Chapter 8

Review of the evidence: personality

Review of the evidence: personality[1]

Background

8.1 Personality has long been a focus of research in various disciplines. Many measures of personality originated outside psychiatry. For example, the first personality measure, devised in 1919, was used in determining mental fitness for military service. Since then many measures of personality, of differing quality, have been developed, such as the Minnesota Multiphasic Personality Inventory (MMPI). However, it should be noted that the prime purpose of psychological tests of personality was not for use in psychiatry but rather to build a theory of personality.

Trait definition and measurement

8.2 Different aspects of personality can be described at different levels. One can either choose the highest level, at which all the traits are independent of one another, or a variety of lower levels, at which the traits are to varying degrees correlated with each other. Genetic research into personality has largely concentrated on the first, highest level; what might be termed 'global' traits.

8.3 The dominant view at present puts the number of independent personality traits at five; this is called the 'Big Five' model of personality. The 'Big Five' traits are: Neuroticism, Extraversion, Agreeableness, Conscientiousness and Openness to Experience (see Table 8.1).[2] Each trait has a normal distribution of scores. These five traits, or factors, are commonly referred to as 'dimensions of personality'. There is disagreement among psychologists about the number of core personality traits; alternative views range from three to seven. The British psychologist Hans Eysenck originally suggested three – Neuroticism, Introversion and Psychoticism. However, in the Big Five Model, Psychoticism is broken down into three separate factors (Agreeableness, Conscientiousness and Openness to Experience). Impulsivity (sensation-seeking) is also sometimes separated out. It is important to note that these traits are used for descriptive convenience, rather than because there is evidence that they have distinct biological causes or pathways that affect personality.

Table 8.1: The 'Big Five' Personality Traits

Trait	Descriptors at high end of scale	Manifestation of trait
Neuroticism	Anxious Depressed Feeling guilty Having low self-esteem Tense Shy	Individuals with high scores on this trait are likely to develop one of a range of neurotic psychiatric disorders, including generalised anxiety disorder, agoraphobia, major depression and obsessive-compulsive disorder. There is

[1] The material in this chapter is taken from a paper commissioned by the Nuffield Council on Bioethics from Professor Jeffrey Gray, Emeritus Professor at the Institute of Psychiatry, Kings College London. The paper is available on the Council's website: www.nuffieldbioethics.org.

[2] Since terms such as Neuroticism are also in common usage, we adopt the practice of psychologists of capitalising the first letter of each trait in order to indicate that we are referring to these traits as they are defined and studied by psychologists.

	Moody Agitated Suspicious Hostile Emotional	considerable comorbidity between these neurotic disorders (but not between them and the psychotic disorders, such as schizophrenia or mania).[3]
Introversion–Extraversion[4]	Sociable Lively Active Assertive Carefree Dominant Venturesome Optimistic Impulsive Sensation-seeking	Individuals with high scores for Introversion tend to be quiet and reserved, introspective, distant except with intimate friends, reliable, non-impulsive, serious, liking order, emotionally restrained, non-aggressive, moral and somewhat pessimistic. High scorers on Extraversion in contrast tend to be sociable, impulsive, sensation seekers, liking of change, easy going, optimistic, aggressive and can be unreliable.
Agreeableness	Trusting Straightforward Altruistic Compliant Modest Tender-minded	Individuals with high scores on this trait are straightforward and frank, co-operative, yielding rather than aggressive in conflict, modest and unpretentious, caring, nurturing, and supportive and tend to see others as honest and trustworthy.
Conscientiousness	Productive Orderly Dependable Having a high level of aspiration Consistent Rational	Highly conscientious people are goal-oriented and efficient. They are dependable, well-organised, methodical and focused. Being rule-oriented, they avoid disorder and impulsive behaviour.
Openness to Experience	Given to fantasy Aesthetically reactive Sensitive to interpersonal cues Concerned with philosophical problems Moralistic Socially poised	High scorers are flexible and broad-minded individuals who are creative, imaginative and intellectual. They like to try new options, seek out variety and find reward in learning and developing new ideas. They avoid situations that are highly , structured, rigid or controlled.

