, the other one a speed score (index numbers 51 and 52).

Last of all, a score was included consisting of the level-speed discrepancy on the Furneaux test (index number 21). Here a high score indicates a lack of such discrepancy; in view of results reported by Eysenck (7), this may be regarded as evidence of normality.

5. RESULTS

Variables indexed in the section above were intercorrelated, the effect of age was partialled out from the intercorrelations, and a factorial analysis undertaken of the resulting matrix. In order to avoid subjective determination of axis rotations by the writer, the rotations were carried out in the statistical section of the writer's department under the direction of Mr. A. E. Maxwell. The results are therefore not influenced by the writer's own conceptions, although this may, of course, intrude in the interpretation of the results given later on. However, the reader will be able to check these interpretations against the figures. Table 1 gives the factor saturations for the 52 variables on the 6 factors extracted, as well as the communalities. The peculiar constitution of the sample, i.e. the fact that it is composed of closely related subjects, makes it impossible to apply any known tests of significance to the residuals, and we have probably erred in taking out more factors than is warranted. However, no interpretation is here attempted of the last three factors, and those with which we shall be concerned are indubitably both significant and meaningful.

The main loadings on factors 1 and 2 have been plotted in Figure 1 and it will be seen that we are dealing essentially with the factors of intelligence and extraversion-introversion. The identification of the intelligence factor leaves very little room for doubt. The Thurstone total score has a loading of .947. All the other Thurstone scores have appropriately high loadings (verbal = .695; number = .569; space = .635; reasoning = .821; frequency = .629). The two Furneaux scores had loadings of .529 and .677. Finger dexterity, as is reasonable with children, has a loading of .389. Two of the rigidity tests have high loadings; the opposites

TABLE I

Variable:	I	II	III	IV	V	VI	h^2
22	.579	-.103	-.055	.091	.019	-.034	.359
14	.389	.012	-.215	.037	.099	-.016	.209
8	.695	-.016	.014	-.181	-.050	.062	.523
11	.258	.090	.061	-.162	-.062	-.025	.109
20	.529	-.006	-.041	-.293	-.092	-.042	.378
16	.635	.105	-.066	.106	.037	-.033	.432
19	.947	.075	.124	.036	-.015	.075	.925
10	.677	-.019	.291	.285	.101	-.086	.642
18	.629	-.071	.225	-.057	-.048	.092	.465
9	.569	.096	.200	.047	.025	.162	.402
40	.232	-.230	.452	.015	-.014	-.046	.314
17	.821	.095	.123	.198	.040	-.021	.739
23	.656	.151	.264	.197	-.011	.038	.563
6	.374	.200	.109	-.301	-.046	-.015	.285
34	-.296	.286	.095	.089	-.124	-.067	.206
24	-.161	-.106	.219	-.140	-.010	-.099	.115
48	-.448	.013	.110	-.231	-.021	.071	.272
51	-.389	.162	.041	-.016	.006	-.098	.189
15	-.159	.165	-.177	.084	.021	.005	.091
44	.031	.300	-.181	-.066	.056	-.023	.132
33	-.090	.501	-.292	.137	-.013	-.046	.365
1	.167	.217	-.166	-.226	.057	-.010	.157
46	-.149	.162	-.026	-.358	-.077	-.002	.183
28	.095	.242	.107	-.227	.023	.106	.142
31	.164	.510	.106	-.192	.047	.077	.343
26	-.004	.229	.129	-.087	.050	.167	.107
53	.073	.632	-.017	.061	.011	-.067	.413
54	.121	.574	-.094	.094	.029	-.083	.370
43	-.121	.200	.620	.034	.011	.096	.450
36	.191	-.626	.175	-.084	-.030	.014	.467
52	-.098	-.378	-.047	-.171	.050	.115	.200
30	.013	-.396	-.022	-.272	.096	-.078	.247
32	.112	-.189	-.191	-.264	-.013	.050	.157
38	-.045	.027	.184	-.215	.051	-.087	.088
49	-.148	-.111	.177	-.250	-.092	-.049	.137
42	.076	-.066	.913	.148	.006	-.026	.894
2	.065	-.057	.855	.122	-.054	-.025	.781
29	-.079	.032	.162	.594	-.126	-.016	.402
5	-.104	-.091	-.282	-.030	-.135	.011	.118
27	-.020	.013	-.197	.141	-.037	.127	.077
50	.124	.007	-.447	.123	-.164	.009	.257
21	-.136	-.015	-.240	-.466	-.172	.035	.324
45	.193	-.002	-.216	-.233	.023	-.049	.141
47	-.096	-.056	-.192	-.406	.001	-.096	.223
13	-.006	-.100	.109	.530	-.118	-.024	.317
7	.076	.095	.140	-.350	-.073	-.023	.163
4	.042	.176	-.042	-.326	.073	-.045	.148
35	.096	.119	.103	-.228	.021	.024	.087
25	.032	-.009	.062	-.197	-.048	.082	.053
39	-.019	-.132	.389	.063	.066	.037	.179
41	.108	-.123	.839	.115	-.002	-.013	.744
37	.065	-.121	.290	-.059	-.027	-.011	.107

