9

BIOLOGICAL FOUNDATIONS OF PERSONALITY

Why are some people generally happy and others sad, some energetic and others lethargic, some impulsive and others cautious? Why do men's and women's behaviors differ; for example, why are women more likely to wear makeup and men more likely to pay for dinner on a first date? Why does everyone recognize that some acts (e.g., incest) are immoral or "taboo," even if they do not directly harm anyone? Do we learn these feelings and behaviors, or might they be part of our biological makeup?

Scholars have contemplated such questions for ages. In the 1880s, the British scientist Sir Francis Galton contrasted "nature" (heredity) with "nurture" (environment), setting the stage for decades of theory, research, and debate about their relative importance. In the recent era, scientific advances have brought many of the issues into sharper focus. This chapter presents some of those advances. We explore six topics: biologically based individual differences evident early in life, or *temperament*; the shaping of personality by processes from our ancestral past, or *evolution*; how personality is influenced by *genes*; the neuroscience of *mood and emotion*; environmental influences on biological structures, or *plasticity*; and the neural bases of cognitively "higher-level" functions, including those involving *self* and *moral* judgment.

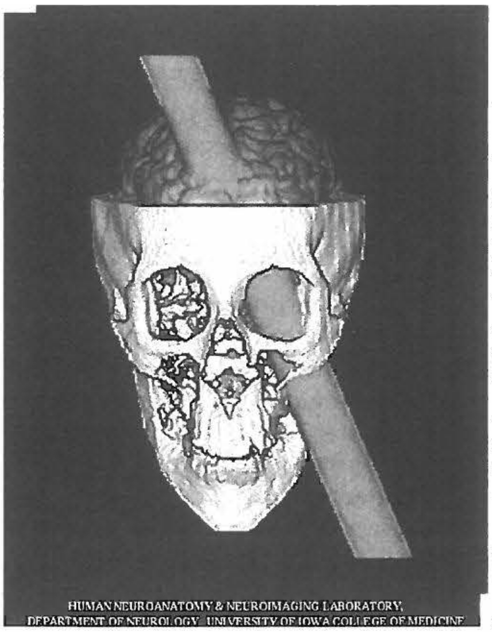
QUESTIONS TO BE ADDRESSED IN THIS CHAPTER

1. How, and why, do infants differ in temperament?
2. How can the study of human evolution inform our understanding of the personalities of contemporary humans?
3. What role do genes play in the formation of personality? How do they interact with the environment in the unfolding of personality?
4. What is the relation between brain processes and personality processes involving mood, self-concept, and moral judgment?

Scientists sometimes learn from accidents. The story of an apple falling on Newton's head—even if it is apocryphal—wisely instructs us that an accident can inspire scientific insight.

Insight into the biological foundations of personality, the topic of this chapter, benefited greatly from an accident that took place in 1848. The accident was suffered by Phineas Gage, a railroad construction foreman who one day in 1848 had a "very bad day on the job": While executing a procedure to blast a path through hard rock—drill a hole in the ground, fill it with explosive powder, insert an iron rod, and light a fuse—Gage become distracted. The charge blew up in his face, and the explosion blew the iron rod up through his left cheek, the base of his skull, and the front of his brain. It destroyed a large section of Gage's frontal cortex before exiting the top of his head.

Gage was stunned but, miraculously, alive. He could walk and speak. Indeed, he could describe the accident in detail and communicate about it rationally.



This illustration shows the location through which an iron rod blasted through the frontal cortex of Phineas Gage—who survived the accident but experienced a profound change in his personality.

From H. Damasio, T. Grabowski, R. Frank, A. M. Galaburda, and A. R. Damasio, The Return of Phineas Gage: Clues about the brain from a famous patient, *Science* 264:1102–1105, 1994. Dornsife Neuroscience Imaging Center and Brain and Creativity Institute, University of Southern California.

Yet Gage had changed deeply. "Gage's disposition, his likes and dislikes, his dreams and aspirations are all to change. Gage's body may be alive and well, but there is a new spirit animating it. Gage was no longer Gage" (Damasio, 1994, p. 7). Previously serious, industrious, energetic, and responsible, Gage now was irresponsible, thoughtless of others, lacking in planfulness, and indifferent to the consequences of his actions.

Gage's story suggests that there are deep interconnections between brain functioning and personality functioning. If the explosion had blown a hole in his leg instead of his brain, it would have been a bad accident, but Gage would have been the same basic person as before. The simultaneity of Gage's (1) loss of frontal-brain material and (2) change in personality qualities was—well, one might say it "was no accident."

Psychological science has systematically explored the body–personality connection suggested by Gage's accident. This chapter reviews some of their findings, and in doing so, it differs from our other chapters. Rather than focusing on a theory, the present chapter focuses on scientific *findings*. (The same is true for Chapter 14, which reviews findings on the relation between personality and social context.) They constitute a body of knowledge that must be taken into account by all personality theorists. Many of the findings relate strongly to the trait theories reviewed in Chapters 7 and 8. But others bear on distinct viewpoints, including a theoretical perspective called evolutionary psychology, which is reviewed later in this chapter.

