

THE INHERITANCE AND NATURE OF EXTRAVERSION*

By H. J. EYSENCK

Introduction

SEVERAL years ago the *Eugenics Society* gave their support to an investigation of the inheritance of neuroticism. This work, carried out by D. B. Prell and the present writer,⁹ gave strong support to the view that hereditary factors played a vital part in determining the degree of neuroticism shown by the children taking part in our investigation. It seemed desirable to follow up this study by another in which the hypothesis was tested that extraversion and introversion were similarly determined by hereditary influences to an appreciable degree. The present paper is a brief report of such an investigation.

In the neuroticism study use has been made of the so-called twin method. In this method advantage is taken of the fact that there are two types of twins, identical and fraternal. In identical twins there are no differences in hereditary endowment, as both are descended from the same fertilized ovum. Fraternal twins, on the other hand, are no more alike than ordinary brothers and sisters as far as hereditary factors are concerned. It follows from this that any differences observed in a pair of identical twins must be due to environmental differences. Differences between members of a pair of fraternal twins, however, might be due either to environment or to heredity. It follows

that when we compare difference on psychological tests of a pair of identical and a pair of fraternal twins, and if we find that fraternal twins are no more different from each other than are identical twins, then it is difficult to avoid the conclusion that heredity has played no part in the determination of this difference. If, on the other hand, identical twins are much more alike than are fraternal twins, then hereditary determination of the trait under investigation may be postulated. Quite generally, the greater the difference in the degree of similarity between identical and fraternal twins respectively, the greater is the influence of heredity. Attempts have been made, mainly by Holzinger,¹² to convert this general statement into a numerical one. As May¹³ has shown, the assumptions which have to be made in order to arrive at such a formula are too unrealistic to enable us to accept the result as a correct statement of the contribution made by heredity. In spite of these imperfections, the twin method is about the one best suited to our purpose, however, and it was accordingly used in this study.

The Genetic Experiment

Our sample of twins was drawn from four metropolitan boroughs of South London, namely those of Camberwell, Southwark, Lambeth, and Lewisham. The London County Council, whose co-operation is gratefully acknowledged, wrote to all the headmasters of all the secondary schools in these boroughs requesting a report of any twins on their registers. Of those located, fifty-two pairs were finally tested, giving equal numbers of male identical, female identical, male fraternal, and female fraternal twins. A thorough check was carried out to avoid various well-known sources of error in the

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The work on the inheritance of extraversion-introversion reported here was carried out by Drs. D. B. Blewett and H. McLeod and the details are recorded in their Ph.D. theses (1, 14.) The results of that part of the study dealing with intellectual functions have been reported elsewhere by Dr. Blewett². A detailed account of the whole experiment, with particular reference to the non-cognitive factors, has been given by the writer⁷. The research was generously aided financially by the *Eugenics Society*.

selection of a sample; these are discussed in detail by Blewett.²

The criteria used for determining the nature of each twin pair were practically identical with those used in the Eysenck and Prell study. They include scales for rating similarity of facial features, general habitus, hair colour and distribution, iris pigmentation, shape of ears and teeth; height and weight were also measured as well as the ability of the subjects to taste phenol-thiocarbamide. In addition, blood groups and finger-prints were taken into account.

As regards the tests used, an attempt was made to make use of as wide a variety of different methods as possible. Fifty different test or sub-test scores were used in our final analysis, including the following groups:

(1) *Intelligence Tests.* Here we used the verbal, number, space, reasoning, and fluency scales from Thurstone's primary mental abilities tests, as well as the Porteus Maze test and the Nufferno tests.

(2) *Projective Tests.* The main test in this section was the Rorschach Ink Blot test. This was chosen primarily because Rorschach himself has discussed a personality dimension, contrasting the extratensive with the introvertive type of personality. This dimension appears very similar to that of extraversion-introversion and it seemed desirable to test this hypothesis formally.*

(3) *Autonomic Tests.* Several writers

* The writer has frequently criticized the Rorschach test, and its inclusion here may therefore appear a little surprising, yet there is no essential contradiction. The Rorschach test may be used in two entirely different ways. In the first place it may be used as a "global" test of personality, subjectively interpreted and evaluated. As such it appears to be almost entirely useless, and the experimental literature leaves little doubt that validation studies of the test used in this fashion nearly always give negative results.