test .579 and the alphabet test .656. The nature of the material used makes these high correlations intelligible and suggests that these tests cannot properly be used with children. It is not unexpected to find that the Mazes "wrong direction" score has a high negative correlation with intelligence ($-.448$) or that inaccuracy on the track tracer has a somewhat slighter negative correlation ($-.389$). It may be surprising and is certainly interesting that the more intelligent apparently give more truthful self-ratings; the correlation between truthfulness on the lie scale and the intelligence factor is .374.

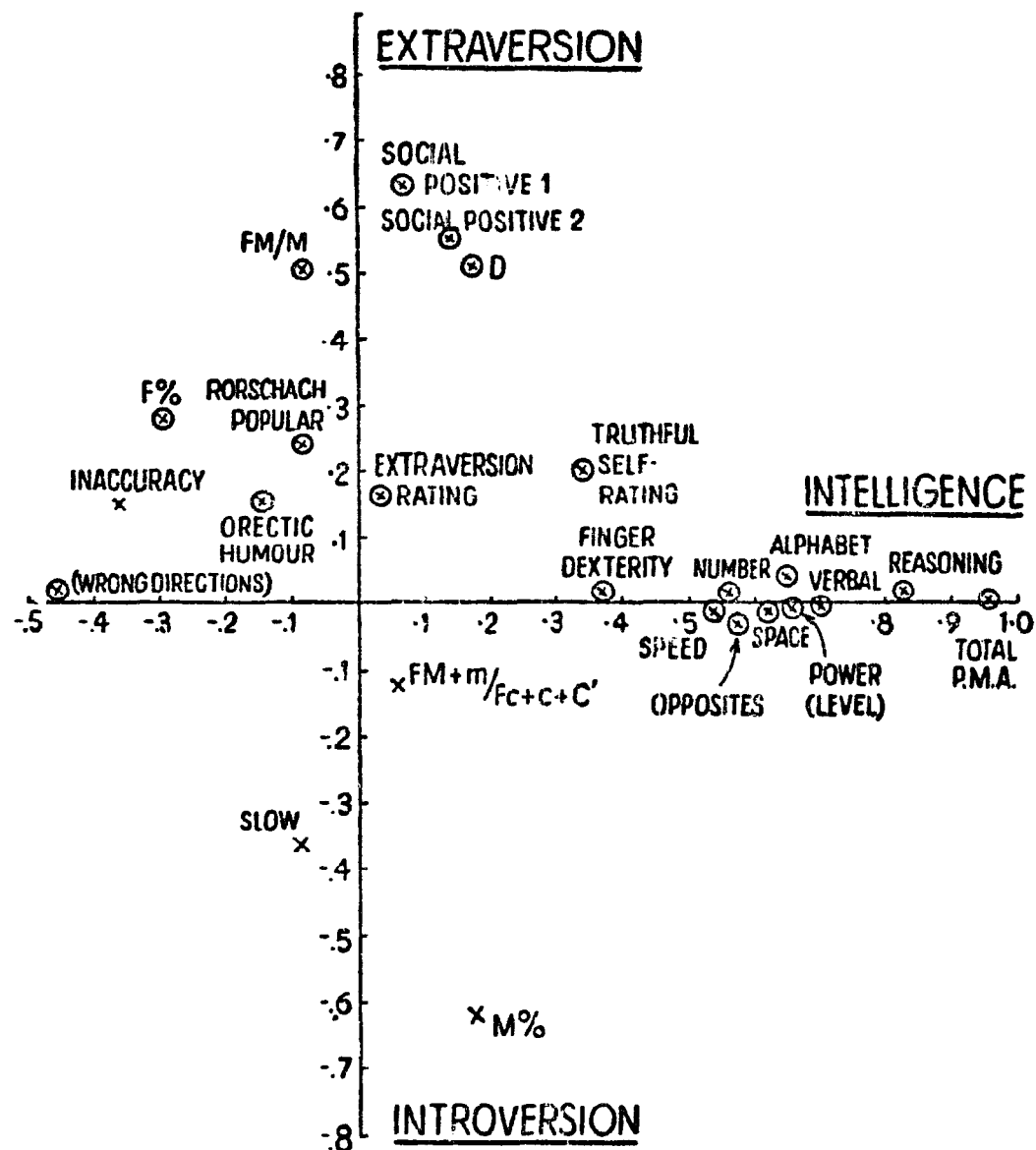


Fig. 1.

An interesting feature of this study is the complete failure of the Rorschach scores to correlate with intelligence. The only one to achieve even the very modest correlation of $-.296$ is the Rorschach $F\%$. This, in spite of the fact that of all the scores included, the $F\%$ score is one of the few that is in general considered *not* to be a measure of intelligence. M , which is usually taken as a good index of intelligence, only achieves a correlation of .191. It is difficult not to conclude that the Rorschach scores which we have used here, and for many of which extravagant

claims have been made as measures of ability, fail to measure intelligence to any significant extent.

We now come to the second factor which has been identified as extraversion. Before discussing this interpretation it will be necessary to present some details regarding the method followed in interpreting the Rorschach scores. While there is a good deal of agreement among Rorschach writers in the interpretation of certain scores, this agreement is far from perfect, and it would be possible in *a posteriori* fashion to explain away discordant findings by referring to