TEMPERAMENT

Right from the start, we differ. Children, even in infancy, vary in their styles of emotion and behavior. Since their experiences with the world are so limited, these variations cannot be the product of social experience; they must have biological roots. **Temperament** refers to biologically based individual differences in emotional and motivational tendencies that are evident early in life (Kagan, 1994; Rothbart, 2011). Early-life variations in the tendency to experience positive or negative moods, to become aroused in response to stimuli, or to calm oneself down after becoming upset are examples of temperament qualities.

CONSTITUTION AND TEMPERAMENT: EARLY VIEWS

Scholars have long been interested in the possibility that psychological differences among people have a biological basis (reviewed in Kagan, 1994; Rothbart, 2011; Strelau, 1998). In ancient Greece, Hippocrates posited that variations in psychological characteristics reflect variations in bodily fluids (see Chapter 7, Figure 7.2). His view reflected the Greeks' beliefs about the universe. The Greeks thought nature was composed of four elements: air, earth, fire, and water. Hippocrates and other ancient scholars analyzed temperament through a similar fourfold scheme. The four elements of nature were said to be represented in the human body by four humors (blood, black bile, yellow bile, and phlegm), each corresponding to a temperament: sanguine, melancholic, choleric, and phlegmatic, respectively. Individual differences in temperament resulted from variations in the bodily humors. The Greeks, then, provided both a taxonomy of temperament qualities and a biological theory of their cause.

This conception was remarkably long-lasting. More than two millennia after Hippocrates, the great German philosopher Immanuel Kant distinguished four types of temperament and suggested that their basis was found in bodily fluids—a conception that was remarkably similar to that of the ancient Greeks. Needless to say, all contemporary psychological scientists reject the details of these bodily fluid theories.

Another view of historical note came from the 19th-century biologist Franz Joseph Gall. Gall founded the field of phrenology, which posited that specific areas of the brain are responsible for specific emotional and behavioral functions (Figure 9.1). Through postmortem inspections of brains, Gall attempted to relate differences in brain tissue to individuals' capacities, dispositions, and traits before death. Bumps on the head were examined, since they might be indicative of the development of underlying brain tissue. Phrenology gained great fame in the 19th century but subsequently was discredited. Contemporary research shows that the brain simply does not work in the way Gall assumed, with localized regions producing specific types of thought and behavior. Instead, most complex activities rest on the synchronized action of multiple, interconnected brain regions (Bressler, 2002; Edelman & Tononi, 2000; Sporns, 2011).

Efforts of more enduring value were seen in the mid-19th century. Three publications were critical: Charles Darwin's *The Origin of Species* (1859) and *The Expression of Emotions in Man and Animals* (1872), and Gregor Mendel's *Experiments on Plant Hybrids* (1865). Darwin's *Origin*, of course, was foundational to the contemporary science of biology. His *Expression of Emotions* documented numerous close relations between emotional expression in humans and emotional expression in other complex mammals; in so doing, it contributed indirectly to the study of temperament and also foreshadowed the development of contemporary evolutionary psychology (discussed later in this

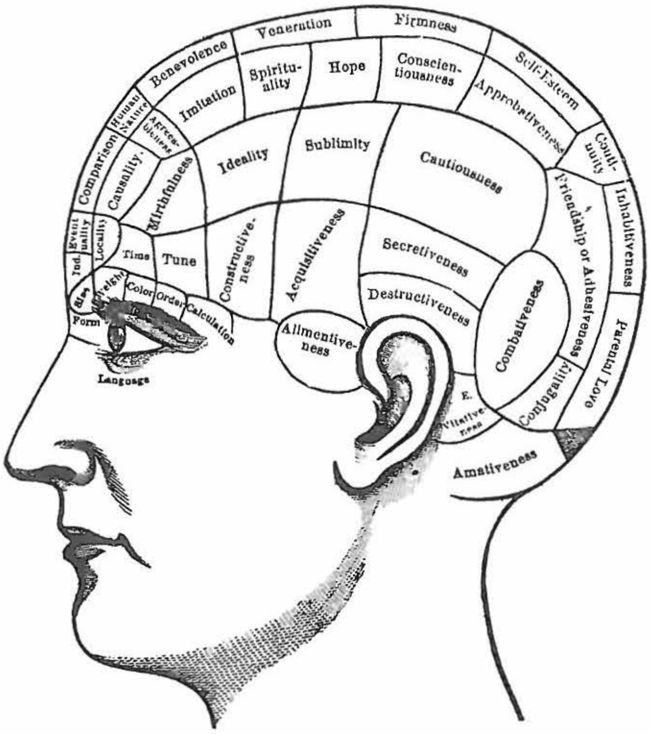


Figure 9.1 *Gall's Localization of Personality Functions of the Brain.*

chapter). Mendel's work reported eight years of research on the breeding of pea plant characteristics and served as the foundation for modern genetics.

Two 20th-century investigators attempted to link temperament to an analysis of body types: the German psychiatrist Ernst Kretschmer (1925) and the American psychologist William Sheldon (1940, 1942). Their efforts were systematic, with careful measures of body type being related to indices of psychological qualities. Yet, in both cases, methodological problems limited the conclusions one can draw from their work; subsequent research indicates that the relationship between body type and personality are weak (Strelau, 1998).

Early 20th-century work of more lasting value was done by Pavlov. In addition to his research on how reflexes are changed by experience (see Chapter 10), Pavlov developed a theory of stable individual differences in nervous-system functioning that highlighted the possibility of variations in nervous system "strength"—that is, in the degree to which normal nervous system functioning could be maintained in the face of high levels of stimuli or stress (Strelau, 1998).