It is possible, however, to use the Rorschach as an ordinary psychometric device, scoring it in a reasonably objective manner for such features as R (total number of replies), W (total number of responses determined by the whole blot), M (so-called movement responses), and so forth. Rorschach's hypothesis of the extratensive and the introverted personality was expressed generally in terms of this more objective type of determinant, and criticisms applying to the global-intuitive method do not necessarily apply to this psychometric method of analysis.

have postulated a correlation between extraversion-introversion and the functioning of the autonomic nervous system; this literature has been reviewed by the author.⁴ Consequently tests were included of systolic and diastolic blood pressure, pulse rate after resting and after stress, sub-lingual temperature and finger temperature, and also dermographic latency.

(4) Ratings have frequently figured in the literature in connection with introversion-extraversion. Use was made here of newly developed rating scales filled in by the teachers of the children concerned, dealing with a variety of personality traits related to neuroticism and extraversion-introversion.

(5) An attempt was made to obtain self-ratings from the children by the use of questionnaire scales also developed for the special purpose of this inquiry.

(6) *Sociometric Examination.* In view of the importance given to the trait of sociability in connection with the literature of extraversion-introversion, it seemed desirable to have psychometric measures of this trait and two special measures were accordingly obtained.

(7) Objective measures of personality formed the most important part of the examination. These were taken from previous work with adults,^{3, 4} and include measures of suggestibility, finger dexterity, rigidity, persistence, expressive movement, speed-accuracy in track-tracing, and sense of humour.

All these tests were administered to the twins in our sample and were then inter-correlated, and the resulting matrix of inter-correlations factor analysed. The reason for this procedure was as follows. In the case of each of the tests included as measures of extraversion-introversion we had a definite hypothesis stating, for instance, that extraverts would be more sociable on the sociometric test, would have lower M scores and higher D scores on the Rorschach test, would be speedier but less accurate in a track-tracing task, and so forth. If our predictions are correct, then we would expect these tests to correlate in a certain manner,

and it is in an attempt to test this hypothesis that we performed correlational and factorial analysis.

Results

The analysis disclosed three major factors. Two of these are of comparatively little interest in connection with our major problem. These two factors had high grading respectively in the intelligence tests and in the autonomic measures, and could accurately be defined as intelligence and autonomic lability respectively. Of much greater interest here is the third factor, which bore out a considerable number of the hypotheses regarding extraversion-introversion we had formulated, and which, therefore, may be interpreted as an extraversion-introversion factor.

We next proceeded to give every child in our sample a score on the three factors isolated so that in the final analysis we had scores for each one of our twins on extraversion-introversion, intelligence, and autonomic lability. These scores were found to be quite independent of each other, all correlations between them being insignificant. We then proceeded to determine the intra-class correlations on these factor scores for identical and fraternal twins respectively. As had been expected, the correlations for identical twins were considerably higher than those for fraternal twins in each case; in other words, with respect to extraversion, intelligence, and autonomic lability, identical twins are more like each other than are fraternal twins. Statistical tests of the significance of this difference were carried out and disclosed that all differences were in fact significant. It is interesting to note that the greatest difference between identical and fraternal twins was observed with respect to the extraversion factor; this suggests that extraversion is determined by heredity to at least as large an extent as is intelligence. The large sampling errors attaching to both means and correlations in a study such as this where relatively small numbers are used make it impossible to regard this conclusion as definitive, and it would seem highly desirable for a repetition

of this study to be carried out. Even so, however, it seems reasonable to conclude that extraverted behaviour is determined to a significant extent by genetic factors.

The type of study described in the preceding sections relies entirely on a descriptive kind of approach. Results of the study suggested strongly that the cause of the observed behavioural patterns might be found in the biological constitution of the individual, and it seemed desirable, therefore, to attempt to test certain hypotheses regarding the nature of this constitutional cause. In this way we might hope to improve our selection of tests for a later repetition of our genetic study, by weeding out those not causally linked with our dimension of extraversion-introversion, and by including more direct measures of the underlying determinants for extraversion-introversion. A certain amount of progress has been made in this attempt to go over from the nosological-descriptive level to the ætiological-causal level. An extended discussion of this new theoretical approach has been given elsewhere⁶; here we can only review briefly the main lines of this approach.