some obscure authority as having interpreted this particular score in the manner required to substantiate one's own hypothesis. To avoid this danger, the following method was followed. The scores used were communicated to an expert who had been using the Rorschach clinically and teaching it to students for a number of years. He was requested to write down in detail the relevance of each of the scores to the three variables of intelligence, extraversion-introversion, and neuroticism. He was to base himself entirely on the agreed interpretations of the most widely accepted Rorschach authorities, and on independent factual research evidence. His decisions were written down and implicitly followed in our interpretation; wherever necessary they will be quoted in full. This, of course, does not ensure that other Rorschach experts will necessarily agree; it does ensure that our interpretation of the results is not falsified by an attempt to justify observed findings in the manner outlined at the beginning of this paragraph.

Let us now look at the variables defining the two poles of the factor which we have identified as one of extraversion-introversion. The variable having the highest saturation on the introverted side is $M\%$ ($-.626$). According to the expert "a high M suggests introversion, a low M extraversion". This interpretation has found a good deal of factual support, such as, for instance, a recent study by Barron (1) who has attempted to devise a psychometric measure of M by means of a series of specially constructed blots, and who found considerable correlations between movement scores and introverted personality traits. The other introversion score is indicative of slow and accurate work on the track tracer ($-.378$); this Himmelweit (14) and Eysenck (5) have found indicative of introversion.