CONSTITUTION AND TEMPERAMENT: LONGITUDINAL STUDIES

The historical efforts to study temperament that we have just reviewed lacked an element that is crucial to contemporary research: *longitudinal* methods—that is, research methods in which a group of persons is studied repeatedly over an extended period of time. Longitudinal methods enable researchers to determine whether psychological qualities are evident early in life and are enduring, as one would expect if they are biologically based.

A pioneering longitudinal study, the New York Longitudinal Study (NYLS), was conducted by Alexander Thomas and Stella Chess (1977). They followed over 100 children from birth to adolescence, using parental reports of infants' reactions to a variety of situations to define variations in infant temperament. On the basis of ratings of infant characteristics such as activity level, general mood, attention span, and persistence, they defined three infant temperament types: easy babies who were playful and adaptable, difficult babies who were negative and unadaptable, and slow-to-warm-up babies who were low in reactivity and mild in their responses. This study and subsequent studies found a link between such early differences in temperament and later personality characteristics (Rothbart & Bates, 1998; Shiner, 1998). For example, difficult babies were found to have the greatest difficulty in later adjustment, whereas easy babies were found to have the least likelihood of later difficulties. In addition, Thomas and Chess suggested that the parental environment best suited for babies of one temperament type might not be best for those of a different temperament type. That is, there is a goodness-of-fit between infant temperament and parental environment.

Subsequently, Buss and Plomin (1975, 1984) used parental ratings of child behavior to identify dimensions of temperament that included *emotionality* (ease of arousal in upsetting situations; general distress), *activity* (tempo and vigor of motor movements; on the go all the time; fidgety), and *sociability* (responsiveness to other persons, makes friends easily versus shy). Individual differences in these temperament characteristics were found to be stable across time and substantially inherited, with identical twins being particularly similar on the temperament dimensions. Their strategy of relying on parental ratings is limited, for parents may be systematically biased when rating the personality of their own children; for example, they tend to overestimate the similarity of identical twins (Saudino, 1997). Nonetheless, Buss and Plomin's work was of enduring value. Many subsequent investigators adhered to their approach, searching for a small set of individual-difference dimensions that characterize major variations in temperament characteristics in the population at large (e.g., Goldsmith & Campos, 1982; Gray, 1991; Strelau, 1998). These efforts partly informed the five-factor model of personality discussed earlier (Chapter 8).

These early longitudinal studies were limited, primarily because they did not identify the exact biological systems that underlie the observed temperament qualities. Doing so requires moving beyond parental self-report measures to direct measures of behavior and indices of biological response. Let's turn to such research now.

BIOLOGY, TEMPERAMENT, AND PERSONALITY DEVELOPMENT: CONTEMPORARY RESEARCH

Inhibited and Uninhibited Children: Research of Kagan and Colleagues

Harvard psychologist Jerome Kagan has spearheaded a highly informative line of research on the biological bases of temperament (Kagan, 1994, 2003, 2011). A key to his research has been his use of direct, objective measures of behavior. Rather than merely asking parents to report about the characteristics of their children, Kagan observes the children directly, commonly in laboratory settings.

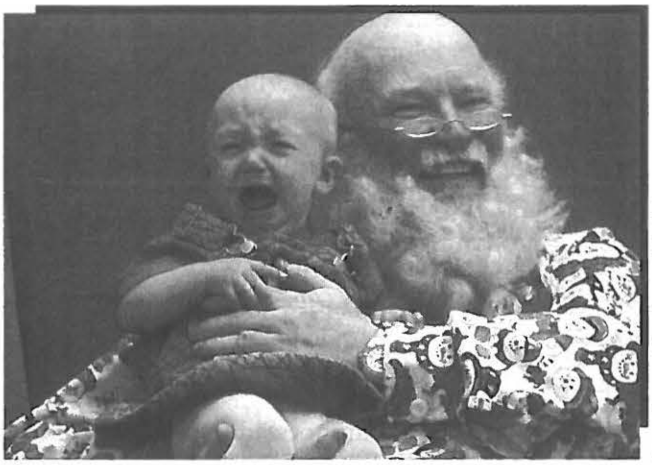
The developmental psychologist Jerome Kagan has identified early differences in temperament, conceptualized as inhibited and uninhibited types.

Based on these observations, Kagan noticed two clearly defined behavioral profiles in temperament: inhibited and uninhibited profiles. Relative to the uninhibited child, the inhibited child reacts to unfamiliar persons or events with restraint, avoidance, and distress, takes a longer time to relax in new situations, and has more unusual fears and phobias. Such a child behaves timidly and cautiously, the initial reaction to novelty being to become quiet, seek parental comfort, or run and hide. By contrast, the uninhibited child seems to enjoy these very same situations that seem so stressful to the inhibited child. Rather than being timid and fearful, the uninhibited child responds with spontaneity in novel situations, laughing and smiling easily.

Struck by such dramatic differences, Kagan set out to address the following questions: How early do such differences in temperament emerge? How stable are these differences in temperament over time? Can some biological bases for such differences in temperament be suggested? His central hypothesis was that infants inherit differences in biological functioning that lead them to be more or less reactive to novelty and that these inherited differences tend to be stable during development. According to the hypothesis, infants born highly reactive to novelty should become inhibited children, whereas those born with low reactivity should develop into uninhibited children.

