CHAPTER 8
Biological Basis of Personality I:
Genetic Heritability of Personality and Biological and Physiological Models of Personality

Key themes
- Behavioural genetics
- Heritability estimates
- Genetic and environmental effects on personality
- Neuropsychology and psychophysiology
- Eysenck, Gray and Cloninger’s models of personality

Learning outcomes
After studying this discussion you should:
- Understand how psychologists have applied the ideas that surround behavioural genetics and heritability estimates to understand influences on personality
- Be aware of theoretical and research evidence surrounding genetic and environmental influences on personality that can be used to assess the value of heritability estimates
- Know how Eysenck, Gray and Cloninger have used neuropsychology and psychophysiology to develop biological models of personality
- Be familiar with evidence that assesses the strengths and weaknesses of biological models of personality
Behavioural genetics

The world of behavioural genetics is an exciting one. In the first section we are going to outline the main findings regarding how much our genes influence our personality, but we will also introduce you to a much wider debate. You will see that, over time, the way in which research has considered how genes influence our personality has gone from a very simple model that compared genes with the environments, to a much more comprehensive model that incorporates a number of genetic and environmental aspects thought to be working together.

Behavioural genetics: basic ideas

In very basic terms, behavioural genetics looks at the relationships between genes, environment and behaviour. Before we start exploring the theory and research that surrounds behavioural genetics, there are two important terms you need to know: genotype and phenotype.

The genotype is the internal genetic code or blueprint for constructing and maintaining a living individual. Your genotype is made up of a number of genes. Genes are made up of DNA, and DNA contains the instructions for building proteins in the body. Proteins control the structure and function of all the cells that make up your body. The genotype is a genetic code that is biologically inherited and is found within all the cells, tissues and organs of the individual because it has helped design and build all of these structures. This genetic code also underlies all the biological functions, such as your heart rate and your metabolism. What is important to behavioural genetics is that the genotype influences the phenotype.

The phenotype is the outward manifestation of the individual: that is, the sum of all the atoms, molecules, cells, tissues and organs. The most obvious example of a phenotype is our physical appearance. The information in our genotype determines what we look like; for example, many children share the physical characteristics of their parents. What is really important to this discussion is that the phenotype can be our personality. In the next section we are going to show you how behavioural geneticists have explored and considered how our genotype – more commonly known as genes – influences our personality.

How the influence of genes is assessed in behavioural genetics

Behavioural geneticists such as Robert Plomin (see Profile: Robert Plomin) have written extensively about behavioural genetics (Plomin, 2004; Plomin et al. 2000). Behavioural genetics begins with the fact that genes are biologically transmitted from biological parents to the child. Children inherit 50 per cent of their father’s genes and 50 per cent of their mother’s genes. We can use this information as a starting point to explore how genes influence personality.

Across certain cultures, superstition and amazement surround twins; Native American tribes and aboriginals in Japan and Australia used to kill twins, as many people used to fear them. Sometimes the mother was also killed as it was believed she must have had sex with two men for two children to be conceived. Although in the modern day less mysticism surrounds twins, findings such as that of Dr Tom Bouchard still attract interest. He found that two identical twins, who had been separated at birth, when reunited after 34 years, wore jewellery in the same way, had named their sons in a similar way, and had even left the same days blank during the year in their diaries.
The assessment of the extent to which any phenotype (physical attractiveness, personality and behaviours) is passed on from parents to children, from the results of their genes, is termed its genetic heritability. The genetic heritability of any phenotype is assessed according to variability (i.e. how much they differ) between the parents and the child. This variability is often assessed within the proportion of shared variance of that behaviour between the parent and child. Proportion of shared variance is presented as a percentage (i.e. out of 100 per cent). When a parent and child are very similar in a particular characteristic, there is thought to be a low variability between parent and child, and the proportion of shared variance of that behaviour is high (nearer 100 per cent). In other words, the parent and child are not very different in this characteristic. Conversely, when a parent and child are very different in a particular characteristic, there is thought to be a high variability between parent and child, and the proportion of shared variance of that behaviour is zero (0 per cent).

The heritability of a human physical characteristic, such as having a nose, is entirely genetic. It is not in any way influenced by factors such as the environment; in fact, the environment is seen as having zero variability, or a proportion of shared variance of 100 per cent. However, with some aspects of human behaviour (including personality), in which the environment is thought to have an influence, there are greater amounts of heritable variability and lower shared variance. For example, choosing which football team to support would be heavily determined by environmental factors such as where you are born, your parents’ football team, your friends, and the first football team you see. Choosing a favourite football team has high variability between parent and child, but the proportion of shared variance of football team caused by genetic heritability would be much lower (i.e. approaching 0 per cent).

In behavioural genetics, researchers are primarily interested in: (1) estimating the extent of genetic heritability of behaviour across a population; and (2) stating the genetic heritability of that behaviour in terms of shared variance. This estimate of genetic heritability is known as $h^2$. The quantity $h^2$ is the estimate of the average proportion of variance for any behaviour thought to be accounted for by genetic factors across a population.

You may have noticed that we emphasised estimating, estimate (estimate meaning ‘to calculate approximately’) and average there. This is because, for a long time in psychology, for any phenotype (in our case, personality) the estimates of the strength of genetics factors was done and interpreted within a process called the additive assumption. This additive assumption suggests that there are only two dimensions that determine heritability of any phenotype (e.g. personality): (1) the genetic part (which we’ve just outlined), and (2) the environment. Consequently, overall, heritability of any phenotype is estimated in terms of the relative average strength of both dimensions. Therefore, the influence of genetic (G) and environmental (E) components in this theory will always add together to account for 100 per cent of the variance of any behaviour. On the basis of this assumption, the heritability coefficient ($h^2$) can be subtracted from 100 per cent to calculate the environmental contribution to any phenotype. If researchers computed that genetics accounted for an estimated average of 25 per cent of the variance for a particular phenotype (i.e. aggressiveness), they would assume that environmental factors account for an estimated average of 75 per cent of the variance in that particular phenotype. However, it is important to note that the additive assumption is now considered a starting point for calculating heritability of personality and for estimating the amount of genes that people are expected to share (e.g. brother and sisters are expected to share 50 per cent).
will see later in this discussion that this view of assessing heritability has advanced a lot. The idea of determining the relative strength of genetics and environmental factors by simply adding together genetic and environmental factors is more complicated than once thought, and we will see that psychologists really now emphasise the words ‘estimate’ and ‘average’ when referring to heritability.

Methods for assessing genetic heritability of personality

So, how might we assess genetic influences on personality? Well, within behavioural genetics of personality, the relationship between genes and personality has traditionally been made by concentrating on the similarities and differences between populations of individuals to assess the relative influence of their shared genes in personality.

Plomin (2004) identifies three main types of studies that use this technique: family studies, twin studies and adoption studies.

As children share 50 per cent of their genes with each of their parents and with their brothers and sisters, it is of interest to behavioural genetics researchers to examine possible associations between parental and child behaviours within a family. This leads to the first type of study, family studies. However, family studies on their own potentially tell us very little, because all children share an estimated average of 50 per cent of their genes with each of their parents and their brothers and sisters. As well as this, using observation, interview or questionnaire measures also presents a problem because similarities between personalities might be because of environmental influence (i.e. an extraverted son might be like his extraverted father because he copies his father’s behaviour). These are real concerns until we consider the occasions when families don’t typically share genes in this way. There are two main examples: twin studies and adoption studies.

Twin studies provide an interesting area of research, as there is a possibility of comparing different types of genetic makeup to compare genetic influences. Different types of twins are thought to share a different proportion of genes with each other. The term ‘twin’ refers to two individuals who have shared the same uterus (the uterus or womb is the major female reproductive organ). Identical (or monozygotic) twins happen when a single egg is fertilised to form one zygote (they are monozygotic), but then the zygote divides into two separate embryos. The two embryos develop into fetuses sharing the same womb. Identical twins are always of the same sex and have the same arrangement of genes and chromosomes (which contain the heritability information necessary for cell life). These twins share 100 per cent of their genes with each other. Fraternal (or non-identical or dizygotic) twins usually occur when two fertilised eggs are implanted in the uterine wall at the same time. The two eggs form two zygotes (hence the ‘dizygotic’). These twins share an estimated average of 50 per cent of their genetic makeup. Therefore, some researchers compare behaviours across non-twins, identical twins and fraternal twins to examine the relative influence of genetics.

The influence of the environment and genetics is often compared in adoption studies. Personality can be compared between parents and adopted children as there is no genetic heritability. Variables are often compared between siblings, or twins, reared apart to examine the extent of genetic and environmental effects. For example, if two twins show similar behaviours, despite being raised in different environments, this suggests that genes may be important in that behaviour.

Once you consider all these types of studies together – in which personality is compared between parents and children, and siblings, that share between 0 and 100 per cent genetic similarity – you can begin to make assessments of the extent of genetic heritability.

It is important to remember that there is no physiological procedure in these sorts of studies. Behaviour geneticists don’t have the ability to assess the genetic heritability of personality using advanced biological measures or a complex scientific genetic analysis (well, not yet). Rather, researchers look for similarities and differences in personality (using personality measures) among individual people by using observation, interview or questionnaire measures. They look for similarities between parents’ and children’s personalities to determine the extent of genetic influence on personality. What is also important to remember is that, when we deal with heritability estimates, we don’t talk about heritability estimates in particular individuals. Rather, researchers estimate the average heritability estimates among certain populations of people; that is, monozygotic (MZ, identical) twins, dizygotic (DZ, fraternal) twins, family members, parents and children. Therefore, across a population there will be a range of scores of concordance between people (i.e. two twins), and heritability estimates represent the average score across the population. So, a heritability estimate of 50 per cent for a personality trait does not mean that we all inherit 50 per cent of our personality from our genes; it means that, across the population, the genetic heritability has been estimated at an average of 50 per cent.

Genetic heritability estimates and personality

There is a lot of evidence to suggest that there is a genetic influence on personality among human populations. To break down this evidence for you, we will look first at some specific studies and then some general findings and major studies that have examined genetic heritability based on the three-factor and five-factor theories of personality.
We covered both these personality theories in detail in the previous discussion (Chapter 7). However, for this section, all you need to know is that, within Eysenck’s theory, there are three personality dimensions:

- psychoticism (solitary, troublesome, cruel and inhuman traits);
- extraversion (sociable, sensation-seeking, carefree and optimistic traits);
- neuroticism (anxious, worrying and moody traits).

You also need to know that the five-factor model comprises five personality dimensions (Costa and McCrae, 1992):

- openness (perceptive, sophisticated, knowledgeable, cultured, artistic, curious, analytical, liberal traits);
- conscientiousness (practical, cautious, serious, reliable, organised, careful, dependable, hardworking, ambitious traits);
- extraversion (sociable, talkative, active, spontaneous, adventurous, enthusiastic, person-oriented, assertive traits);
- agreeableness (warm, trustful, courteous, agreeable, cooperative traits);
- neuroticism (emotional, anxiety, depressive, self-conscious worrying traits).

Genetic heritability estimates and personality: heritability estimates from twin studies

To illustrate the evidence on the genetic heritability of personality, we will first concentrate on the different ways in which twin studies can be used to show heritability. Researchers have compared two different types of twins to examine genetic influences on personality: monozygotic (MZ, identical) twins, who share 100 per cent of their genes, and dizygotic (DZ, fraternal) twins, who share 50 per cent of their genes.