The Nature of Extraversion

A hint as to the possible theory comes from two sources. Jung has formulated the hypothesis that extraverts who have a nervous illness tend to show symptoms of hysteria, while introverts under similar circumstances tend to show symptoms of a dysthymic nature (anxiety, reactive depression, obsessional disorders). This hypothetical relationship has been verified by the writer in a long series of researches summarized elsewhere.⁴ The second clue has been given us by Pavlov.¹⁶ As is well known, this great experimentalist became interested in the last years of his life in the problem raised by psychiatric disorders. After lengthy observation, he concluded that hysterics showed predominantly symptoms which appeared to be analogous with behaviour patterns shown by a certain kind of dog on which Pavlov had carried out his experimental work, and which had been characterised by *excessive cortical inhibition*.

Conversely, dysthymic patients, i.e. those showing symptoms of anxiety and depression, were found by Pavlov to resemble in their behaviour another group of dogs, namely those in whom cortical inhibition was insufficient, and *cortical excitation predominant*. It appears possible, therefore, that we may find the answer to our problem in terms of the excitation-inhibition ratio. Let us study these concepts for the moment and see whether it is possible to design experiments which can test this very general theory.

Modern learning theory has attached very definite meanings to the terms excitation and inhibition. These are illustrated in Fig. 1. This figure gives in diagrammatic form the results of a learning experiment. The task the subject has to perform is a relatively simple one. An electric motor drives a turntable into which is set a small metal disk. The subject holds an articulated rod with a metal tip in his preferred hand. As

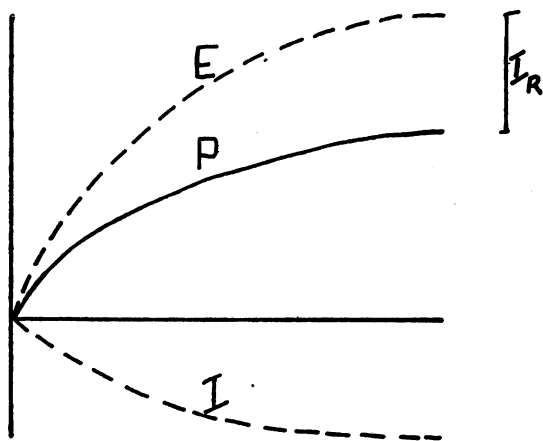


Figure 1.—Diagrammatic representation of the improvement of performance (P) as a function of excitatory potential (E) minus inhibitory potential (I). Also shown is the reminiscence phenomenon as a function of the dissipation of inhibition during the rest period.

the turntable spins round at a uniform speed it is his task to follow the movement with his stylus and to try and keep its point in contact with the metal disk. Whenever the subject succeeds in touching the disk, an electric connection is made and the current

activates an electric clock which records the amount of time during which contact has been maintained. The subject goes on without a break for five minutes; at the end of this period he is given a ten-minute rest and is then tested again on this pursuit rotor. His performance is recorded at the end of every ten-second period in terms of the percentage of this time during which he succeeded in maintaining contact.

The solid curve marked P for performance illustrates a typical learning curve under these conditions. The curves marked E and I respectively are theoretical curves which illustrate the concepts of excitation and inhibition. While the subject is practising he is forming connections in the central nervous system which will facilitate performance on this task. It is this connection-forming activity which goes by the name of *excitation*. Conversely, at the same time that these connections are being formed in the subject's nervous system, he also accumulates a certain amount of *inhibition*. This concept of inhibition is similar to that of fatigue; according to this hypothesis every time that the neural impulse goes through a set of neurons and synapses it produces a certain amount of fatigue in these structures which works against the easy passage of another impulse. On this conception, performance is the end product of an interplay between excitation and inhibition, being proportional to the total amount of excitatory potential *minus* the total amount of inhibitory potential.