To test this hypothesis, Kagan brought four-month-old infants into the laboratory and videotaped their behavior while they were exposed to familiar and novel stimuli (e.g., mother's face, voice of a strange female, colorful mobiles moving back and forth, a balloon popping). The videotapes then were scored on measures of reactivity such as arching of the back, vigorous flexing of limbs, and crying. About 20% of the infants were designated as high-reactive, characterized by arching of the back, intense crying, and unhappy facial expression in response to the novel stimuli. The behavioral profile suggested that they had been overaroused by the stimuli, particularly since the responses stopped when the stimuli were removed. In contrast, the low-reactive infants, about 40% of the group, appeared to be calm and laid-back in response to the novel stimuli. The remaining infants, about 40%, showed various mixtures of response.

To determine whether, as predicted, the high-reactive infants would become inhibited children and the low-reactive infants uninhibited children, Kagan again studied the children when they were 14 months old, 21 months old, and 4½ years old. Again the children were brought to the laboratory and exposed to novel, unfamiliar situations (e.g., flashing lights, a toy clown striking a drum, a stranger in an unfamiliar costume, the noise of plastic balls rotating in a wheel at the first two ages, and meeting with an unfamiliar adult and unfamiliar



Research on temperament indicates that some children inherit a predisposition to become highly distressed in the presence of novel situations and people–even smiling, friendly ones!

children at the later age). In addition to behavioral observations, physiological measures such as heart rate and blood pressure in response to the unfamiliar situations were obtained. Again, findings revealed continuity in temperament. High-reactive infants showed greater fearful behavior, heart acceleration, and increased blood pressure in response to the unfamiliar at 14 and 21 months, and smiled and talked less than low-reactive children during social interactions at 4.5 years of age. Further testing at age 8 indicated continuing consistency, with a majority of the children assigned to each group at age four months retaining membership in that group. As you'll see later in the chapter, evidence of differences in biological functioning also was obtained.

Although there is consistency across time in temperament, there also is evidence of change (Fox et al., 2005). Many high-reactive infants did not become consistently fearful. Change in these children seemed particularly tied to having mothers who were not overly protective and placed reasonable demands on them (Kagan, Arcus, & Snidman, 1993). And some of the low-reactive infants lost their relaxed style. Despite an initial temperamental bias, environment played a role in the unfolding personality. "Any predisposition conferred by our genetic endowment is far from being a life sentence; there is no inevitable adult outcome of a particular infant temperament" (Kagan, 1999, p. 32). Yet, Kagan notes that not one of the high-reactive infants became a consistently uninhibited child, and it was rare for a low-reactive infant to become a consistently inhibited child. Thus, change was possible, but the temperamental bias did not vanish; it appeared to set constraints on the direction of development. As Kagan summarizes, "it is very difficult to change one's inherited predisposition completely" (1999, p. 41).

Another question is whether temperament qualities vary dimensionally (e.g., like height) or categorically (e.g., like eye color or biological sex). Woodward, Lenzenweger, Kagan, Snidman, and Arcus (2000) employed statistical techniques that are designed to answer this question. These statistical methods are designed to identify categories or "classes" that may explain patterns of variation in data obtained from a large group of persons. To illustrate, suppose you did not know that some people are men and others are women. If you asked people a large number of questions about their personal habits, you might find out that there are distinct groups. A statistical analysis could indicate that some responses go together so strongly (e.g., people who say that they wear skirts also tend to say that they wear lipstick and own high-heel shoes) that they indicate a group of people that is a categorically distinct class (women). Woodward and colleagues (2000) found that the group of infants showing high reactivity (limb movements, crying) in response to novel situations is a distinct class. A distinct group of about 10% of a large population of children was found to be consistently more reactive than the population at large. This finding is important because it conflicts with the common assumption that individual differences in personality inevitably involve continuous dimensions.

Research also illuminates the brain regions that contribute to inhibited and uninhibited tendencies (Schmidt & Fox, 2002). More than one region appears to be involved, with behavioral tendencies reflecting interactions among the different neural systems. One important region is the amygdala, a region of the brain that, as we note below, is centrally involved in fear response. A second region is the frontal cortex, which is involved in regulating emotional response, in part by influencing the functioning of the amygdala. Interestingly, the functioning of these brain regions is not entirely determined by inherited factors; social experiences appear to modify brain functioning and thus influence children's emotional tendencies (Schmidt & Fox, 2002).

Neuroimaging methods provide particularly clear evidence of the role of the amygdala in inhibited versus uninhibited temperament (Schwartz, Wright, Shin, Kagan, & Rauch, 2003). Researchers studied a group of young adults who had been categorized as highly inhibited or uninhibited at age two. The adults participated in a laboratory study in which, while in an fMRI scanner, they viewed pictures of human faces of two sorts: (1) familiar faces (i.e., pictures of people that the participant had seen previously, in an earlier portion of the experiment) and (2) novel faces (faces that had not been seen previously). Brain-imaging results supported the hypothesis that uninhibited versus inhibited persons differ in amygdala functioning (**Figure 9.2**). When they viewed the novel faces, adults who back when they were only two years old had been identified as inhibited children, showed higher levels of amygdala reactivity. Individual differences in a biological mechanism underlying inhibited behavior thus were stable across years of life.