The first common way in which this research has been done is to compare identical twins (MZ) who have been reared apart. For example, there have been a number of findings from the Minnesota Study of Twins Reared Apart, which involves the medical and psychological assessment of identical (MZ) and fraternal (DZ) twins separated early in life and reared apart. This study is overseen by the US behavioural geneticist Thomas Bouchard. In one study from this data, Thomas Bouchard and his colleague Matt McGue (Bouchard and McGue, 1981) found a large correlation ($r = 0.70$) for neuroticism between MZ twins who were reared apart.

Within this model, researchers tend to have to assume that twins reared together have generally similar environmental influences on their personality. Consequently, researchers suggest that any difference between the heritability is caused by the difference in the estimated percentage of genes shared by MZ (100 per cent) and DZ (50 per cent) twins. Therefore, if MZ twins are more similar than DZ twins are, this is considered as evidence of heritability. For example, let us use the findings of German behavioural geneticist Rainer Riemann and his colleagues (Riemann et al., 1997), who looked at over 1,000 pairs of German and Polish twins and compared MZ and DZ twins on the five-factor model of personality. These findings are summarised in Table 8.1. Within this table you will see that the correlations between MZ twins for the five factors of personality range from 0.42 to 0.56, and the correlations between DZ twins for the five factors of personality are smaller and range from 0.13 to 0.35. This type of finding is evidence for the genetic heritability of personality.

You will see that these types of results are replicated across samples and apply to different models of personality. Table 8.2 provides a summary of results presented by US behaviour geneticist John Loehlin (1989), regarding Eysenck’s measures of extraversion and neuroticism among

<table>
<thead>
<tr>
<th>Personality dimension</th>
<th>Monozygotic (MZ; identical) twins</th>
<th>Dizygotic (DZ; fraternal) twins</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extraversion</td>
<td>0.56</td>
<td>0.28</td>
</tr>
<tr>
<td>Neuroticism</td>
<td>0.53</td>
<td>0.13</td>
</tr>
<tr>
<td>Agreeableness</td>
<td>0.42</td>
<td>0.19</td>
</tr>
<tr>
<td>Conscientiousness</td>
<td>0.54</td>
<td>0.18</td>
</tr>
<tr>
<td>Openness</td>
<td>0.54</td>
<td>0.35</td>
</tr>
</tbody>
</table>

Source: Based on Riemann et al. (1997).

<table>
<thead>
<tr>
<th>Sample</th>
<th>Extraversion</th>
<th>Neuroticism</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Monozygotic</td>
<td>Dizygotic</td>
</tr>
<tr>
<td></td>
<td>males</td>
<td>males</td>
</tr>
<tr>
<td>Sweden</td>
<td>0.47</td>
<td>0.21</td>
</tr>
<tr>
<td>Finland</td>
<td>0.50</td>
<td>0.19</td>
</tr>
<tr>
<td>Australia</td>
<td>0.46</td>
<td>0.14</td>
</tr>
</tbody>
</table>

Source: Based on Loehlin (1989).
10,000 Swedish, 3,000 Australian and 7,000 Finnish adult twins for both males and females. Again, you will see that the correlations between MZ twins for the five factors of personality are much larger than the correlations for DZ twins. In fact, correlations between MZ twins on measures of personality are frequently twice the size of the correlations found between DZ twins. Heritability estimates are subsequently derived from this type of study by doubling the difference in correlations between MZ and DZ twins. A heritability estimate for a twin study that compares MZ and DZ twins will be the correlation statistic for MZ twins \((r_{\text{mz}})\), minus the correlation statistic for DZ twins \((r_{\text{dz}})\) and then doubled \([h^2 = 2 (r_{\text{mz}} - r_{\text{dz}})}\), and then expressed in percentage terms. To show how this works, let us return to Riemann’s findings among German and Polish twins (see Table 8.3). In this table, in addition to the correlation statistics, we have computed the heritability statistics. For example, for agreeableness, we have taken 0.19 (correlation for DZ twins) away from 0.42 (correlation for MZ twins), which is 0.23 and doubled it; which is 0.46. Expressed as a percentage, this is 46 per cent.

To help you in your study, we will summarise some more of the evidence regarding the genetic influence on personality from overviews and recent papers using twin studies (see Table 8.4).

Following numerous studies using measures of Eysenck’s personality dimensions, in which genetic effects were found for all three of Eysenck’s personality factors, Lindon J. Eaves, a US behavioural geneticist, Hans J. Eysenck and an Australian behavioural geneticist, Nick Martin, provided a meta-analysis of early twin studies (Eaves et al., 1989). They found that heritability estimates \((h^2)\) for extraversion were 0.58 (58%), for neuroticism 0.44 (44%) and for psychoticism 0.46 (46%). More recently, the US behavioural geneticists John C. Loehlin and Nick Martin (2001) compared Eysenck personality scales that had been given to 5,400 pairs of twins from the Australian Twin Registry. The heritability estimates for extraversion, neuroticism and psychoticism were 0.47, 0.40 and 0.28, respectively. Table 8.4 shows that similar sized heritability statistics have been computed from twin studies using the five-factor model of personality in the United States and Canada; results range from 0.33 to 0.58.

These types of findings suggest that personality is influenced by genetic factors. Towards the end of the last century, commentators on behavioural genetics, including the US academics Saudino and Plomin (1996) and the

---

**Table 8.3** Correlations on the five-factor model of personality between monozygotic and dizygotic twins reared together, with heritability statistics

<table>
<thead>
<tr>
<th>Personality dimension</th>
<th>Monozygotic (MZ; identical) twins</th>
<th>Dizygotic (DZ; fraternal) twins</th>
<th>Heritability estimate (h^2 = 2 (r_{\text{mz}} - r_{\text{dz}})})</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extraversion</td>
<td>0.56</td>
<td>0.28</td>
<td>56%</td>
</tr>
<tr>
<td>Neuroticism</td>
<td>0.53</td>
<td>0.13</td>
<td>80%</td>
</tr>
<tr>
<td>Agreeableness</td>
<td>0.42</td>
<td>0.19</td>
<td>46%</td>
</tr>
<tr>
<td>Conscientiousness</td>
<td>0.54</td>
<td>0.18</td>
<td>72%</td>
</tr>
<tr>
<td>Openness</td>
<td>0.54</td>
<td>0.35</td>
<td>38%</td>
</tr>
</tbody>
</table>

Source: Based on Riemann et al. (1997).

---

**Table 8.4** Examples from heritability estimates of the main personality factors from major twin studies

<table>
<thead>
<tr>
<th>Personality dimension</th>
<th>Three-factor model of personality</th>
<th>Five-factor model of personality</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Meta-analysis study (Eaves et al., 1989)</td>
<td>Australian twin study (Loehlin and Martin, 2001)</td>
</tr>
<tr>
<td>Extraversion</td>
<td>0.58</td>
<td>0.47</td>
</tr>
<tr>
<td>Neuroticism</td>
<td>0.44</td>
<td>0.40</td>
</tr>
<tr>
<td>Psychoticism</td>
<td>0.46</td>
<td>0.28</td>
</tr>
<tr>
<td>Agreeableness</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conscientiousness</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Openness</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
European academics Riemann and De Raad (1998), estimated, from studies looking at early infancy through to old age and across a number of American, Australian and European samples, that there is a moderate heritability of personality from genetic factors, accounting for between 20 and 50 per cent of phenotypic variance.

**Behaviour genetics and personality: heritability estimates from adoption studies**

Furthermore, when researchers have been able to obtain measures from both biological and adoptive parents, children have been found to be more similar to their biological parents than to their adoptive parents in personality. A frequently cited study of this was done on a Texas sample by US psychologists Loehlin, Willerman and Horn (1985). The authors didn’t use a direct measure of extraversion as measured with the three- and five-factor models of personality, but included measures such as sociability and activity from two personality measures called the California Psychological Inventory (Gough, 1987) and the Thurstone Temperament Schedule (Thurstone, 1953), which measure extraversion traits. Table 8.5 shows a summary of the strength of correlations between the adopted children and their adoptive and biological parents. As you can see, the correlations between biological parent and child are much larger than the correlations between adoptive parent and child. This finding suggests evidence of genetic influence between genetic parents and adopted children in their personality.

**Table 8.5 Correlations between adopted child and their biological and adoptive parent**

<table>
<thead>
<tr>
<th>Personality dimension: Indices of extraversion</th>
<th>Biological parent</th>
<th>Adoptive parent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social presence (California Psychological Index)</td>
<td>0.34</td>
<td>0.12</td>
</tr>
<tr>
<td>Vigorous (Thurstone Temperament Schedule)</td>
<td>0.33</td>
<td>0.06</td>
</tr>
<tr>
<td>Sociable (Thurstone Temperament Schedule)</td>
<td>0.18</td>
<td>0.02</td>
</tr>
<tr>
<td>Sociability (California Psychological Index)</td>
<td>0.17</td>
<td>0.04</td>
</tr>
<tr>
<td>Active (Thurstone Temperament Schedule)</td>
<td>0.16</td>
<td>0.02</td>
</tr>
</tbody>
</table>

Source: Based on Loehlin et al. (1985).

Other authors have looked at differences between identical (MZ) and fraternal (DZ) twins reared together and reared apart to look for genetic influence on personality. Some findings for the genetic influence on the major personality dimensions have been found from the Swedish Twin Registry by Swedish and US psychologists Nancy Pedersen, Robert Plomin, Gary McClearn and Lars Friberg (1988). In this study Pedersen and her colleagues looked at two dimensions from the three-factor model (and five-factor model) of personality – extraversion and neuroticism. This sample comprised 160 pairs of identical twins reared together, 99 pairs of identical twins reared apart, 212 pairs of fraternal twins reared together and 229 pairs of fraternal twins reared apart. As you can see from Table 8.6, the correlations for identical twins reared together and apart are larger than for fraternal twins reared together and apart. Most importantly, in terms of the evidence derived from adoption studies, the fact that the correlations for identical twins reared apart are greater than for fraternal twins reared together and apart suggests a genetic influence on personality for both extraversion and neuroticism.

US psychologists Scott L. Hershberger and Robert Plomin and Swedish psychologist Nancy Pedersen returned to the same sample and, in 1995, examined it for genetic influence on 24 personality traits from the same twin registry. Among this study, findings from using 58 pairs of identical twins reared together, 35 pairs of identical twins reared apart, 81 pairs of fraternal twins reared together and 68 pairs of fraternal twins reared apart were obtained from

**Table 8.6 Correlations in personality variables for identical twins reared together, identical twins reared apart, fraternal twins reared together and fraternal twins reared apart**

<table>
<thead>
<tr>
<th>Pedersen et al. (1988)</th>
<th>Identical twins (MZ) reared together</th>
<th>Identical twins (MZ) reared apart</th>
<th>Fraternal twins (DZ) reared together</th>
<th>Fraternal twins (DZ) reared apart</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extraversion</td>
<td>0.54</td>
<td>0.30</td>
<td>0.06</td>
<td>0.04</td>
</tr>
<tr>
<td>Neuroticism</td>
<td>0.41</td>
<td>0.25</td>
<td>0.28</td>
<td>0.24</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hershberger et al. (1995)</th>
<th>Identical twins (MZ) reared together</th>
<th>Identical twins (MZ) reared apart</th>
<th>Fraternal twins (DZ) reared together</th>
<th>Fraternal twins (DZ) reared apart</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extraversion</td>
<td>0.20</td>
<td>0.36</td>
<td>−0.04</td>
<td>0.09</td>
</tr>
<tr>
<td>Neuroticism</td>
<td>0.39</td>
<td>0.31</td>
<td>0.09</td>
<td>0.09</td>
</tr>
<tr>
<td>Openness</td>
<td>0.18</td>
<td>−0.08</td>
<td>0.15</td>
<td>0.05</td>
</tr>
</tbody>
</table>
the Swedish Adoption/Twin Study of Aging (Pedersen et al., 1991). This time the researchers looked at a number of personality traits, and Table 8.6 shows three personality traits we are familiar with from the three-factor and five-factor model: neuroticism, extraversion (Pedersen et al., 1988; Hershberger et al., 1995) and openness (Hershberger et al., 1995). Again, the correlations show evidence for the genetic influence on extraversion and neuroticism, but perhaps not for openness.