At first sight it may appear unnecessary to involve such a complex interplay of theoretical conceptions in order to explain the very simple curve of learning we have obtained. However, there are many facts which cannot be explained without recourse to a complex system of this kind. One of these phenomena, which at the same time concerns us as a measure of inhibition, is the fact of *reminiscence*. Inhibition, being as it were a fatigue product, quickly dissipates in time; excitation, as a habit, does not. The end point of our performance curve was given us in our theory by subtracting the total amount of inhibition accumulated by the

subject from the total amount of excitation. Our theory demands that when we now interpose a ten-minute rest period inhibition should dissipate, while excitation should remain just about where it was before the pause. It would follow, as can be seen quite clearly from Fig. I, that after the rest, performance, which is no longer depressed by the inhibitory potential now dissipated by the rest pause, should go up to the level of the excitatory potential. Thus we should observe experimentally *a rise in performance consequent upon the interpolation of the rest pause*. It is this rise in performance which is referred to under the title of reminiscence, and there is incontrovertible evidence for its occurrence in connection with many different types of task. It would be extremely difficult to explain reminiscence phenomena without having recourse to some such theoretical construct as inhibition, and it should be remembered that there are many other facts in the experimental literature of learning which also require the postulation of inhibition.¹⁴

The Experimental Evidence

It has already been noted that in this theoretical assessment we can use the amount of reminiscence as a direct measure of inhibition. (In modern learning theory the type of inhibition here discussed is often referred to as reactive inhibition or I_R . There is another kind of inhibition referred to as conditioned inhibition or sI_R ; this will not be discussed here as it does not affect our argument in any direct manner.) If the theory that extraverts tend to produce more reactive inhibition than introverts is correct then we would here have a possible method of proof. It would follow from the theory that reminiscence effects should be stronger and more pronounced for extraverts than for introverts. Fig. II shows the general result of an experiment carried out on fifty university students in an attempt to test this deduction. There are three periods of practice on the pursuit rotor each lasting for five minutes; these periods are separated by ten-minute rest pauses. The reminiscence phenomenon is obvious after both

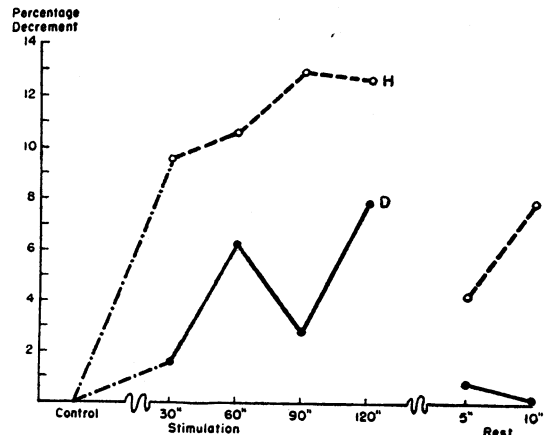


Figure 2. -- Average performance on the pursuit rotor of 50 university students during three practice periods separated by 10 minute rest periods.

rest pauses; initial performance in periods 2 and 3 is clearly superior to final performance in periods 1 and 2 (there are other phenomena in these curves such as the steep initial rise in periods 2 and 3, and the subsequent decline in performance in these curves, which can only be explained in terms of additional concepts such as sI_R ; no attempt will be made to do so here). When individual differences in reminiscence were related to the position of the fifty subjects on the extravert-introvert continuum as determined by means of a specially designed questionnaire, a highly significant relationship was established in the predicted direction, thus showing the possibility of making verifiable deductions from our general hypothesis.⁸

Another prediction which may be made directly from the Pavlovian assessment relates to ease of conditionability. On Pavlov's showing, dogs in which the excitation-inhibition balance is tilted in the direction of greater excitation are relatively easy to condition, whereas dogs in which the balance is tilted in the opposite direction are relatively difficult to condition. If our general theory is correct then we should expect extraverts (and hysterics, the neurotic form of the extravert) to be more difficult to condition than introverts (and dysthymics, the neurotic prototype of the introvert).