More recent evidence suggests a molecular basis for fear—at least in animals, whose neural systems of fear may sufficiently resemble that of humans that results can be generalized. In this work (Shumyatsky et al., 2005), researchers identified a gene that contributes to levels of a protein, called stathmin, that influences the functioning of the amygdala. Mice with and without the stathmin gene differed in behavioral measures of fear, such as "freezing" in the presence of a potentially fear-provoking stimulus and exploring (or not) novel open spaces (Shumyatsky et al., 2005). A fascinating aspect of this work is that it was not only observational but truly experimental (see Chapter 2). The research included genetic "knockout" techniques in which genetic material is manipulated experimentally (Benson, 2004).

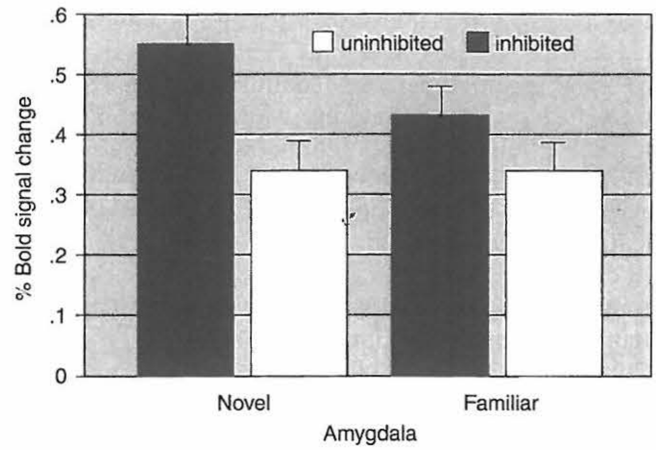


Figure 9.2 *fMRI measures of brain reactivity to novel and familiar faces among people who had been classified as uninhibited and inhibited.*
From Schwartz, Wright, Shin, Kagan, & Rauch (2003).

Interpreting Data on Biology and Personality

In summary, the evidence that genetically based biological processes contribute to individual differences in inhibition and fear in response to novelty is strong, as is the evidence that the amygdala is involved in fear responses. Nonetheless, it is important not to *over*interpret this evidence. Some interpretations that may at first appear appealing are overinterpretations, that is,

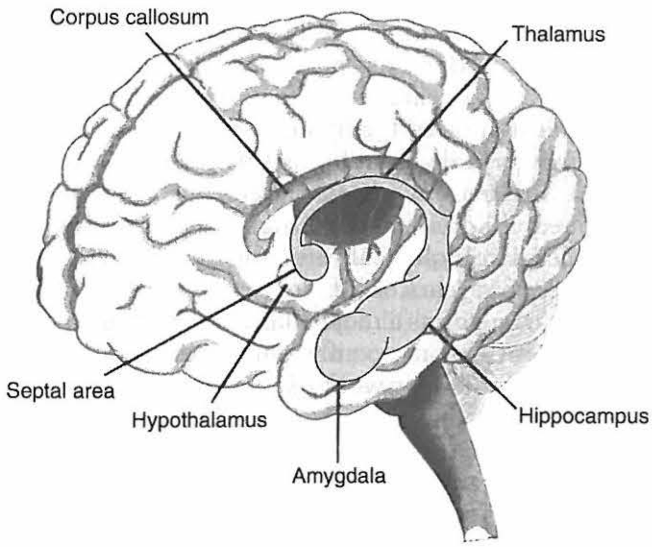


Figure 9.3 *The Limbic System. The limbic system, located within the cerebrum, consists of the septal area, amygdala, and hippocampus.*

conclusions that go beyond the actual data. Considering them is important to thinking critically about the biological foundations of personality.

One might conclude that the amygdala is a kind of fear-production machine: the necessary and sufficient cause of fear. This interpretation of the scientific evidence would be unwarranted for a number of reasons. First, the amygdala can be involved in many psychological functions *other than* fear responses; it is not specifically dedicated to the emotion of fear. Second, the amygdala is *the only* biological mechanism in fear responses. Some evidence suggests that it is not even necessary for the experience of emotions such as fear, even if it typically is involved in the fear response. Anderson and Phelps (2002) compared the daily emotional experiences of people with amygdala damage (lesions to and/or removal of portions of the amygdala, done surgically as a medical procedure to alleviate seizures these individuals had experienced) to people with normal, intact amygdalas. If the amygdala was necessary to the experience of emotions, these people's emotional life should have differed dramatically. But it turns out that they did not differ at all! People with amygdala damage experienced the same range of emotions as did biologically normal persons. The authors conclude that "the complexity and richness of human emotional life do not appear to be supported by the amygdala alone" (Anderson & Phelps, 2002, p. 717).

Furthermore, the amygdala may primarily be involved in the processing not of fear but of novelty. Kagan (2002) has reviewed evidence indicating that, in fact, "a state of surprise is a more reliable incentive for amygdalar activation than a state of fear" (p. 13).