On the extraverted side, the two scores having the highest saturations are the two sociometric scores indicative of social popularity and general social liking (.632 and .574). This relationship between extraversion and positive social relationships is, of course, in line with our hypothesis. Only slightly less highly correlated with extraversion is the Rorschach D score (.510). This is what our authority has to say about a high D score:

"A high D is said to indicate "practical" man, a down to earth extravert; a low D is said to indicate a "theoretical" man, a "theoriser". A high D is associated with hysteria, a low D with dysthymia." The interpretation is thus in accord with our hypothesis. Almost equally high as the D score is the $FM \div M$ score (.501). This score, of course, is not independent of the M score we have already considered, and can therefore not be used to add very much to our interpretation of the latter. However, for what it is worth, our authority summarizes the literature by saying that a high $FM \div M$ ratio "may indicate extraversion", a low $FM \div M$ ratio "may indicate normality, but also introversion and intelligence."

The $F \%$ score has a correlation with the extraversion factor of .286. The interpretation of this score appears excessively difficult. Our authority says that "a high $F \%$ is found in the records of psychopaths"; a high $F \%$ is found in the records of many hysterics ("flat hysterics"). This would suggest that a high $F \%$ is indicative of extraversion. Against this hypothesis speaks the fact that "a high $F \%$ indicates "over-control" which could characterize an introverted neurotic". Altogether, "experts seem in some disagreement" so that we cannot really interpret this particular score. The next Rorschach score, the number of popular replies, has a factor of .242. According to our expert "a large number of popular responses suggests a dull extraverted person or hysteric." Apparently "a small number of popular responses suggests a person out of contact with his environment, or may be due to a perfectionist attitude exhibited by obsessive, compulsive neurotics". In all, he concludes that "a high number of popular responses might, therefore, suggest extraversion, a low number introversion".²

Three more scores are to be considered and lend weight to this interpretation. Inaccurate work on the track tracer has a loading of .162 which, although low, is in the right direction. Orectic humour also has a loading of .162 which is also low, but again in the right direction. Truthful

² Score 37, the Rorschach $FM + m \div Fc + c + C'$ has a loading of -.121 and should therefore be a measure of introversion. According to our authority "high $FM + m$ is probably introverted, high $Fc + c + C'$ probably extraverted by majority opinion". This is in line with our hypothesis, but the correlation is much too small to carry any weight. It may, however, serve to counterbalance item 32, the Rorschach $To \div de$ where "a high score is indicative of an uncritical attitude, perhaps suggesting abnormal extraversion". Here also the correlation (-.189) is too small to carry much weight. Ratios, in view of their well-known statistical unreliability, should never be used in work of this kind, particularly when the scores entering into the ratios are themselves not very reliable (18).

self-ratings, with a loading of .200, is slightly higher and also in line with previous work which has shown a slight tendency for extraverts to obtain more truthful scores on the lie scale. With the possible exception of the *F* % score, we can therefore say that all the scores considered support the interpretation of this factor as one of extraversion-introversion.

A number of items have moderately high correlations with the factor but have not been considered in this connection because they neither argue for nor against our interpretation and may be chance projections on this factor. Among these scores are, for instance, item 44, high finger temperature, which has a correlation of .300, and item 40, high diastolic blood pressure, which has a correlation of $-.230$. Our data are not sufficient to make it possible for us to say whether these additional items, which the reader may like to study intensively in Table 1, throw any additional light on either the identification of the factor or its measurement. The work of Theron and of Van der Merwe (21, 22), as summarized in "The Structure of Human Personality", has opened up the possibility that extraversion-introversion may be related to certain autonomic measures, and certainly this line of enquiry is promising and deserves to be followed up. It cannot, however, be maintained that at the present moment our results throw any further light on this problem.

A few words may be said about the third factor. This, quite clearly, is an autonomic one, having very high saturations indeed on pulse rate resting (.913), pulse rate stressed (.839), systolic and diastolic blood pressure (.389 and .452), and on sub-lingual temperature (.620). Finger temperature is rather out of line ($-.181$), but this may be due to difficulties and inaccuracies of measurement. Dermographic latency has a relatively low loading of $-.216$. The interpretation of this factor as an autonomic one appears somewhat invalidated, however, by the fact that item 2 (sex) has a very high loading of .855. This suggests that quite possibly the correlations observed are produced very largely by sex differences, and are therefore of less interest than they might otherwise be. No further analysis or discussion of this factor will be given here as it does not seem relevant to our main purpose. The same may be said of the remaining three factors, which do not lend themselves to any obvious interpretation and will therefore not be considered any further.