These two predictions relating to the superior conditionability of normal and of neurotic introverts as compared with normal and neurotic extraverts have been experimentally investigated in this department by Franks.¹¹ The experiment was carried out in a sound-proof conditioning laboratory used for this purpose at the Institute of Psychiatry.¹⁰ The reflex to be conditioned was the eye-blink occurring as the response to a puff of air administered to the eyeball. The rubber tube carrying the air duct to the eye was imbedded in a spectacle frame worn by the subject; the eyeblink itself was recorded by means of a light-sensitive cell affixed to the spectacle frame and activated by the change in the amount of reflected light produced by the closing of the eyelid. The conditioned stimulus was a tone transmitted over a pair of earphones; all signals and responses were electrically recorded. The procedure used was as follows. After establishing that the tone by itself did not produce the eyeblink reflex but that the puff of air did so, the two stimuli were presented in combination a number of times, the tone always preceding the puff of air by a fraction of a second. Eighteen trials were interpolated in this series in such a way that during these trials only the tone was given but no puff of air. The eyeblink occurring as a response to the tone alone was accounted as a conditioned response, and it will be seen that the possible number of conditioned responses varies from zero to eighteen. At the end of the conditioning period, the acquired reflex was extinguished by a non-reinforced repetition of the tone for ten trials. Here again, the number of conditioned responses occurring in each stage constituted the score for each subject.

In Fig. III are given the results of carrying out this experiment on twenty hysterics, twenty dysthymics, and twenty normal people. It will be seen that, as required by the hypothesis, the dysthymics are in all stages, both of the acquisition and the extinction trials, superior to the hysterics. In other words, hysterics are much more difficult to condition than are dysthymics. Normals are intermediate between the two

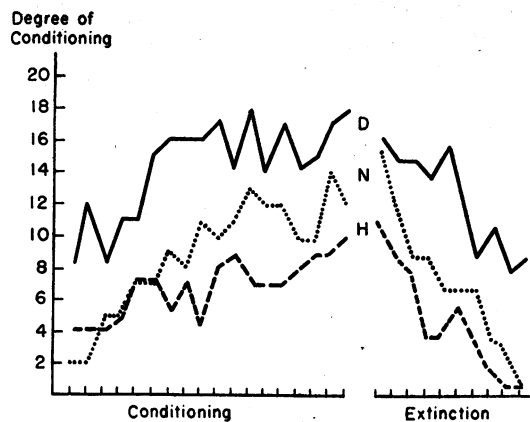


Figure 3.—Growth and extinction of conditioned responses of dysthymics, normals, and hysterics.

neurotic groups, as might have been expected; if chosen at random they are likely to be intermediate between extraverts and introverts. Fig. IV shows the actual scores made during the acquisition period by our hysterics and dysthymics, i.e. the number of

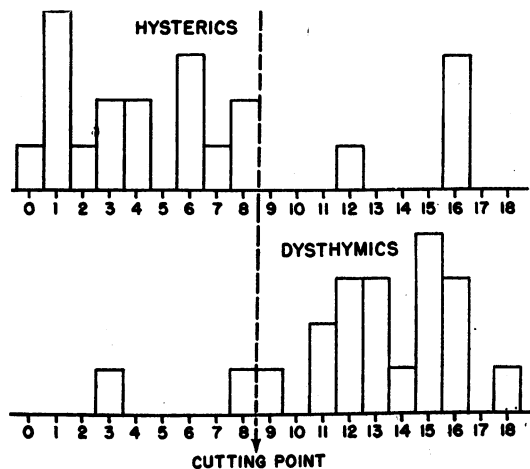


Figure 4.—Conditioning scores of hysterics and dysthymics respectively.

times during the eighteen trials that each person in these groups responded to the conditioned eyeblink. It will be seen that the separation is reasonably good. When the results of this experiment were combined with another conditioning experiment using

the psychogalvanic response, the two groups were discriminate at a 100 per cent level, i.e. there was no overlap whatsoever between the groups.

A similar result to the one outlined above was found in connection with a normal group of sixty university students. They also were administered the eyeblink test and their level of conditioning determined. Their personality was assessed by means of the questionnaire already mentioned, and a highly significant relationship observed in the expected direction, introverts being easier to condition than extraverts. Here also then we find considerable support for our general hypothesis.