Finally, to complete the picture in terms of the five-factor model, US psychologist Cindy S. Bergeman, with a number of European and US psychologists – given the genetic influence on extraversion and neuroticism – assessed the genetic influence on the other three components of the five-factor model of personality: openness to experience, agreeableness and conscientiousness. In this study an abbreviated version of the NEO Personality Inventory (NEO-PI-R) was administered to 132 pairs of identical twins and 167 pairs of fraternal twins reared together and 82 pairs of identical twins and 171 pairs of fraternal twins reared apart. Estimates of genetic and environmental effects for openness and conscientiousness were similar to those found in other studies of personality for extraversion and neuroticism. However, these researchers found a much weaker relationship for agreeableness. None the less, these series of adoption studies suggest a genetic influence on personality for most aspects of personality.

In general, the studies summarised here suggest substantial heritability for genetic influence on personality. Genetic factors can sometimes explain as much as 40 to 50 per cent of the variance within the main personality dimensions.

Considerations within behavioural genetics and personality

However, it may not surprise you to learn that things are not quite as simple as they first seem in behavioural genetics. The idea of how genes and the environment are viewed and used to predict the heritability of personality (or any phenotype) has changed over recent years.

Authors such as US psychologists E. E. Maccoby (2000) and Plomin (2004) suggest that the additive principle of determining heritability of personality (or any phenotype) is not applicable any more. The validity of the additive assumption in computing the relative strength of genetics and environment in determining behaviour has been widely challenged. The first problem is that estimating the environment (E) is usually done without utilising any direct measures of environmental factors. For example, researchers often compute genetic heritability, and then subtract that from 100 per cent. Obviously, if the estimates of heritability are indeterminate or prone to error, so are the estimates of E derived by subtracting from 100 per cent. A further problem with the additive assumption of computing heritability is that, when genetic heritability is large, it assumes that all environmental factors associated with that behaviour must be small. It is better to see human personality as a joint result of an interaction between the individual’s genes and their environmental factors. Consequently, personality should not be seen as the result of ‘Genetics + Environment’ but rather ‘Genetics × Environment’. For example, it is better to view the relative influences of genes and environment on personality as the result of a long-term interaction, with environmental factors triggering certain genetic behaviours and the effects of the environment differing between individuals because of their genetic makeup.

What is important for you to note is that these changes and developments in research and thinking have been suggested, encouraged and developed by both theorists and researchers, many of whom we have already mentioned, who support and criticise the idea of genetic inheritability in personality. So what has brought about, and resulted from, such a general shift in thinking, from the additive principle of ‘Genetics + Environment’ to the later, more integrative, idea of ‘Genetics × Environment’? Well, there are six considerations surrounding modern-day thinking in behavioural genetics that are important when considering any phenotype, particularly personality:

- conceptions of heritability and the environment;
- different types of genetic variance;
- shared versus non-shared environmental influences;
- the representativeness of twin and adoption studies;
- assortative mating;
- the changing world of genetics.

Conceptions of genetic heritability and the environment

Gregory Carey (2002) suggests that there are two important contexts within which to consider heritability and environmental influence on personality. Carey notes that genetic heritability and the influence of the environment are largely:

- Abstract concepts – That is, they are generally theoretical (not applied or practical) concepts. As Carey explains, whatever the numerical estimates of either genetic or environmental influences, they provide us with little information about the specific genes or specific environmental variables that influence personality.
- Population concepts – We covered this topic earlier, but it is worth remembering that all these estimates refer to is any group of people that is considered a population; they tell us very little about any single individual. For example, just because personality may have a genetic heritability of around 40 per cent, it does not mean that
for any one individual 40 per cent of their personality is due to genes and 60 per cent of their personality is due to the environment. Rather, it is estimated across the population that genetic heritability of personality is an average of 40 per cent, and individuals will vary around that estimate.

Different types of genetic variance

So far in this discussion we've just treated genetic influence on personality as a single entity, namely the influence of your genes on your personality. However, behavioural genetics researchers such as Thomas Bouchard and M. McGue (1981) note that genetic influence does not simply comprise one aspect, but in fact three aspects:

- additive genetic variance;
- dominant genetic variance;
- epistatic genetic variance.

Additive genetic variance, which we have previously described in this discussion, is genetic variation in behaviour that is the total of the individual's genes inherited from their parents.

However, the two other types of genetic variation are known as non-additive genetic variance. Dominant genetic variance is part of a process by which certain genes are expressed (dominant genes) and other genes are not expressed (recessive genes). Every person has two copies of every gene, one inherited from their mother and one from their father. Sometimes the two genes, which determine a particular trait (for example, eye colour) will actually code for two types of characteristics (for example, blue eyes and brown eyes). If one of these genes is dominant, then only its character is expressed and not that of the other gene. For example, if blue eyes were a dominant gene, then if your mother had brown eyes and your father had blue eyes, you would be likely to inherit blue eyes.

The second non-additive type of genetic variation, epistatic genetic variance (also known as interactive genetic variance), refers to a process by which genes interact. It is now known that several different genes not only influence physical characteristics and behaviour on their own, but work and interact together. Unlike dominant genetic variance, which just applies to one gene replacing another, epistatic genetic variance is the result of the way certain genes that we inherit determine whether other genes we inherit will be expressed or suppressed (this process is epistasis).

It is difficult to measure dominant genetic variance and epistatic genetic variance when it comes to personality. However, it is now accepted that all three aspects – additive genetic variance, dominant genetic variance and epistatic genetic variance – are thought to make up total genetic variance of personality.

You can see that understanding the genetic side of things is a lot more complicated than viewing genes as a single entity; genes themselves interact and suppress other genes. You will see in the literature that behavioural geneticists refer to terms such as 'narrow heritability' and 'broad heritability'. Narrow heritability is just additive genetic variance. Broad genetic heritability is all three aspects of genetic heritability (additive genetic variance + dominant genetic variance + epistatic genetic variance).

Because of the complexity of genetics, authors such as Thomas Bouchard and M. McGue (1981) and US psychologists Heather Chipeur, Michael Rovine and Robert Plomin (1990) have suggested that original estimates of the percentage of parental genes that children inherit and siblings share may have been oversimplified. For example, these authors suggest that genetic variations in heritability of phenotypes should be made in the following terms:

- identical (MZ) twins = additive genetic variance + non-additive genetic variance (where previously it was presumed to be just additive genetic variance);
- fraternal (DZ) twins = 0.5 of additive genetic variance + 0.25 of non-additive genetic variance (rather than just 0.5 of additive genetic variance).

As you can see, computing levels of genetic variance may be more complicated than previously thought, and today behavioural geneticists take these factors into account when suggesting the strength of heritability estimates.

Shared and non-shared environments

We saw in the last section that the conception of genetics as simply a single dimension has changed. The same could be said of environmental factors. Within behavioural genetics, the conception of how the environment influences personality is based on two sets of experiences: shared and non-shared. When growing up, siblings (brothers and sisters) are thought to experience both shared and unique environments. Shared environments are environments that are shared between two individuals, while non-shared environments are environments that are not shared between two individuals. Siblings growing up within the same family will share many environments. These environments may range from very small experiences to larger ones. Two siblings having the same parents, living within the same house, going to the same school, experiencing particular times together (e.g. same family relatives, home environment, chaotic mornings before school, dad's awful jokes) are shared environments. A unique environment is an environment that has not been shared by siblings. Again, these environments may range from very small experiences to larger ones. Examples of unique environments might be when two siblings have been raised by different families. However, siblings raised in the same family might also...
have unique environments from each other. Siblings may have different sets of friends, go to different schools, have different types of relationships with their parents and have different interactions with teachers.

What is important in this area is that the theory and research around the differences between environmental influences on personality have grown in complexity. To begin with, researchers tend to concentrate on comparing how shared and non-shared environmental factors influence personality. Early consideration by reviewers such as Bouchard (1994) and Eysenck (1990a) suggested that environmental influences shared by siblings or twins contribute only marginally to personality differences. However, one interesting point to emerge from the literature, carried out by such researchers as US behavioural geneticists Braungart et al. (1992b), is that those environmental factors that are unique (non-shared) to family members are influential, over shared environmental factors. Consequently, non-shared environmental factors, such as different peer friendships, are important mechanisms that explain why members of the same family may differ in their personalities. This idea is supported by two pieces of research suggesting that the extent of differences in the experiences during childhood among siblings has been found to be related to personality differences in adulthood (Baker and Daniels, 1990; Plomin and Daniels, 1987). Such a finding has developed whole areas of research that have emphasised how important non-shared environmental factors are to personality. The majority of research in this area considers how non-shared environmental factors develop: (1) within the family; and (2) outside the family.

**Within-family factors**

US behavioural geneticist David Reiss (1997) identifies three ways in which inherited genes form phenotypes (behaviours) based on the family environment (see Figure 8.1). These are:

- the passive model;
- the child-effects model;
- the parent-effects model.

On the left of the figure is the **passive model**. This model suggests that personality is generally explained by the 50 per cent overlap between a child and their parent. Consequently, behaviour may occur in the child as the result of the child and parent sharing the same genes that influence a

![Figure 8.1 Reiss' three models of genetic transmission.](image-url)
particular type of behaviour. For example, if a child is aggressive because of genetic influences, they are so because one of their biological parents had the genes that cause aggressiveness. The model very much assumes just a general genetic overlap and inheritance of behaviour, without considering possible other factors and interactions within the family, and this is why it is called the passive model. The other two models very much emphasise other dynamics occurrences.

In the child-effects model, the genes cause a behaviour in the child, which in turn causes the same or similar behaviour in the parent. Within this model, the parent does not matter in the development of the behaviour, as the child’s development of the behaviour is the result of genes. An example of this is that the shared genes cause the child to be aggressive to the parent (because of their genetic makeup), which in turn causes the parent to be aggressive back to the child (because of their genetic makeup). The parent’s own aggressiveness does not matter in the development of the behaviour, as the child’s shouting is a consequence of the genetic makeup of the child rather than the parent.