Finally, the fact that inherited differences in a biological system, the amygdala, contribute to fearful behavior may prompt the interpretation that environmental experiences are unimportant and that a person's fearful tendencies cannot change. This conclusion, too, would be a mistake. Research (Fox et al., 2005) indicates that genetic factors interact with environmental ones in predicting behavioral inhibition in childhood. The environmental factor these researchers investigated was social support, specifically, the degree to which mothers provided nurturing, intimate social support when children were 4 years old. They also measured molecular genetic factors already known to be linked to inhibited behavioral tendencies. The genetic and environmental factors were used together to predict inhibited behavior with peers when children were 7 years of age. The main finding was that the link from genetics to behavior depended on the environmental factor, social support. Genetics were less strongly linked to behavior among children who received a high level of social support (Fox et al., 2005); high levels of social support, in other words, lessened the genetic differences that one would observe among children who experience less supportive environments.

In sum, "just because a person is born with a particular temperament . . . doesn't mean there is a simple set of instructions or blueprints. Nor . . . are [people] 'stuck' with their personalities from birth. On the contrary, one of the marvelous features of temperament is a built-in flexibility that allows us to adapt to life's hurdles and challenges. Everyone has the ability to grow and to change at every stage of life" (Hamer & Copeland, 1998, p. 7).

Effortful Control and the Development of Conscience

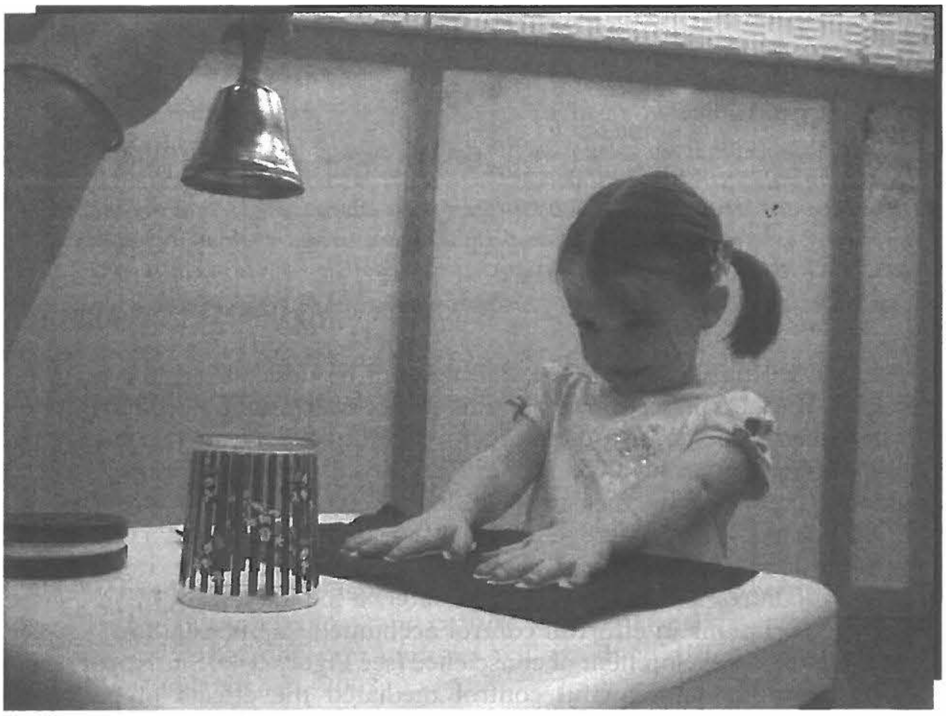
Inhibitedness is not the only psychological quality of interest to students of temperament. Important advances also have been made in understanding the role of temperament in people's ability to exert influence over, or regulate, their own emotions and actions. The psychologist Mary Rothbart and her colleagues, for example, posit that a specific psychological quality is necessary for regulating one's emotions and actions. This is a quality they call *effortful control* (e.g., Rothbart, Ellis, Rueda, & Posner, 2003). People often need to stop doing one thing in order to do another. One might need to stop watching TV in order to start studying, to stop talking to a friend in order to pay attention to a teacher, to stop eating donuts in order to lose weight. Effortful control refers to this capacity; it is "the ability to suppress a dominant response in order to perform a subdominant response" (Rothbart et al., 2003, p. 1114).

A feature of research on effortful control that makes it of particular interest to personality theory is the potential relation between effortful control processes and the development of a psychological capacity that has been of great interest to personality theorists since the time of Freud. This capacity is moral conscience—or what Freud would have called superego functioning (see Chapter 3). It is the capacity to adhere to social norms by internalizing moral and ethical standards for behavior.

The basic question addressed in contemporary research is the one considered by Freud: What determines the development of a sense of conscience? Why do people differ in the degree to which they adhere to social norms and constraints? In trying to answer this question, Freud focused on the child's experience with the parents. An alternative focus would examine differences in inherited biology. A more interesting third possibility is that inherited biology and parental influence *both* influence the child's level of conscience. This third possibility has been explored in research by Grazyna Kochanska and her colleagues.

Kochanska and Knaack (2003) examined the relations among (1) effortful control, (2) the development of conscience, and (3) one particular aspect of parenting, namely, the degree to which mothers forcefully assert their authority in their interactions with children. Asserting parental authority may be important and beneficial in many settings. However, it also may carry a cost. When parents authoritatively control their children's action, the child may fail to develop his or her own internal controls. The child with authoritative parents may fail to internalize rules for proper social conduct. Kochanska and Knaack hypothesized that this may occur for reasons involving effortful control. Children who experience authoritative parenting may fail to fully develop the self-control skills that enable them to regulate their behavior independently.