Factor scores were estimated for the first three factors. For the Extraversion-Introversion factors, the following items were used: 53, 54, 31, 33, 28, 4, 6, 46, 52, 36. For the Intelligence factor, the following items were used: 17, 10, 16, 18, 8, 9, 20, 14, 48. For the Autonomic factors, the following items were used: 39, 40, 41, 42, 43, 44, 45. Thus,

each one of our subjects obtained scores on the three factors of intelligence, extraversion, and autonomic activity.

Intercorrelations of factor scores were calculated for fraternal twins and identical twins separately, and are given in Table 2. It will be seen

TABLE II

	Intelligence	Extraversion	Autonomic
Intelligence	—	.030	-.103
Extraversion	.155	—	-.018
Autonomic	-.074	.001	—

Intercorrelations of factor scores for identical twins (below leading diagonal) and for fraternal twins (above leading diagonal).

that there are no significant relationships between the factors. Next, intra-class correlations were run for the three factors between the identical and also between the fraternal sets of twins. These correlations, as well as the h^2 values calculated from them, are given in Table 3. A test was

TABLE III

	Identical:	Fraternal:	h^2
Intelligence	.820	.376	.712
Extraversion	.499	-.331	(.624)
Autonomic	.929	.718	.748

Intraclass correlations for identical and fraternal twins, on three factor scores.

made of the significance of the differences between the intraclass correlations. For the intelligence factor, $t = 2.13$; for the extraversion factor, $t = 2.43$; for the autonomic factor, $t = 2.09$. The t values for the intelligence and autonomic factors are significant at the 5 % level; the t value for extraversion is significant at the 2 % level. We may, therefore, conclude with some statistical justification that the differences observed between identical and fraternal twins are unlikely to have been caused by chance factors and would be found again if the study were duplicated. From this it may be concluded that heredity plays a significant part in the causation of all three factors.

One feature in Table 3 requires discussion. It will be seen that the intra-class correlation for the fraternal twins on the extraversion factor has a negative sign. This is an extremely unlikely occurrence on any reasonable hypothesis, but a thorough checking of the figures failed to reveal any errors in calculation. It seems likely that this value represents

a chance deviation from a true correlation of zero, or of some slight positive value, an assumption strengthened by the fact that a correlation of the observed size is not statistically significant. Under the circumstances, however, we cannot regard the h^2 statistic derived for the factor of extraversion as having very much meaning, and it has therefore been put in brackets in Table 3 to indicate its extremely doubtful status. Much more reliance, fortunately, can be placed on the significance of the differences between identical and fraternal twins for this factor which, as has been shown above, is fully significant.

6. SUMMARY AND CONCLUSIONS

In this study an effort has been made to provide evidence for the existence of a factor of extraversion-introversion among children, similar to that found among adults, and to measure this factor. By and large, this attempt has been successful and the factorial analysis reported in this paper gives clear evidence of a strong factor of extraversion-introversion.

It was hypothesized that the concept of extraversion-introversion, as operationally defined in the writer's previous work, would be closely parallel to Rorschach's concept of extratensive-introvertive personality. The inclusion of a number of R scores in the factor analysis made it possible to test this hypothesis, and the results on the whole favoured acceptance of this theory.

Two further factors were isolated in the analysis, namely, one of intelligence and one of autonomic activity. These additional factors were found to be independent of each other and also to be independent of extraversion-introversion. Factor scores were calculated for all three factors for the members of the experimental populations.

As the major aim of the investigation was to study the effects of heredity on extraversion-introversion, the subjects of the investigation were 13 pairs of male identical twins, 13 pairs of female identical twins, 13 pairs of male fraternal twins, and 13 pairs of female fraternal twins. By using standard methods of intra-class correlation for different types of twins, it was shown that for all three factors, identical twins resembled each other significantly more closely than did fraternal twins. This was regarded as proof that heredity played an important part in the determination of intelligence, extraversion, and autonomic reactivity.

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