US psychologist Judith Harris (1995) has expanded this viewpoint to child-driven effects that influence family circumstances that then influence the child’s personality. Harris documents studies showing that adults do not behave in the same way to a child who shows different tendencies. They will treat a very attractive child differently to one of their children who is less attractive; they react differently to the one child who shows bad behaviour than they do to the one who is well behaved. They treat children who are healthy and ill differently, and they treat children who are active and quiet differently. Imagine a family with two twin children, one who is active and one who is quiet. These differences in the children will cause different reactions in the parents. The parents will begin to treat their children differently. The active one may be encouraged to be more active and be allowed to go out and play, while the quiet one will be allowed to read their books. Harris suggests that these reactions by parents to their children’s natural personality tendencies can be viewed in two ways: as positive feedback loops and negative feedback loops. Positive feedback loops arise from parents reinforcing children’s natural tendencies, as in the example just described, so that children’s natural personalities are encouraged and these personalities will come out. Any differences between children in their personalities will also be developed – the active child is encouraged and allowed to be active, while the quiet child is encouraged and allowed to be quiet. Negative feedback loops occur when children are stopped from behaving in ways consistent with their natural tendencies. A quiet child might be encouraged to get out of the house more; an active child might be encouraged to spend less time outside playing but more time in their bedroom reading.

In the parent-effects model, the behaviour of the child is responded to by the parent, which in turn brings out the behaviour in the child. Within this model, how the parent responds does have an effect in the development of the behaviour. For example, the child may be being noisy; this then leads the parent to be aggressive (as it is part of their genetic makeup) with the child, which, in turn, causes the child to become aggressive also (as it is part of their genetic makeup). Within this model, how the parent acts leads to the development of aggression, which then leads to the development of shouting.

Again, Harris extends this idea to within-family situations. In these situations, children might be treated in a particular way by parents, not because of that child’s own characteristics, but because of the parents’ own beliefs or the characteristics of a child’s siblings (brothers or sisters). Let us first look at the example of how a parent’s own beliefs shape natural tendencies of children. Again, take our family with the one active twin and the one quiet twin. Our parents of the family may have certain beliefs about behaviour, such as ‘children should be seen and not heard; and consequently the children will be encouraged and directed to behave in such ways. In our case of the active and quiet twin, the active child who is noisy will be encouraged to be quieter, and the quiet child will be encouraged to be more visible by coming out of their bedroom; thus both children have had their new behaviour (being seen and not heard) driven by their parents’ behaviour. Secondly, let us look at how parents might influence children’s behaviours in terms of a child’s siblings. Harris notes research that suggests parents who consider their first child to be ‘difficult’ tend to label their second-born ‘easy’. We can also see how active children might be asked or encouraged to calm down and be more like their quieter sibling. Equally, the quiet sibling might be encouraged to go out and play more like their brothers and sisters.

What Reiss and Harris’ commentaries do is to suggest that within-family effects pose problems when considering genetic heritability. That is, child effects and parent effects can lead to overestimations and underestimations of heritability. Remember, behavioural geneticists looking at personality are only looking at the concordance between sets of children based on their scores on a personality test at some point. However, let us return to the family mentioned earlier, the one with one active twin and one quiet twin. Let us imagine that the parents of these twin children have been engaged in a negative feedback loop and have been trying to encourage both children to be similar; that is, somewhat active and somewhat quiet. The active child has been discouraged from being active all the time, and the quiet child has been discouraged from being too quiet. If we then compared these two children, we would find that these twin children have similar personalities; but this is, in fact, not because of genetic tendencies at all, but simply because of the parents trying to encourage similar behaviour in both children (i.e. not too active or not too quiet).
Therefore, any estimation of similarities in personality being caused by genetic heritability of the twins would be an overestimation.

However, if the same pair of twins had been reared differently and both been in a positive feedback loop (that is, the active child had been encouraged to be more and more active, and the quiet child had been encouraged to be more and more quiet), then any estimation of the similarities in personality being caused by genetic heritability would be an underestimation. As Harris concludes, children's within-family situations not only play an important role in shaping of personality but are also an important consideration in estimating the genetic heritability of personality.

**Outside-family factors**

Harris has suggested that non-shared factors outside the family may in fact be more important in developing people's personalities. Harris presents the group socialisation theory to explain the importance of non-shared environmental factors in determining personality.

Group socialisation theory is based largely on the ideas surrounding social identity theory and social categorisation (Tajfel and Turner, 1986). Social psychologists have provided a lot of theoretical and empirical research work looking at how individuals perceive their social world as comprising in-groups and out-groups and suggesting that these categories help us form our social identity. Social psychologists argue that one mechanism humans use for understanding the complex social world is social categorisation. In social categorisation, individuals are thought to place other individuals into social groups on the basis of their similarities and differences to the individual. Put simply, individuals who are viewed as similar to the person tend to be placed within their in-group. Individuals who are viewed as different to the person tend to be placed within an out-group. As a consequence, the individual's identity (social identity) is based on and derived from the groups we feel we belong to and our understanding of our similarities and differences in relation to different social groups. Social groups can be based on anything; however, common groups could be sex group, ethnic group, your religion, your peers, your interests, your educational status and so on. As such, your identity is based to a greater or lesser extent on how much you identify with different social groups. What is also important to our identity is that, when we attach ourselves to certain groups, we also try to fit in with those groups, and our personality might begin to reflect the characteristics of the group (i.e. you might make friends with people who are outgoing, and you may do more outgoing activities than you used to, and consequently you become more active in your life).

Harris uses this theoretical basis to show how social groups can influence people's personalities and how these non-shared environments that occur in children of the same family can have a huge effect on personality. As part of this theory, Harris lists five aspects that are important to consider in how non-shared characteristics might influence our personality (see Figure 8.2).

1. **Context-specific socialisation.** This aspect refers to the fact that children learn behaviours not only at home but also outside the home, and that, as children get older, they become less influenced by their family life and more influenced by their life outside the family
home. Possible influences include friends, your friends’ parents, your extended family, teachers and even celebrities. What is also important is that contexts for behaviour of a child shift between environments. For example, one child might be very quiet. Let us consider the possible different contexts in which the child’s quietness is considered, and responded to, by other people.

- Parents might not say anything to the child about being quiet because they believe in not criticising or praising their child over their personality.
- The child’s friends might encourage this behaviour because they are also quiet and enjoy doing the same quiet activities.
- At school the child’s teachers might try to encourage them to be less quiet by getting them to speak up more and get involved in class more.
- Other children at school might tease the child for being quiet.

Thus, we can see that there are many influences, both from inside the home and outside the home, that affect how a child learns behaviour.

2 **Outside the home socialisation.** In this aspect, Harris makes the point that children may identify with a number of social groups, based on people’s age, gender, ethnicity, abilities, interests and personality. In other words, we have a range of groups that we identify with and share norms with (attitudes, interests, personality), and these groups have different influences on our personality. For example, compare the sort of person you are with the friends you made at school and with the friends you made at university. Are there differences in the sort of personality you have in these two groups?

3 **Transmission of culture via group processes.** In this aspect, Harris makes two points about the transmission of culture via group processes that establish norms in our social world and in turn influence our personality.

The first point is that the shared norms that might influence a child’s personality aren’t necessarily the result of parents sharing them with their children. They are really the result of shared norms among the parents’ peers and social groups being passed on to the children. That is, your parents’ values, abilities and personality are not the result of their parents’ norms, but rather of their social identity, their identification with their own social groups. Your parents’ identity isn’t isolated to them on their own; it is a result of their interactions with their friends and others. For example, we’re sure your parents don’t agree on everything; in many cases, your father’s personality might be closer to those of some of his friends, while your mother’s personality might be closer to those of some of her friends. Therefore, influences on our personalities are not the result of interactions with our parents’ personalities, but actually an interaction with our parents’ social identities.

The second point considers that our individual norms, which we have developed from our family, are shared with other people only if they are accepted. For example, an individual might be quiet and enjoy listening to classical music and going to classical concerts. However, when they mention it to their friends, they are laughed at because the others are all into dance music and like clubbing. You can imagine how the individual will cover up this norm and may actually make an extra effort to like dance music and go clubbing; at home, they may stop listening to classical music and going to classical music concerts.
your identification with people of your own sex, but on your rejection of characteristics of the opposite sex. For example, some young men develop their identity not just based on what it means to be a young man but also in terms of trying not to adopt behaviours associated with being a young woman (and vice versa for women). Your personality is influenced by what you identify with as well as by what you don’t wish to identify with. This principle applies across the whole range of social groups; young women rarely want to adopt characteristics and personality traits associated with old women, men from ethnic minorities sometimes don’t want to adopt behaviours or personality traits that are associated with men from ethnic majorities and so on.

5 Group processes that widen differences among individuals within the group. So far we have assumed that all the groups we are involved in basically share the same structure. However, we know that within all our social circles we play different roles that might influence, or bring out, different aspects of our personality. In our family, as a child, we take a less senior role; however, with our friends we might be more of a leader and allowed to be more like ourselves. On the other hand, the opposite may be true; we might not feel that we lead a group of friends, but tend to do what others say. It may even be possible that, among one group of friends, you feel more comfortable than you do among others. Harris’ point is that our position in groups changes, and that our personality – and influences on our personality – change as a result of the hierarchies within a group. For example, if you are in a group of friends and they all look up to you, your personality will be influenced because you might think there is an expectation to come up with ideas for things to do, to become more dominant; also, you might become more and more active in the group because you are the one who holds the group together and organises things and so on.

What is important to consider in both within-family and outside-family factors is that these aspects can influence personality of children to a much wider extent than previously thought. It is not Harris’ point that behavioural genetics is wrong and that environmental factors are more important, but rather that behavioural geneticists may have previously oversimplified family influences. By ignoring these variables, behavioural geneticists might be underestimating or overestimating the heritability effects of either genetics or the environment.

Problems with the representativeness of twin and adoption studies

One of the considerations put forward by psychologists such as Eleanor Maccoby and Leon Kamin and Arthur Goldberger (Kamin and Goldberger, 2002) concerns adoption and twin studies. A significant portion of studies examining heritability effects is devoted to twin and adoption studies. Twin studies are important because they allow the comparison of different types of twins to study genetic influences: monozygotic (MZ, identical) twins, who share 100 per cent of their genes, and dizygotic (DZ, fraternal) twins, who share 50 per cent of their genes. Adoption studies are important because they include two sets of factors that may account for differences in behaviour: biological parents and environmental parents. It is argued that, because these families are not necessarily representative of the general population, this natural bias in sampling may lead researchers to underestimate or overestimate the genetic heritability across the whole population.

This issue is particularly important when considering research that assesses heritability of personality using twin and adoption studies. Kamin and Goldberger (2002) suggest that twin studies might overestimate the role of genetics, particularly because identical twins have more similar environments than do same-sex fraternal twins. Also, research shows that identical twins are treated more similarly by their parents, spend more time together and have the same friends more often. Therefore, their environmental experience comprises a greater proportion of each other’s social environment than does that of fraternal siblings. Consequently, if genetic heritability estimates are usually larger in twin studies than in adoption studies, then some of the estimated similarity that is attributed to genetic influence might not be correct. Stoolmiller (1998) has suggested that adoption studies also lead to a similar restriction in the measurement of environmental factors. Stoolmiller argues that the placement strategies of adoption agencies might influence heritability estimates. For example, adoption agencies might always place children in affluent or middle- to high-income families; thus the effects of economic status are never fully explored in these studies, because an adopted child would very rarely be placed into a household suffering from poverty.

Assortative mating

Nicholas Mackintosh (Mackintosh, 1998), animal-learning theorist at the University of Cambridge, raises the issue that assortative mating can have an effect on genetic variance and, consequently, on estimates of heritability. Assortative mating is a complicated name for the simple concept that, when couples mate, they either have traits in common or contrast widely in their traits. A lot of the understanding of human genetic variation is based on the assumption that two individuals mate quite randomly with random people, and therefore any genetic similarity between them occurs by chance. But we know that this is not true. We know that
people mate with people who they perceive are similar to them. For example, we tend to see people mating with people who are of a similar size or similar in their ‘good-lookingness’ (you rarely see one partner who is very tall and one who is very short, or one who is very beautiful and one who is ugly). This is called positive assortative mating. Though, equally, we find people mating who are completely the opposite; that is, ‘opposites attract’. This is called negative assortative mating.