Testing these ideas is difficult, and Kochanska and Knaack's efforts in overcoming the difficulties are exemplary. Their work contains two critical features that also were evident in the work of Kagan and colleagues: (a) a *longitudinal* research design, that is, research in which the same people are studied over long periods of time, and (b) *behavioral* measures of the people studied, rather than merely measures involving the completion of questionnaires. When children were about 2–3 years of age, they were given behavioral tests of effortful control. These tests involved tasks such as slowing down their walking, talking in a whisper, and delaying before eating a piece of candy. To learn about mothers' behavior, the researchers also observed them directly. Mothers were observed while giving instructions to their children, and researchers coded the mothers' behavior to determine the degree to which their parenting style involved forceful assertiveness. Finally, much later in time when children were almost 5 years old, they participated in lab activities designed to measure their sense of conscience.



A child participating in the research program on effortful control by Kochanska and colleagues. The child is participating in a "Snack Delay" task in which children must try to wait with their hands on a table until an experimenter rings a bell before they can then have a snack. The research provides a behavioral measure of children's ability to control their behavior.

For example, children played a game in which they had the opportunity to cheat, and the experimenters observed them to determine whether they were cheating. They also were shown puppets, some of whom (in the storyline presented to children) always did what they were told, whereas others did not; children indicated which of the puppets was more like them.

Research findings supported the predictions regarding how authoritative parenting and effortful control contribute to the development of conscience

The developmental psychologist Grazyna Kochanska has explored the origins of children's capacity for self-control.

Figure 9.4. *Conceptual representation of relations among mother's assertion of power, children's effortful control, and the development of conscience among children, based on data from Kochanska and Knaack (2003). The minus and plus signs indicate that higher levels of power assertion among mothers predicted lower levels of effortful control in children, and higher levels of effortful control predicted higher levels of conscience.*

(Kochanska & Knaack, 2003). The findings can be understood in a series of steps. First, mothers' assertion of parental power was found to predict individual differences in the temperament quality of effortful control. To a highly significant degree, mothers who were more authoritative had children who were less able to succeed on the measures of effortful control. Second, effortful control predicted individual differences in conscience. Again, this was a very strong effect; to a highly significant degree, children who displayed greater capacity for effortful control also displayed, years later, a higher sense of conscience. Finally, the variations in effortful control accounted for the relation between parenting and the development of conscience (see Figure 9.4). Statistical analyses demonstrated that effortful control mediated the effects of parenting (Kochanska & Knaack, 2003).

GENES AND PERSONALITY

Whatever we inherit, we inherit it thanks to our genes. We possess 23 pairs of chromosomes, one of each pair from each of our biological parents. The chromosomes contain thousands of genes. Genes are made up of a molecule called DNA and direct the synthesis of protein molecules. Genes may be thought of as sources of information, directing the synthesis of protein molecules along particular lines. Information in the genes, then, directs the biological development of the organism.

In appreciating the relation of genes to behavior, it is important to understand that genes do not govern behavior directly. Thus, there is no "extraversion gene" or "introversion gene," and there is no "neuroticism gene." To the extent that genes influence the development of personality characteristics such as the Big Five, described in Chapter 8, they do so through the direction of the biological functioning of the body.

BEHAVIORAL GENETICS

The study of genetic contributions to behavior is called the field of behavioral genetics. Behavioral geneticists employ a variety of techniques to estimate the degree to which variation in psychological characteristics is due to genetic factors. As we shall see, the methods of behavioral genetics also can, and do, provide evidence of environmental effects on personality. Behavioral geneticists employ three primary research methods: selective breeding studies, twin studies, and adoption studies.

Selective Breeding Studies

In selective breeding studies, animals with a desired trait for study are selected and mated. This selection and reproduction process is used with successive generations of offspring to produce a strain of animals that is consistent within itself for the desired characteristic. Selective breeding is not only a research technique; it is used, for example, to breed race horses or breeds of dogs with desired characteristics.

Once one has created different strains of animals through selective breeding, one not only can study their typical behavioral tendencies. It also is possible to subject the different strains to different experimentally controlled developmental experiences. Researchers then can sort out the effects of genetic differences and environmental differences on the observed later behavior. For example, the roles of genetic and environmental factors in later barking behavior or fearfulness can be studied by subjecting genetically different breeds of dogs to different environmental rearing conditions (Scott & Fuller, 1965).

Selective breeding research has enhanced our understanding of how genes contribute to problems that often are blamed solely on the individual. Consider work on alcoholism (Ponomarev & Crabbe, 1999). The researchers bred various strains of mice that proved to exhibit qualitatively different responses to alcohol. This work illustrated that genes play a role in responsiveness to alcohol, addiction, and withdrawal. It contributed to a more complete understanding of the fact that genetic factors present some individuals with severe vulnerabilities to lifelong problems with alcohol (Hamer & Copeland, 1998).

Twin Studies

Even the most enthusiastic researcher realizes that selective breeding research cannot and should not be done with humans. Ethical factors force the researcher to consider alternatives. Fortunately for science, a ready alternative exists: human twins. Twins provide a naturally occurring experiment. What the scientist wants, ideally, is a circumstance in which there are known variations in degree of genetic similarity and/or environmental similarity. If two organisms are identical genetically, then any later observed differences can be attributed to differences in their environments. On the other hand, if two organisms are different genetically but experience the same environment, then any observed differences can be attributed to genetic factors. The existence of identical (monozygotic) twins and fraternal (dizygotic) twins offers a good approximation to this research ideal. Monozygotic (MZ) twins develop from the same fertilized egg and are genetically identical. Dizygotic (DZ) twins develop from two separately fertilized eggs and are as genetically similar as any pair of siblings, on the average sharing about 50% of their genes.