[3] Quantitative genetics research has shown that the genetic influences on Neuroticism affect almost exclusively its comorbidity with other traits as distinct from the liability to any one particular disorder. The studies show also that scores on self-report scales of Neuroticism provide a good measure of the heritable component of the comorbidity of neurotic disorders. Thus, this trait is best regarded as one of susceptibility to the entire gamut of neurotic disorders, with the actual nature and occurrence of such a disorder depending upon life events.

[4] This is the best established of all personality traits. Like Neuroticism, Extraversion has been embedded in several, experimentally testable, neurobiological theories and progress is being made towards identifying the underlying brain mechanisms.

8.4 Most research indicates that the two most robust traits are those of Neuroticism and Introversion–Extraversion. These are highly replicable, they account for a considerable portion of the variance across a very wide range of measures, and they can each be reliably measured by relatively short self-report scales ideally suited to large-scale genetic studies.

8.5 Using factor analysis, it is possible to determine how many independent factors or traits exist within a given body of data, but not how these factors are related. Thus, from the results of descriptive studies alone, we are unable to tell whether a given dimension of personality merely provides us with a convenient set of coordinates within which to locate an individual's personality (as, say, East–West and North–South are used as convenient sets of coordinates within which to fix spatial location), or whether it has a basis in underlying causal reality (as, say, up–down has a basis in the force of gravity). Because of this ambiguity, many of the trait terms used in personality research (even when they all operate at the highest, dimensional, level) do not reflect entirely different traits, but rather rotations of one another. For example, the trait of novelty-seeking blends some lower-order traits that, in alternative descriptive systems, make up Extraversion with others that make up Psychoticism.

8.6 A further problem is that different investigators may refer to what is essentially the same dimension by different names (often reflecting different theories into which the dimension has been embedded). There are no clear pre-existing signposts to suggest for which personality traits researchers will most likely find genetic influences. However, if there is a substantial heritable component to a given personality trait, then this can itself provide both an external criterion by which to validate the factor purporting to represent the trait as well as a theoretical framework for prediction and experiment to establish its causal reality. For example, if research in quantitative genetics shows a substantial genetic influence on variation in Neuroticism, this simultaneously provides support for the reality of the underlying trait of Neuroticism, for the tests by which it is measured, and for the factor-analytic solution that has yielded the factor of Neuroticism.

Current findings: quantitative genetics

8.7 The two most important conclusions to emerge to date from quantitative genetic studies of personality are of broad generality. First, across a range of traits, heritability estimates from twin studies lie in the range 0.30–0.50[5] (though estimates from adoption studies are consistently lower, suggesting that non-additive genetic variance may have an important role in personality).[6] This is the result obtained for Neuroticism, Extraversion, Conscientiousness, Openness to Experience and Agreeableness (though in the latter case, heritability in one study was estimated at only 0.12). Sensation-seeking has been reported to have somewhat higher heritability, about 0.60. This consistency in the pattern of results is surprising. Between them, these findings, extending as they do over the entire Big Five model, cover all known personality traits. Thus, the genetic contribution to personality is thought to be substantial and appears to be roughly equal across all aspects of personality.

[5] Plomin, R., DeFries, J. C., McClearn, G. E. & McGuffin, P. (2001). *Behavioral Genetics*. 4th ed. New York: Worth.

[6] Bouchard, T. J. Jr. & Loehlin, J. C. (2001). Genes, Evolution, and Personality. *Behav. Genet*. **31**, 243–73. Another interesting feature of heritability calculations that the authors discuss is the variation between sexes.

8.8 There is no *a priori* reason to expect all personality traits to be influenced equally by genetic causes. However, the results obtained to date are mutually consistent and apparently robust. It is possible that the uniformity of genetic influence is an artefact due to the imperfect alignment of personality traits derived from descriptive, factor-analytic studies. Future research combining genetic and factor-analytic methods may be able to improve this alignment. In that case, traits would emerge with greater estimates of heritability than the 0.30–0.50 that have emerged so far, but these would be balanced by others with lesser estimates of heritability (with the total genetic contribution across the whole of personality space necessarily being conserved).