There is evidence that people do engage in assortative mating, though usually it is positive assortative mating. Israeli human geneticists at Tel Aviv University (Ginsburg et al., 1998) found that body height was positively correlated between spouses in four ethnically and geographically different populations: Kirghizians, Turkmenians, Chuvashians and Israelis. German psychologists Wirth and Luttinger (1998) found, by examining German national data from the German census between 1970 and 1993, that men and women were very similar in their social class. Whitbeck and Hoyt (1994) found that students’ assortative mating was related to prestige. In much the same way, the assortative mating principle can be applied to personality. That is, individuals may seek to mate with people who are of similar personality, or of a particularly different personality. Think about your boyfriend or girlfriend, or an ideal mate. Do you think they are of a similar personality level to you?

What the theory of assortative mating suggests is that people don’t tend to mate with people randomly. People make choices about their potential mate based on physical and behavioural characteristics that are influenced by genes. This genetic similarity (or dissimilarity) has an effect of reducing and expanding the range of genetic variation found between two mates. Consequently, assortative mating is a factor that may have influence on genetic heritability estimates in populations.

**Changing world of genetics**

You are reading this at an exciting time in biology. The Human Genome Project, a 13-year effort, was completed in 2003. The project has involved thousands of scientists. It was coordinated by the US Department of Energy and the National Institutes of Health, with the United Kingdom, Japan, France, Germany and China all making major contributions. The largest international collaboration ever undertaken in biology, it had the immense task of determining the three billion bases of genetic information residing in every human cell to identify all the approximately 20,000–25,000 genes in human DNA. Since then, researchers have been investigating each gene. Even though the functions are unknown for over 50 per cent of discovered genes, over 30 genes have been associated with breast cancer, muscle disease, blindness and deafness. However, what is an exciting time is also a revealing time for scientists. A number of projects stemming from the Human Genome Project, such as the Encyclopedia of DNA Elements (ENCODE), have suggested that the innermost workings of genes are more complex than was previously thought, with what was thought to be redundant DNA actually being active and important to our functioning. Ewan Birney and his colleagues (Birney et al., 2007 (The ENCODE Project Consortium)) carried out an analysis on just 1 per cent of our DNA code and found that DNA, which had previously been described as ‘junk DNA’ as it was thought to have no biological function, but makes up 97 per cent of the genome, was indeed active in an intricate control network of our physiological and biological functioning. Therefore, for researchers such as Birney, the future research is much more complex than previously imagined, but also potentially much more insightful.

What you should first remember about this area is that, as scientific advancements are made in what is known about the genes of humans, so will theoretical perspectives and research evidence regarding behavioural genetics and personality. For example, the mapping of the human genome (i.e. the complete set of genes found in mankind’s 23 pairs of chromosomes) is an exciting and important development, which is still in its earliest stages and may uncover more about human potentials. Because this is a theoretical and research area in which knowledge is growing and changing all the time, critical assessment should be placed within the context of an ever-changing knowledge base.

One such advance in behavioural genetic research is in molecular genetics. So far we have talked about genes as single entities, but molecular genetics are concerned with the structure, makeup and activity of genes. Consequently, where there was a reliance on using twin and adoption studies to guess the strength of genetic influence on the genetic resemblance between individuals (e.g. identical and fraternal twins, biological parents and adoptive parents), US psychologists Saudino and Plomin (1996) explain that molecular genetics techniques can now identify thousands of DNA markers of genetic differences among individuals. This process will allow researchers to examine differences between individuals in their DNA related directly to behavioural variation, rather than assessing it simply through the genetic resemblance of relatives. Although it is accepted that there is no major gene for personality, research has suggested that multiple genes (rather than a single one) are related to traits. These multiple genes are referred to as quantitative trait loci (QTL). Within molecular genetics, a QTL (multiple genes) might be considered to be associated with personality if there is a higher frequency among affected versus unaffected individuals. Dina et al. (2004) found that a chromosome (this structure contains the heritability information necessary for building the human body and behaviour) called 8P gives evidence for a QTL (multiple
genes) contributing to individual differences in an anxiety-related personality trait. Fullerton et al. (2003) found a QTL that influences neuroticism. As Saudino and Plomin (1996) emphasise, researchers are entering a new era in which molecular genetics techniques will revolutionise genetics research on personality by identifying specific genes that contribute to genetic variation in behavioural dimensions.

A framework for considering heritability in personality

As you can see, the area of behavioural genetics presents substantial findings and considerations and certainly would seriously challenge any academic who felt that all human behaviour and personality was solely down to just genes or the environment. Instead we have gained, through family, twin and adoption studies that have compared genetic heritability estimates, an interesting insight into how genetic factors influence personality. However, we have also seen how consideration of different influences on personality is important (e.g. dominance and interactive genetic variance, shared and non-shared environmental influences, assortative mating).

Bouchard and Loehlin (2001) suggest a framework regarding sources of population variance in personality (see Figure 8.3).

Bouchard and Loehlin not only provide a good overview of the debate but also set some prudent criteria in terms of assessing factors such as genetic effects (such as heritability) and environmental effects. So, in all, Bouchard and Loehlin (2001) suggest that we must consider these factors:

- **Genetic influences** – what gene is involved; which aspects of molecular genetics; what type of genetic variation (for example, additive or non-additive); is there a sex limitation on personality?
- **Environmental influences** – to what extent does environment influence the personality; why are types of environments involved; are there gender effects?
- **Interaction between genetic and environmental influences** – what type are the interactions between genes and the environment that influence the personality?
- **Developmental influences** – do different genes influence the personality during development, and do different environmental factors influence the personality during development?
- **Assortative mating** – is assortative mating present in personality, and are there sex differences in mate preference for personality?
- **Evolution** – what sort of selective factors were at work during the original evolution of the personality behaviour? Are there current selective factors at work? (You may need to also refer to later discussion (Chapter 9) on evolutionary psychology to grasp some of these ideas fully.)

Clearly some of these areas are easier to identify than others when it comes to personality. However, many of the areas – assessing the level of genetic influence, the types of environmental influence and the possible interactions between genes and the environment – are known, or at least are sources of debate (see Stop and think: Crime and
Genetic
1. To what extent is the trait influenced by genes?
2. What type of genes are involved?
3. How many loci are involved?
4. Is there a sex limitation or sex linkage?
5. Are chromosomal effects involved?

Environmental
1. To what extent is the trait influenced by the environment?
2. What type of environment is involved?
3. Are there gender effects?
4. Is transmission horizontal, or is it vertical?

Genetic and environmental influence
1. Are there any genetic x environmental interactions?
2. What type are the interactions between genes and the environment?

Developmental
1. Do different genes influence during development?
2. Do different environmental factors influence during development?

Assortative mating
1. Is assortative mating present?
2. Are there sex differences in mate preference for the trait?

Evolution
1. What sort of selective factors were at work during the original evolution of the trait?
2. Are there current selective factors at work?
3. Is the trait an adaptation?

Figure 8.3 Framework and questions regarding sources of population variance in behaviour.

By applying Bouchard and Loehlin’s model, we can provide a focus to an area that comprises speculation and debates over the influences on the personality of: (1) genes; (2) the environment; and (3) the interactions between genes and the environment. But, as Thomas Bouchard and John Loehlin summarised in 2001, ‘The behavior genetics of personality is alive and flourishing but [that] there remains ample scope for new growth and [that] much social science research is seriously compromised if it does not incorporate genetic variation in its explanatory models.’

Career focus: Working in neuropsychology

According to the British Psychological Society website, neuropsychologists work with people with brain injury or other neurological diseases. This would include people with neurological problems, which include brain injury, stroke, tumours and neurodegenerative diseases. Largely, a neuropsychologist will combine clinical and neurological relevant skills to work in the assessment and rehabilitation of people. A neuropsychologist will work in a variety of settings including rehabilitation centres and with community services.

Dr Camilla Herbert, Consultant in Neuropsychology and Rehabilitation at the Brain Injury Rehabilitation Trust

1. How/why did you choose to pursue the area of psychology that you did?

As an undergraduate I studied behavioural disorders on a course taught by a clinical psychologist. I was interested in what caused the various conditions and in the scientific approach to treatment. I came from a biological sciences background but was also interested in the philosophy of mind. Individual differences in personality, the interactions between nature and nurture, and between genetic predispositions and life experiences, have always interested me. I trained as a clinical psychologist, and went on to specialise in neuropsychology.
Psychophysiology, neuropsychology and personality

Your brain and your body are complicated and wonderful things. There are 10 billion nerve cells in your brain. Your brain is thought to send information messages at the rate of 240 miles a second. Your heart beats about 100,000 times a day. Placed end to end, all your body’s blood vessels would measure about 62,000 miles. Neurons transmit messages from one part of your body to another. Your brain monitors and regulates unconscious body processes such as your digestion and your breathing to coordinate most movements of your body. It controls your consciousness, allowing you to think, evaluate situations and react appropriately. It is not surprising then to find that your body can influence your behaviour. When your body is tired or hungry, it is likely to put you in a bad mood. The colder the room you sleep in, the better the chances are that you’ll have a bad dream.

Psychophysiology and neuropsychology are both branches of psychology that are concerned with the physiological bases of psychological processes. Neuropsychology is predominantly concerned with how the brain influences psychological processes, while psychophysiology deals with all aspects of biological functioning and how it influences psychological processes. A common aim of both these areas of psychology

Crime and genes

1. Since the development of criminology in the 1700s, academics have speculated on the genetic explanation of criminal behaviour. The Human Genome Project and the mapping of human DNA research have again turned attention to whether criminality has a genetic influence. Indeed, there are some who support the notion of a genetic basis to criminal behaviour (Tehrani and Mednick, 2000). If there proves to be evidence suggesting that criminality is influenced by genes, consider:
   a. What consequences does this have for understanding and treating criminals?
   b. What role can psychology then play in the treatment and rehabilitation of criminals?
   c. What consequences does this have for government policies towards criminal behaviour?

2. There is also evidence to suggest that addiction has a genetic basis (Crabbe, 2002). For example, four out of five twin studies report greater concordance for alcoholism in identical (MZ) than in fraternal (DZ) twins. If there is evidence that addiction has a genetic basis:
   a. What are the consequences of this for understanding and treating criminals?
   b. What consequence does this have for government policies towards addiction?

3. Drug use often begins in early teen years, is most prevalent in the late teens and early twenties and then generally declines substantially thereafter. In the United States, it is estimated that between 60 million and 70 million Americans have tried an illegal drug at some time in their lives. Does this mean nearly everyone inherits vulnerability for addiction?
is to use objective and scientific techniques to link behaviours to the biological functioning of the body: for example, activity levels of neural cells in the brain or heart rate. One of the assumptions underlying these research areas is that all behaviour, including personality and individual differences, can be influenced by physiological and neurological factors. Both psychophysiological and neuropsychological approaches suggest that human behaviour can be understood through exploring physiological factors.