The other prediction made in terms of our theory relates to what are commonly called figural after-effects. This term, introduced by Kohler, refers to the effects of a hypothetical satiation during prolonged exposure to sensory stimulation. These satiation effects are very similar to the effects of reactive inhibition in the learning field, and the writer has argued elsewhere that if both reactive inhibition and satiation can be shown to be due to identical single processes then a considerable degree of unification and simplification in psychological theory would be possible.⁵

The figural after-effects have been studied most widely in the visual field. In a typical case the subject equates the size of the two circles or squares which appear to the right and left respectively of a fixation point. He is then asked to look at an inspection figure slightly smaller than the test figure previously shown and appearing to the left of the fixation point in the same position as the previous test figure. After five minutes or so, the inspection figure is removed and the test figure, i.e. the original two circles, is brought back. This time the satiation effects produced by the inspection figure will result in appearing to push outwards the contours of the left circle which are adjoining the field stimulated by the inspection figure, but will leave in order the contour of the right circle. To the subject, therefore, the left circle will now appear larger than the right, and the extent of the difference can

be used as a measure of the degree of association achieved.

If we identify association effects and reactive inhibition then it follows from our general theory that extraverts and hysterics

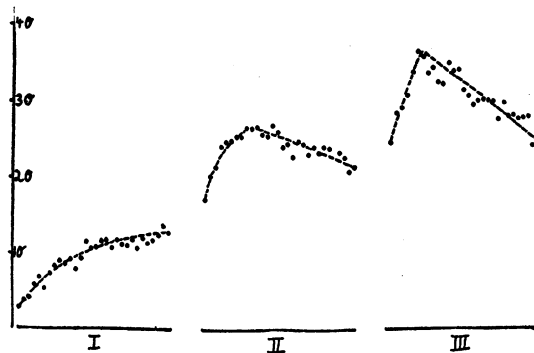


Figure 5.—Figural after-effects as a function of different periods of stimulation for hysterics and dysthymics respectively.

should show more pronounced figural after-effects than do introverts and dysthymics. An experiment along these lines has been reported by the present writer, using, however, a kinæsthetic rather than a visual type of task.⁵ Changes resulting from four different inspection periods (30 seconds, 60 seconds, 90 seconds, and 120 seconds) are shown in Fig. V for a group of hysterics and a group of dysthymics respectively. Also shown are the after-effects of stimulation when rest pauses of varying lengths (5 minutes, 10 minutes) are interpolated. From the diagram it will be seen that the reactions of the hysterics are much more pronounced than those of the dysthymics. Here again, therefore, we found results significantly supporting our general theory.

Conclusion

There would be little point in going thoroughly into a detailed discussion of experimental findings supporting this general theory; enough has probably been said to give the reader an idea of the type of theory which is being developed here, and the methods used for making deductions from the theory. So far deductions have all been

successfully verified by experiments, and it seems unlikely, therefore, that our theory can be altogether erroneous. However, until a great deal of further work has been done in connection with this verification no more will be claimed for it at this point than that here we have a possible causal hypothesis which can account for a great number of facts descriptively collected under the title of *extraverted behaviour patterns*. If future research should go on supporting this view, then we would indeed seem to have available a very powerful tool for investigating the inheritance of extraversion-introversion. We would now be concerned, not so much with the kind of test described in the first part of this paper which can only trace its relationship to extraversion-introversion through the long and haphazard way of correlational analysis, but would rather be in a position to use tests measuring in a much more direct way the underlying properties of the nervous system which give rise to the type of behaviour which formed the starting point of our inquiry. Studies carried out on that basis should give us much more clear-cut, much more secure, and much more definitive information than is available at present. The main advance, therefore, which the writer would claim as the outcome of the present series of studies would be not so much that the final answer has been found for the problem investigated, but rather that we are now in a position to carry out such an investigation with improved tools, improved theories, and a better knowledge of the underlying dynamics. It would be un-

reasonable if we expected a much more positive outcome of a pioneering investigation.

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