8.9 Secondly, quantitative genetics research has shown that when considering the environmental effects on personality, non-shared environmental factors have the largest effect (see paragraphs 4.9–4.10 which explain the difference between shared and non-shared environment).[7] However, unless specific measures of environmental risk factors are included in these studies, little can be surmised as to what these influences might be, or even the degree to which they are likely to yield to systematic analysis.

Current findings: molecular genetics

8.10 A large number of genes are known to influence brain function. Moreover, in the present state of knowledge, a plausible hypothesis can be constructed to link almost any of the known genes with virtually any aspect of personality. And many other genes with influence on the brain remain to be discovered and so cannot yet serve as candidates.

8.11 There are many grounds for believing that levels of anxiety, psychoticism or impulsivity may in part reflect differing levels of functioning of particular neurotransmitters in the brain. Prominent in this respect are the monoamine transmitters: dopamine, serotonin and noradrenaline. Thus, an experimenter may investigate whether trait scores differ as a function of a polymorphism in a gene that determines, for example, the rate of synthesis or transport of one of these neurotransmitters or the structure of the receptors upon which the neurotransmitter acts.

8.12 There has recently been a flurry of studies that claim to identify particular genetic influences on personality traits. Associations have been reported between: (i) novelty-seeking and a polymorphism in the gene for the D4 receptor (one of several different types of receptor) for dopamine;[8] and (ii) anxiety and a polymorphism in the gene for the serotonin transporter.[9] (The serotonin transporter terminates the action of serotonin by transporting it from the synaptic junction back into the cell that has just released it.) There have since been numerous attempts to replicate these findings, with very mixed results. Several of these experiments, especially those reporting negative outcomes, have used samples too small to yield conclusive results. However, there have now been a sufficient number of positive replications of the initial report concerning

[7] Riemann, R., Angleitner, A. & Strelau, J. (1997). Genetic and environmental influences on personality: a study of twins reared together using the self- and peer-report NEO-FFI scales. *J. Pers.* **65**, 449–76.

[8] Ebstein, R. P. *et al*. (1995). Dopamine D4 receptor exon III polymorphism associated with the human personality trait of novelty-seeking. *Nat. Genet.* **12**, 78–80; Benjamin, J. *et al*. (1996). Population and familial association between the D4 dopamine receptor gene and measures of novelty-seeking. *Nat. Genet.* **12**, 81–4. See also paragraphs 5.9-5.10.

[9] Lesch, K. P. *et al*. (1996). Association of anxiety related traits with a polymorphism in the serotonin transporter gene regulatory region. *Science* **274**, 1527–31.

the serotonin transporter gene that this finding is reliable.[10] These studies concur in showing that alleles of the serotonin transporter gene which result in reduced serotonin re-uptake are associated with higher anxiety. These results are, however, unexpected, given that drugs which reduce serotonin re-uptake, such as Prozac, are used to alleviate both depression and anxiety. As noted in paragraph 5.10, the evidence for a link between the DRD4 gene and novelty-seeking does not seem convincing, despite the initial findings.

Quantitative trait loci (QTL) research

8.13 Several studies of QTLs for Neuroticism are in progress around the world. QTL studies in humans, that use sibling pairs and linkage strategies, require very large numbers; around 20,000 pairs of siblings who either both score high (or low) on the trait (concordant pairs), or one of whom scores high and the other low (discordant pairs).[11] Results from these studies are likely to become available in the next year. In the light of the results from rodent studies (see paragraphs 8.14 – 8.16) it is likely that at least some of these results will be positive. However, to move beyond the identification of a QTL to the actual gene with which it is associated remains a very difficult technical problem that has not so far been achieved for any QTL thought to affect human behaviour.

Current findings: research involving animals

8.14 Numerous animals have been tested in genetic studies of personality, including primates, rats, mice and even fish. The most developed animal model is that of Emotionality, which is used as an analogue of the human trait of Neuroticism. Neuroticism has been embedded within several neurobiological theories which can be tested experimentally; and there has been good progress in understanding the nature of the systems in the brain whose functioning most likely underlies scores on the trait. Across a wide range of behavioural tests with good credentials as putative measures of anxiety, rodents which obtain high scores on one test are likely also to get high scores on the others. Furthermore, it has proved possible to inbreed and selectively breed strains of mice or rats such that they reliably obtain high (or low) scores on such tests, generation after generation. It remains to be demonstrated, however, that the genes which influence Emotionality in rodents are similar to those that determine human Neuroticism.