**Eysenck’s biological model of personality and arousal**

The German psychologist Hans Eysenck (1967; 1990a), though he lived all of his working life in London, was one of the first theorists to attempt to relate biology to personality. Eysenck suggested that the human brain has two sets of neural mechanisms, excitatory and inhibitory. The **excitatory mechanism** relates to keeping the individual alert, active and aroused, while the **inhibitory mechanism** relates to inactivity and lethargy.

Eysenck said that the individual seeks to maintain a balance between the excitatory and inhibitory mechanisms, and that this balance is regulated by something identified as the ascending reticular activating system (ARAS). The ARAS, which is located in the brain stem, connects to the areas of the brain such as the:

- **Thalamus** – manages and relays nerve impulses in the brain.
- **Hypothalamus** – regulates the body’s metabolic processes, by which substances (i.e. food) are broken down to provide the energy necessary for life, and the autonomic process (heart rate, digestion, respiration and perspiration).
- **Cortex** – is responsible for sophisticated neural processing.

The ARAS manages the amount of information or stimulation that the brain receives and maintains individuals’ waking and their sleep, and keeps individuals alert and active (Figure 8.4). Within Eysenck’s theory, this information and stimulation process is known as arousal. Two circuits are thought to manage arousal within the individual: the reticulo-cortical and reticulo-limbic. The reticulo-cortical circuit controls the cortical arousal generated by incoming stimuli, whereas the reticulo-limbic circuit controls arousal to emotional stimuli. Eysenck suggests that arousal is a central variable allowing personality to be linked to a number of responses.

Eysenck linked arousal to two of his personality dimensions: extraversion and neuroticism. Neuroticism comprises personality traits such as anxiety, worry and moody traits. Extraversion comprises personality traits such as sociability, sensation-seeking and being carefree and optimistic.

![Figure 8.4 Eysenck’s biological model of personality.](image-url)
Extraversion and arousal

Eysenck proposes that extraversion–introversion personality traits are related with the arousal of the reticulo-cortical circuit (incoming stimuli), and that extraverts’ and introverts’ ARASs operate in different ways, particularly when aroused. Eysenck explained that an introvert would have an ARAS that provides a lot of arousal, while an extravert would have an ARAS that does not provide a lot of arousal. Although this seems the opposite way to what one might expect, Eysenck explains that, when an individual’s ARAS continually makes them overly aroused, they will then attempt to avoid stimulation because they already have a lot of it. Consequently, this person will be introverted because they will avoid stimulation and exciting situations. On the other hand, when an individual’s ARAS continually makes them under-aroused, they will seek stimulation. This person will be extraverted because they will always be seeking stimulation and exciting situations.

Let us work through an example of this theory to see how extraverts and introverts might differ in work situations. Suppose that our extravert and introvert both work as personal assistants in a company. They both have similar job descriptions; but for our extraverted personal assistant, their working life has to be full of excitement, chatting with co-workers, spending their time in meetings, contributing all the time in meetings, talking to people, enjoying the social aspects of work, and looking to be included in initiatives because they feel the need to be aroused all the time. However, for our introverted personal assistant, their working life is not full of these sorts of activities. Rather, we would find our introverted personal assistant preferring to get on with their own work rather than chatting to co-workers, attending meetings but rarely saying something, rarely engaging in office chat and tending to avoid social occasions, because they feel sufficiently aroused already by the job. What is crucial is that, although the two effectively do the same job, if the extravert and introvert are put into each other’s situations, then they will find it difficult to manage. The extravert placed in a personal assistant’s job where they simply have to get on with the work and not interact with people will become under-aroused and soon find the job boring; the introvert, when encouraged to interact more, contribute to meetings and organise social events, as they are already sufficiently aroused, will become over-aroused, find these aspects of the work unsatisfying and get upset by the demands of the job role.

A good research example is a well-cited experiment by US psychologist Geen (1984). Geen had two experimental groups: introverts and extraverts. He asked each group to choose the appropriate noise levels of some music to listen to while they were asked to do a difficult and boring task. As predicted, extraverts chose higher levels of music to listen to when working than introverts did. Geen found that both groups completed the task well under these chosen conditions. However, he then switched around the music level for the groups, so that introverts listened to the higher music level while working and extraverts listened to the lower levels of music while working. Under these conditions, extraverts very quickly got bored with the task while the introverts got upset, and both groups’ performance at the task worsened.

Neuroticism and arousal

Neuroticism is related with the arousal of the reticulo-limbic circuit. Eysenck explains that neurotics become more aroused owing to emotional stimulation via the reticulo-limbic circuit, whereas people who are not neurotic (emotionally stable) will be less aroused. Eysenck suggested that this difference would be most obvious in stressful situations.

Let us take an example of two students; a neurotic university student and a non-neurotic university student who are about to take an exam. Clearly, taking an exam is a stressful situation – the build-up, the revising, the unseen questions, the actual day of the exam and the post-mortem of the event with one’s friends on the course. Our neurotic student would be more aroused by the stress (emotional stimulation) surrounding the exam, and we would find this student worrying about the exam, fretting that they had not done enough revision, frantically searching for extra reading, having sleepless nights before the exam, feeling sick on the day; when the exam was finished, they would worry that they had done really badly and talk about it with their friends. However, in the case of our non-neurotic student, they are not aroused by the stress surrounding the exam. They would tend to worry less when doing their revision, not have sleepless nights before the exam and may prefer not to talk about the exam with their friends after it was over. What is important here is that there is no research to suggest that either personality type leads to better exam performance (we all know students who constantly worry and fret that they have done badly in an exam and end up not done enough revision, frantically searching for extra reading, having sleepless nights before the exam and may prefer not to talk about the exam with their friends after it was over) but rather that the personality types and level of arousal lead to different reactions (individual differences) in their behaviour around the same stressful event.

Gray’s BAS/BIS theory

UK psychologist Jeffrey A. Gray introduced reinforcement sensitivity theory (Gray, 1970; 1981; 1987). This theory began as a modification to Eysenck’s theory but is now usually considered as an alternative theory. At the heart of this theory is the view that biological mechanisms move towards things they desire. Gray used the findings of research on animals to study human personality. Gray proposes that personality is based on the interaction between two basic
systems in the brain: the behavioural approach system (BAS) and the behavioural inhibition system (BIS).

The first system, the **behavioural approach system** (BAS), comprises motivations to approach (Figure 8.5). This system causes the individual to be sensitive to potential rewards and to seek those rewards. Therefore, motivations arise from reward-seeking and are used to explain attractions to other people, certain objects and events, as they are seen by the individual as comprising rewards.

The second system, the **behavioural inhibition system** (BIS), comprises motivations to avoid. Within this system are those motivations that make the individual sensitive to punishment or potential danger and inclined to avoid those consequences. Fear of certain things, such as animals or persons, are a result of this system.

**Figure 8.5** Gray’s reinforcement sensitivity theory.

**Profile**

**Jeffrey A. Gray**

Jeffrey A. Gray was born in London and studied at Magdalen College, Oxford, for two degrees, the first in Modern Languages, the second in Psychology and Philosophy. In 1959–1960 he studied clinical psychology at the Institute of Psychiatry in London, after which he studied for a PhD which comprised experimental studies of environmental, genetic and hormonal influences on emotional behaviour in animals.

In 1964 Professor Gray was appointed to a university lectureship in experimental psychology at Oxford. He remained there until he retired from the chair of psychology in 1999, but continued his work as an emeritus professor. Professor Gray’s work encompassed a wide area of topics, including neuroanatomical, neurochemical and molecular bases of behaviour in animals and the clinical investigation of abnormal human behaviour in a variety of psychiatric and neurological disorders. He published over 400 papers, comprising journal articles and book chapters as well as writing seven books, including *Consciousness: Creeping Up on the Hard Problem* (Oxford University Press, 2004). His honours included Presidents’ Award, British Psychological Society (1983); President, Experimental Psychology Society (1996); and Honorary Member, Experimental Psychology Society (2000).

We did say that originally Gray’s model was seen as an alternative model to Eysenck’s theory of arousal of personality. Whether Gray’s model is a modification or an alternative to Eysenck’s theory, it is worth noting how the two models go together. Figure 8.6 shows how Gray’s model maps onto Eysenck’s model of arousal and personality.
Gray linked this theory to two personality variables: impulsivity and anxiety. Those individuals with high levels of behavioural approach are described as impulsive, as they will be highly motivated to seek many rewards, and see the potential for rewards in many aspects of their lives. Individuals with low levels of behavioural approach are described as not impulsive. Individuals who have high levels of behavioural inhibition are described as anxious, as they are particularly responsive to potential punishment or danger. That is, they will tend to see many aspects of their lives as having the potential for possible punishment. Individuals with low levels of behavioural inhibition are described as not anxious.

Examples of how these systems can be measured were produced by US psychologists Charles Carver and Teri White (1994). Carver and White produced a 24-item questionnaire measure (BIS/BAS scales) of the behavioural approach system and the behavioural inhibition system. Questions that measure an individual's BAS include ‘I go out of my way to get things I want [item 3]; ‘I'm always willing to try something new if I think it will be fun [item 5]’ and ‘When good things happen to me, it affects me strongly [item 18]; Questions that measure an individual's BIS include ‘I feel pretty worried or upset when I think or know somebody is angry at me [item 13]; ‘If I think something unpleasant is going to happen I usually get pretty “worked up” [item 16]’ and ‘I worry about making mistakes [item 24].

Again, let us consider our example of two personal assistants at work to illustrate these two systems. A worker who has high levels of behavioural approach will be impulsive in their work. They tend to seek rewards in their work, looking for opportunities for promotion, looking to contribute all the time, or looking for congratulations or appreciation from work colleagues. We might find our worker who has high levels of behavioural approach immediately volunteering for things and speaking out suddenly in work meetings. Meanwhile, our worker who has high levels of behavioural inhibition, who is particularly responsive to potential punishment or danger, will tend not to want to draw attention to themselves at work for fear of disapproval by managers and co-workers. They might worry and be anxious about talking at meetings, making mistakes at work and giving presentations in case they say the wrong thing or show themselves up.

The final point to highlight from Gray’s theory is how the notions of reward and punishment relate to impulsive and anxious individuals. Impulsive people respond well to rewards, and not well to punishment. Anxious individuals respond well to punishment and not to rewards. If you are a manager in the workplace and you want to motivate impulsive people, you would do better to offer promotions and wage rises rather than suggest possible punishments, such as redundancies. Conversely, if you want to motivate anxious people, you would do better to indicate the possibilities of punishment rather than offer promotions and wage rises. For example, we can imagine how an impulsive person would spend their workdays doing things looking for promotion, never concerning themselves with the possibility of losing their job. We can also imagine how an anxious person in work worries about the possibility of the sack, rather than potential promotion, thinking they would never be able to reach such heights.

A research example of how the BAS and the BIS work was carried out by Finnish psychologists Tarja Heponiemi, Liisa Keltikangas-Järvinen, Sampa Puttonen and Niklas Ravaja (2003). This research concentrates on looking at the effects of reward and punishment on positive and negative feelings alongside measures of the BAS and the BIS. In this experiment, the researchers measured the BAS and the BIS using Carver and White's BIS/BAS scales. The researchers also asked participants in the experiment to complete a number of tasks, during which they were asked to indicate each time their own levels of positive and negative emotion. The tasks that participants were asked to complete included tasks designed to induce a negative experience (punishment tasks, such as being startled by a loud noise, and a reaction-time task where completion is done within a set time while loud noises are being played) and a task designed to induce a positive experience (reward) – a mental arithmetic task with a monetary prize ($40) for the best performance. Heponiemi and colleagues found that a greater degree of behavioural approach was related to more positive feelings during the appetitive task. Additionally, they found that a greater degree of behaviour inhibition was related to more negative feelings during aversive tasks and especially during the startle task (Figure 8.6).

Cloninger’s biological model of personality

C. Robert Cloninger, a US biological psychiatrist, proposed a psychobiological personality theory, including seven personality dimensions. His theory of personality is based on combining findings from a series of family, psychometric, neuropharmacologic (a branch of medical science dealing with the action of drugs on and in the nervous system) and neuroanatomical (a branch of anatomy that deals with the nervous system) studies of behavioural conditioning and learning in man (Cloninger et al., 1993).

To begin with, Cloninger's model included only three dimensions, but it has since been expanded to include seven domains of personality. The theory of personality is broken down into four temperament domains:

- novelty-seeking;
- harm avoidance;
- reward dependence;
- persistence,
and three character domains:

- self-directedness;
- cooperativeness;
- self-transcendence.

The temperament domains are the areas we are most interested in from a personality perspective. Like the theories of Eysenck and Gray, they are linked to biological systems and are thought to be inherited. The four temperaments are thought to be organised as independent brain systems aligned to specific nerve cells or fibres that transmit nerve impulses by neurotransmitters. Neurotransmitters are chemicals that are used to relay, amplify and modulate electrical signals in the brain. Cloninger links our personality to those neurotransmitters that are responsible for the activation and inhibition of our behaviour and the learning and responses to both real and perceived rewards and punishments. Cloninger’s four temperament dimensions are:

- **Novelty-seeking** – This dimension reflects impulsive behaviour and activation of behaviour. The key term to describe novelty-seeking is ‘behaviour activation’. Novelty-seeking is a tendency to like excitement, responding to novel stimuli. A person who scores high on novelty-seeking likes to explore, meet new people and find out about new things. Novelty-seeking is thought to be connected to the dopamine neurotransmitter. Dopamine is crucial to the parts of the brain that control our movements and is commonly associated with the pleasure aspects of the brain, providing feelings of enjoyment and motivation to do things. In the frontal lobes of the brain, the part of the brain involved with planning, coordinating, controlling and executing behaviour, dopamine controls the flow of information from other areas of the brain. You can clearly see that Cloninger is using the brain’s operations regarding motivation, enjoyment and planning to do things to define the temperament of novelty-seeking.

- **Harm avoidance** – This dimension reflects cautious and low-risk-taking behavioural traits. The key term to describe harm avoidance is ‘behaviour inhibition’. Harm avoidance includes a tendency to respond intensely to aversive stimuli or to inhibit behavior in order to avoid punishment or novelty. People who display harm avoidance traits are afraid to try out new things or are shy with people. Harm avoidance is thought to be connected to the serotonin (or 5-hydroxytryptamine, 5-HT) neurotransmitter that is known to modulate mood, emotion and sleep, and it is involved in the control of numerous behavioural and physiological functions.

- **Reward dependence** – This dimension reflects friendliness and a tendency for seeking rewards. People who are high on reward dependence respond well to reward, such as verbal signals of social approval or positive responses from other people. The key term to describe reward dependence is ‘behaviour maintenance’. Reward dependence is thought to be connected to norepinephrine.

**Figure 8.6** The relationship between Gray’s model and Eysenck’s model of personality and arousal.
(also called noradrenaline). Norepinephrine is a stress hormone that affects parts of the human brain where attention and impulsivity are controlled. It is related to activation of the sympathetic nervous system, which regulates our responses to stress.

- **Persistence** – This dimension reflects a tendency to persevere in behaviour despite frustration and tiredness. Someone high in persistence would have the ability to stay with a task and not give up easily. Persistence wasn’t in Cloninger’s model originally but emerged from the reward dependence dimension. Cloninger had found, when trying to measure reward dependence, that certain items relating to persistence weren’t associated with reward dependence. Persistence also represents behaviour maintenance. Similarly to reward dependence this dimension is thought to be connected to norepinephrine.

The character traits in Cloninger’s theory contrast to temperaments because they are not biological in origin, but rather refer to how individuals understand themselves in their social world. Character traits represent our emotions, habits, goals and intellectual abilities that we have formed in response to the outside world. Cloninger’s three character traits are:

- **Self-directedness** – This trait reflects the individual’s own concept of how autonomous a person is; for example, the extent to which they are independent in mind or judgement. In this dimension people show feelings such as self-esteem, personal integrity and leadership.

- **Cooperativeness** – This trait is based on the person’s self-concept of how they fit into humanity or society. Feelings of morality, ethics, community and compassion are included in this dimension.

- **Self-transcendence** – This trait reflects individuals’ self-concept in terms of their common beliefs about mystical experiences. Concepts such as religious faith and spirituality are formed within this dimension.

Although Cloninger separated out temperament and character traits, he did propose that the two interact. For example, individuals with the same temperament may behave differently as a result of character development. For example, one person might be high in novelty-seeking and also high in cooperativeness, and consequently, they might spend a lot of their time going out and seeking to raise money by doing a lot of charity work. Another person might be high in novelty-seeking and also high in self-transcendence, and therefore, they might travel the world exploring their spirituality by visiting a number of countries with different religious and spiritual backgrounds.

Cloninger’s model of personality is measured by the Temperament and Character Inventory-Revised (TCI-R), which contains 240 items. Responses are scored on a 5-point scale (1, definitively false; 2, mostly or probably false; 3, neither true nor false, or about equally true or false; 4, mostly or probably true; 5, definitively true). These items reflect each of the temperament and character dimensions, for example:

- **Novelty-seeking** – These items ask the individual about how excitable, exploratory, impulsive and extravagant (high novelty-seeking) they are, as opposed to how reserved and reflective they are (low novelty-seeking).

- **Harm avoidance** – These items ask the individual about how much they worry and are pessimistic, fearful of uncertainty and shy (high harm avoidance) versus how optimistic they are (low harm avoidance).

- **Reward dependence** – These items ask the individual about how attached and dependent they are (high reward dependence) versus how detached and independent they are (low reward dependence).

- **Persistence** – These items ask the individual about their responses to potential rewards, their ambitiousness, their perfectionism (high persistence) versus their laziness, frustration when not achieving and their tendency to quit when faced with obstacles (low persistence).

- **Self-directedness** – These items ask the individual about their tendency to act and take responsibility, their purposefulness and resourcefulness (high self-direction) versus their tendency to blame people and have a lack of self-direction (low self-direction).

- **Cooperativeness** – These items ask the individual about their feeling of social acceptance, empathy and helpfulness (high cooperativeness) versus their social intolerance, social disinterestedness and tendency to want to take revenge (low cooperativeness).

- **Self-transcendence** – These items ask the individual about their tendencies to identify with transpersonal ideas and spiritual acceptance (high self-transcendence) versus a tendency to emphasise materialism (low self-transcendence).

Clearly there are links between Cloninger’s model of personality and Eysenck’s and Gray’s models of personality. Novelty-seeking is thought to mirror Eysenck’s extraversion, and harm avoidance is thought to mirror Gray’s behavioural inhibition and Eysenck’s neuroticism. Also, Cloninger’s reward dependence seems to be equivalent to Gray’s behavioural approach system.

**Empirical evidence for biological theories of personality**

In the last section, we introduced three theories that have linked personality variables to psychophysiological and neuropsychological processes. But how do researchers set about establishing such links? In this section we are going to give you a brief introduction to the types of physiological
measures and studies that are used to examine whether these biological personality dimensions are related to psychophysiological and neuropsychological processes. What we are interested in most, here, is direct evidence that links physiological factors to personality dimensions, because then we would be able to show that there is a biological basis to the theories of Eysenck, Gray and Cloninger. There is a lot of research that looks at this area, so, to give you the best idea of the sort of physiological measures and physiological evidence for biological theories, we are going to use the 1999 summary of psychologists Matthews and Gilliland (1999), who looked at the biological personality theories of Eysenck and Gray.

Now, it is crucial to remember what we are looking for. With Eysenck's theory we are looking for extraversion being related to physiological measures of stimulation, and neuroticism being related to physiological measures of emotion. With Gray, we would expect to find that anxiety is associated with high sensitivity to signals of punishment and impulsivity, with high sensitivity to signals of reward.

UK psychologists Matthews and Gilliland (1999) suggest that two sets of measures have been used to examine these aspects of Eysenck's and Gray's theories: (1) measures of the central nervous system; and (2) measures of the autonomic nervous system.

The central nervous system and biological personality dimensions

The central nervous system comprises the brain and spinal cord; this system supervises and coordinates the activity of the entire nervous system and is the part of the body that transmits information to, and from, our senses or sensations. Measures of the central nervous system involve measuring brain activity.

A first measure of central nervous system activity is the electroencephalogram (EEG). The EEG, a measure of the electrical activity produced by the brain, is obtained by placing electrodes on the scalp and is presented in waveform. The waveform can then be analysed and is broken down into four ranges; delta, theta, alpha and beta. Electrical activity that falls within the alpha range is considered to reflect activity, while electrical activity that falls within the beta range is considered to reflect low states of arousal.

Remember that, in Eysenck's theory, we are looking for extraversion being related to physiological measures of stimulation, and neuroticism being related to physiological measures of emotion. Gale (1973; 1983) reviewed a number of studies suggesting support for Eysenck's theory. In reviewing these studies, Gale shows that, when placed in aroused situations, introverts tend to show significantly higher levels of alpha activity (low arousal) than extraverts do. However, Swedish psychologist George Stenberg (1992) found no significant relationship between a number of EEG measures and either extraversion or neuroticism.

A second measure of central nervous system activity suggested is the event-related potential (ERP). The ERP, like the EEG, measures electrical activity in the brain, but does so in response to stimuli in the environment. ERP is measured by responses within the first 100–500 milliseconds following stimuli, and Eysenck (1994) explains that waveforms of 300 milliseconds, something called P300, indicates when the cortical systems are showing arousal. Stelmack and Houlihan (1995) found higher levels of P300 amplitudes (arousal) in introverts and neurotics in response to stimuli, which suggests higher arousal and supports Eysenck's model. However, Matthews and Gilliland note that there are very few replications of this finding. In terms of extraversion and ERP, Fishman et al. (2011) found that higher scores on extraversion were found to be associated with higher amplitudes of the P300 component of the ERPs in response to human faces (i.e. a social based stimuli).

There is evidence to support Gray's theory of personality. With Gray we would expect to find that anxiety is associated with high sensitivity to signals of punishment and impulsivity with high sensitivity to signals of reward. Again, research has concentrated on similar measures of the central nervous system (i.e. EEG and ERP measures). For example, Stenberg (1992) found that impulsive participants showed signs of lower arousal, and more anxious participants showed higher levels of the beta waveform (remember that the beta range is considered to reflect activity) in response to negative emotional stimuli.

However, Matthews and Amelang (1993) and Matthews and Gilliland (1999) have suggested that the significant relationships between personality traits of both Eysenck and Gray and EEG and ERP measures are often very small, suggesting that the evidence supporting the predicted relationship between personality and brain activity is weak.