8.15 The first QTL study of a behavioural trait, reported by Flint *et al*,[12] investigated Emotionality in mice. This study was an important demonstration of principle. Nearly 1,000 mice were derived from intercrossing two highly inbred, selectively bred strains with very high and very low scores on behavioural tests of Emotionality. The intercrossing mixes the genes from these two parental strains; and the DNA markers can then be used to determine which genes

[10] Greenberg, B. D. *et al*. (2000). Association between the serotonin transporter promoter polymorphism and personality traits in a primarily female population sample. *Am. J. Med. Genet. (Neuropsychiatric. Genet.)* **96**, 202–16; Sher, L. *et al*. (2000). Pleiotropy of the serotonin transporter gene for seasonality and neuroticism. *Psychiatr. Genet*. **10**, 125–30; Osher, Y. *et al*. (2000). Association and linkage of anxiety-related traits with a functional polymorphism of the serotonin transporter gene regulatory region in Israeli sibling pairs. *Mol. Psychiatry* **5**, 216–19; Melke, J. *et al*. (2001). Serotonin transporter gene polymorphisms are associated with anxiety-related personality traits in women. *Am. J. Med. Genet. (Neuropsychiatric. Genet.)* **105**, 458–63; Jang, K. J. *et al*. (2001). Covariance structure of neuroticism and agreeableness: a twin and molecular genetic analysis of the role of the serotonin transporter gene. *J. Pers. Soc. Psychol*. **81**, 295–304; Du, L., Bakish, D. & Hrdina, P. D. Gender differences in association between serotonin transporter gene polymorphism and personality traits. *Psychiatr. Genet*. **10**, 159–64.

[11] Risch, N. & Merikangas, K. (1996). The future of genetic studies of complex human diseases. *Science* **273**, 1516–17.

[12] Flint, J. *et al*. (1995). A simple genetic basis for a complex psychological trait in laboratory mice. *Science* **269**, 1432–5.

in the offspring have been inherited from each strain. QTLs were identified by correlations between these markers and scores on various behavioural tests for Emotionality. Three QTLs were identified, having the important property of *pleiotropy*: that is, each was associated with several different behavioural measures, rather than with any single item of behaviour. The QTL with the greatest effect was situated on chromosome 1. This finding has since been replicated several times. Additional analysis using quantitative genetics techniques assessed the amount of the variance in scores on the tests that could be attributed to genetic factors to be, at most (depending on the particular behavioural measure), about 30%. Importantly, the additive effects of the identified QTLs, taken together, were able to account for nearly all of this genetic variance. Finally, the study confirmed the conclusion, derived from mathematical simulations, that (given a large enough sample size) the QTL approach is able to identify QTLs that account for a very small portion of the phenotypic variance – as little as about 3% in the Flint *et al* study.

8.16 Even for the well-replicated research on the QTL on chromosome 1, however, it has not yet been possible to identify the gene involved; although subsequent work has narrowed down the relevant chromosomal region. Until the gene in question has been identified, it is not possible to test its effects in humans. If the gene were identified in both animals and humans, this would permit investigation of the causal chain by which the gene contributes to the specification of values on the trait. In this respect, the rat is preferred to the mouse, since much more is known about the behavioural functions of the brain in rats. Flint's group have now identified a QTL in the rat which appears to be related to Neuroticism, since it has pleiotropic effects across a large battery of behavioural tests that are sensitive to the effects of drugs used in human beings to reduce anxiety.[13]

Future directions for research

8.17 Future research in behavioural genetics in the field of personality traits is likely to focus on the use of molecular genetic research techniques to identify candidate genes and regions of DNA that have an effect. If such genes are identified, they could provide the basis for experiments aimed at determining the neurobiological pathways by which genetic influences are brought to bear. Detailed knowledge of the genes that affect personality would then, in turn, provide the basis for investigation of non-genetic influences on personality.

[13] Fernandez-Teruel, A. *et al*. (2002). A quantitative trait locus influencing anxiety in the laboratory rat. *Genome Res.* **12**, 618–26.