The autonomic nervous system and biological personality dimensions

The autonomic nervous system is the part of the brain that regulates unconscious or involuntary actions of the body, such as muscles, heart rate and glands (that produce secretions from the body, such as sweating). Measures of the autonomic nervous system measure those systems that are associated with regulating arousal (for example, the heart). Two further sets of measures tend to be used: cardiovascular and electromodal. Cardiovascular measures involve measuring the heart and the blood vessels. Electromodal measures (EDA) ascertain the electrical
activity of the skin. There are two main ways of classifying EDA measures:

- **Baseline EDA measures** – are often obtained through a small electric current to the skin via an electrode leading to the measure of skin resistance or skin conductance.

- **Phasic EDA measures** – are skin responses to known stimuli, such as caffeine, noise or visual stimuli.

In applying Eysenck’s theory, cardiovascular activity (e.g. heart rate) should be higher in neurotics and introverts as they both get upset by arousal and over-arousal, and EDA measures should be able to discriminate between introverts and extraverts. Some studies have explored the relationship between arousal and personality using cardiovascular activity. Richards and Eves (1991) found increased heart rate to arousal stimuli among introverts, though Naveteur and Roy (1990) did not. In terms of EDA measures, Matthews and Gilliland suggest that overall studies using baseline EDA measures have provided little information that supports Eysenck’s theory, but studies using phasic EDA measures found general support for Eysenck’s model. For example, Smith (1983) and Fowles et al. (1977) found evidence that introverts have higher levels of EDA than extraverts do where respondents are presented with arousal stimuli such as caffeine or stress. However, neuroticism is not generally found to be related to EDA measures (Matthews and Gilliland, 1999).

**Biological personality dimensions and other biological and physiological systems**

There are other studies that link biological personality dimensions to other biological and physiological systems. Dopamine is a neurotransmitter (it transmits signals from a neuron to cells) that regulates emotional responses and activity. Dopamine not only allows us to recognise rewards but also engage in behaviour that seeks out those rewards. Depue and Collins (1999) found that extraversion was related to higher sensitivity of the mesolimbic dopamine system (a pathway within the brain that carries dopamine from one part of the brain to another). Cohen et al. (2005) also found extraversion to be related to dopamine activation during a gambling task. This finding suggests that extraversion is associated with a physiological system that recognises and seeks out rewards. Johnson et al. (1999) have found extraversion to be related to blood flow activity in the anterior cingulate cortex (thought to be related to reward anticipation, as well as regulating blood pressure and heart rate), temporal lobe (contains the hippocampus and is important in the formation of long-term memories) and the posterior thalamus (relays sensory and motor signals to the cerebral cortex). Again, this finding suggests that extraversion is related to reward-sensitive regions of the brain.

A lot of research has concentrated on the effects of reward and punishment on physiological measures among impulsive and anxious people, as according to Gray’s theory. Gray’s theory asserts that anxiety is associated with high sensitivity to signals of punishment and impulsivity (best described as the behavioural approach system within his theory), with high sensitivity to signals of reward. One example is the study carried out by US psychologists Peter Arnett and Joseph Newman (2000). Arnett and Newman studied prison inmates at a minimum security prison in southern Wisconsin. These researchers measured a number of physiological responses while the prisoners took part in an experiment that involved positive and negative stimuli that were linked to gaining money or losing small amounts of money. Among this sample, there were increases in heart rate when participants were given a reward. This finding is consistent with predictions around the behavioural approach system and the theory that rewards are related to physiological responses. Arnett and Newman also found that participants showed significant increases in the electrical activity of the skin in response to punishment. This finding is consistent with predictions around the behavioural inhibition system regarding punishment and its relationship to physiological responses.

**Consideration of biological theories of personality**

The strength of biological theories of personality (Eysenck, Gray and Cloninger) is that they use important psychological mechanisms to explain the different dimensions of personality. Within these theories the concepts of arousal, activation and inhibition are important variables that allow personality to be linked to many different types of behaviours and responses to stimuli. Of particular note is Eysenck’s theory of arousal and personality as this was the first modern attempt to examine personality within biological factors. The fact that it was developed before many modern physiological measures were developed certainly was an admirable attempt to try to understand human behaviour in relation to brain and body functioning. We can also see from some of the evidence that is outlined that personality dimensions are linked to physiological activity such as brain activity (EEG and ERP) and EDA measures (skin conductance or heart rate).

However, the main problem with biological theories of personality is the lack of consistent evidence supporting
these theories. For example, Matthews and Gilliland (1999) suggest that, when you consider the EEG studies looking at Eysenck's personality dimensions, the relationships that are found to be consistent with Eysenck's theory tend to be weak. There is very little evidence to suggest that neuroticism is related to arousal. If Eysenck's theory should be deemed adequate, given that we are dealing with biological factors, the research evidence should perhaps be much stronger and much more consistent. Such a problem is found with research evidence across Eysenck's, Gray's and Cloninger's theories; although sometimes evidence is found to support the theory, sometimes it is not, and usually the results are not strong enough. Matthews and Gilliland (1999) suggest the reason for this might be that Eysenck's, Gray's and Cloninger's theories may have oversimplified a number of biological processes in their theory. For example, Zuckerman (1991) illustrates that the ascending reticular activating system (ARAS), thought to be a major system in Eysenck's theory, may not be as important to arousal as Eysenck thought. Arousal has been found to affect other aspects of the brain, and Eysenck's view that the ARAS regulates arousal by switching it on and off may represent an oversimplification of the brain. Furthermore, although Gray's and Cloninger's theories are more recent developments, they may also represent an oversimplification of complicated biological processes. As we noted before, there are links between Cloninger's model of personality and Eysenck's and Gray's models. Novelty-seeking is thought to mirror extraversion, and harm avoidance is thought to mirror Gray's behavioural inhibition and Eysenck's neuroticism. Also, Cloninger's reward dependence seems to be equivalent to Gray's behavioural approach system. However, there are differences between the personality theories in terms of which parts of the brain the theory emphasises. While Eysenck emphasises the ARAS and arousal, Gray emphasises two separate systems, the behavioural approach system (BAS) and the behavioural inhibition system (BIS), and Cloninger links the personality to dopamine, serotonin and norepinephrine. As evidence is found for each of the theories, it is probably likely that, on their own, each theory represents an oversimplification of the brain processes, and a combination of the different brain systems and activities identified by these theorists may best explain a biological basis to personality.

Together then, there does seem to be some biological evidence to support biological theories of personality. Reviews of the area, such as Matthews and Gilliland's (1999), suggest that further work needs to be done to explore such theories of personality fully. None the less, Eysenck's, Gray's and Cloninger's theories clearly link a number of personality and individual difference variables to neural processes, although their theories have had varying degrees of success in demonstrating this link empirically. Even so, these theories may produce important and dynamic foundations to expand our understanding of personality.

**Final comments**

The aim of this discussion was to introduce you to theories that explore biological bases of personality, behavioural genetics, neuropsychology and psychophysiology. We have shown you how psychologists have applied the ideas that surround behavioural genetics and heritability estimates to understand influences on personality. We have presented theoretical and research evidence surrounding genetic and environmental influence on personality that can be used to assess the value of heritability estimates. We have shown you how Eysenck, Gray and Cloninger have used neuropsychology and psychophysiology concepts to develop biological models of personality. We have also given you some evidence and general comments to assess the strengths and weaknesses of biological models of personality.

**Stop and think**

**Personality and arousal, reward and punishment**

1. Consider whether you are more an impulsive person or an anxious person. Do you generally respond well to reward or punishment?
2. Consider whether you are more an impulsive person or an anxious person in two situations: (1) when you are working or in university; or (2) when you are with your friends. Try to examine whether you respond well to reward or punishment in these situations.
3. Imagine you are a teacher trying to teach a class a new skill. Within this class some of the students are extraverted, some are impulsive, some are neurotic and some are anxious. Discuss how the issues of arousal, reward and punishment are going to influence how you teach the class this new skill.
Connecting up

- You will want to look back at Chapter 7 (The Trait Approach to Personality) for more information on the three-factor and five-factor models of personality that are mentioned in this chapter.
- We will revisit many of these issues regarding heritability estimates in Chapter 14 (Heritability and Socially Defined Race Differences in Intelligence) when we look at intelligence.

Critical thinking

Discussion questions

- How well do you think biological factors can predict personality?
- Think about the personality of three immediate family members. Try to assess them in terms of the five-factor model of personality (extraversion, neuroticism, openness, agreeableness and conscientiousness). Describe how similar, or different, the personality of each of these three family members is to your own personality. Speculate on reasons for this.
• Think about the personality of three of your closest friends. Again try to assess them in terms of the five-factor model of personality. How similar or different is the personality of each of your friends to your own personality? Speculate on reasons for this.
• Consider Harris' list of outside-family factors that influence personality (see Figure 8.2). Have any of these factors influenced your own personality?
• What do you think is the most important predictor of personality: genetics or the environment?
• How useful do you think the concepts of arousal, reward and punishment are to understanding personality?

**Essay questions**

• Critically compare genetic versus environmental predictors of personality.
• Is personality purely a result of the environment? Critically discuss.
• Critically examine how biological factors influence personality.
• Critically compare Eysenck's, Gray's and Cloninger's biological models of personality.
• Critically evaluate the relationship between arousal and personality.

**Going further**

**Books**


**Journals**


You may wish to search the following journals on an online library database (Web of Science; PsycINFO) with the search term ‘Personality’:

- *Behavioural Brain Research*. Published by Elsevier. Available online via Science Direct.

**Web links**

- *Human Genome Project*. Completed in 2003, the Human Genome Project (HGP) was a 13-year effort coordinated by the US Department of Energy and the National Institutes of Health. During the early years of the HGP, the Wellcome Trust (UK) became a major partner; additional contributions came from Japan, France, Germany, China and others. ([http://www.ornl.gov/sci/techresources/Human_Genome/home.shtml](http://www.ornl.gov/sci/techresources/Human_Genome/home.shtml) and [http://www.ornl.gov/sci/techresources/Human_Genome/elsi/behavior.shtml](http://www.ornl.gov/sci/techresources/Human_Genome/elsi/behavior.shtml))

**Film and literature**

- *Eternal Sunshine of the Spotless Mind* (2004, directed by Michel Gondry). To what extent does knowledge of physiological aspects influence our behaviour? Joel is stunned to discover that his girlfriend Clementine has had her memories of their relationship erased. Out of desperation, he contacts the inventor of the process to...
have Clementine removed from his own memory. But, as Joel's memories progressively disappear, he begins to rediscover their earlier passion. From deep within the recesses of his brain, Joel attempts to escape the procedure.

- In this discussion we looked at Harris' identification of a number of outside-family factors and their possible influence on personality. There is an excellent portrayal of how environmental factors interplay with personality in the film *The Departed* (2006, directed by Martin Scorsese).

- *Little Women* (1868–1869, Louisa M. Alcott). *Little Women* is the story of the March family. This is the story of five sisters, who share genetic similarities but, through their shared and non-shared environments, develop different personalities. Of course, this is a fictional story, but it shows you how non-shared environments can influence personality. Despite their efforts to be good, the girls show different personality traits through their own experiences. Meg becomes discontented, Jo becomes angry regularly, Amy becomes rather unnatural and artificial in her behaviour and Beth is always kind and gentle. The most recent adaptation to film was released in 1994 (directed by Gillian Armstrong and starring Winona Ryder, Kirsten Dunst, Claire Danes, Susan Sarandon and Christian Bale).

Explore the website accompanying this text at www.pearsoned.co.uk/maltby for further resources to help you with your studies. These include multiple-choice questions, essay questions, web links and ideas for advanced reading.