Matt Campbell/AFP/Newscom.

These identical twins were reared apart and met only after reaching college age. Research has demonstrated that identical twins are surprisingly similar in their personalities even if they do not grow up together.

Researchers capitalize on these systematic differences between MZ and DZ twins by conducting twin studies to gauge the degree to which genetic factors explain person-to-person variations in psychological characteristics.

Two logical considerations underpin the twin method. The first is that, since MZ twins are genetically identical, any systematic difference between them must be due to environmental effects. Interestingly, then, the study of genetically identical persons is particularly valuable for revealing the effects of environmental experience. Second, it is the difference in similarity between MZ twin pairs and DZ twin pairs that is crucial to estimating the effects of genetics. Specifically, we know that MZ twins are more similar to one another genetically than DZ twins are similar to one another genetically. If genetics influence a given personality characteristic, then MZ twins, as a result of being more similar genetically, also should be more similar on the given personality characteristic than are DZ twins. If they are not, then there is no genetic effect. When studying both MZ and DZ twin pairs, then, the researcher can compare them (MZ similarity compared to DZ similarity on a trait of interest) to determine the magnitude of the influence of genetic factors. This genetic influence usually is expressed numerically in terms of a heritability coefficient (described below).

The twin strategy usually is conducted with twins who grow up in the same household. However, circumstances sometimes force parents to give up children for adoption early in life. As a result, MZ and DZ twins sometimes are reared apart. This creates a circumstance of remarkable interest to the psychological scientist and the public at large, namely, biologically identical people who are raised in different environments. What happens? Does biology win out, with genetically identical twins being psychologically identical despite their different experiences? Or do social experiences win out, with people differing substantially despite their identical genes? These questions can be answered thanks to an international data set that features large numbers of reared-apart twins who have completed various psychological measures (Bouchard, Lykken, McGue, Segal, & Tellegen, 1990). Results provide clear evidence that the effects of biology endure across different circumstances. On multiple personality trait measures, MZ twins raised apart were found to be similar to a significant degree; twin correlations indicating the degree of similarity between the twins were in the .45 to .50 range. Of particular interest is that MZ twins raised apart were about as similar to one another as were MZ twins raised together (Bouchard et al., 1990). Being raised in the same household did not make the twins more similar on broad personality trait measures. We return to this fascinating finding, and its interpretations and implications, after reviewing further research findings below.

Adoption Studies

Studies of children who grow up with caregivers other than their biological parents are called adoption studies. (Adoption studies sometimes involve identical twins, as in the research reviewed in the paragraph immediately above, but commonly may involve nontwin siblings.) Adoption studies offer another method for studying genetic and environmental effects. When adequate records are kept, it is possible to consider the similarity of adopted children to their natural (biological) parents, who have not influenced them environmentally, and to compare this with the similarity to their adoptive parents, who share no genes in common with them. The extent of similarity to their biological parents is indicative of genetic factors, while the extent of similarity to their adoptive parents is indicative of environmental factors.

Finally, such comparisons can be extended to families that include both biological and adoptive children. Take, for example, a family of four children; two of the children are the biological offspring of the parents and two of the children have been adopted. The two biological offspring share a genetic similarity with one another and with the biological parents that is not true for the two adopted children. Assuming the two adopted children are unrelated, they share no genes in common but share a genetic similarity with their parents and any siblings who might exist in other environments. Thus, it is possible to compare different parent–offspring and biological sibling–adoptive sibling combinations in terms of similarity on personality characteristics. For example, one can ask whether the biological siblings are more similar to one another than are the adoptive siblings, whether they are more similar to the parents than the adoptive siblings, and whether the adoptive siblings are more similar to their biological parents than to their adoptive parents. A "yes" answer to such questions would be suggestive of the importance of genetic factors in the development of the particular personality characteristic.

It should now be clear that in twin and adoption studies we have individuals of varying degrees of genetic similarity being exposed to varying degrees of environmental similarity. By measuring these individuals on the characteristics of interest, we can determine the extent to which their genetic similarity accounts for the similarity of scores on each characteristic. For example, we can compare the IQ scores of MZ and DZ twins reared together and apart, biological (nontwin) siblings reared together and apart, adoptive siblings and biological siblings with parents, and adoptive siblings with their biological and adoptive parents. Some representative correlations are presented in Table 9.1. The data clearly suggest a relationship between greater genetic similarity and greater IQ similarity.

Table 9.1 Average Familial IQ Correlations ®

As genetic similarity increases, so does the magnitude of the correlations for IQ, suggesting a strong genetic contribution to intelligence.

Relationship	*Average R*	*Number of Pairs*
REARED-TOGETHER BIOLOGICAL RELATIVES		
MZ twins	.86	4,672
DZ twins	.60	5,533
Siblings	.47	26,473
Parent offspring	.42	8,433
Half-siblings	.35	200
Cousins	.15	1,176
REARED-APART BIOLOGICAL RELATIVES		
MZ twins	.72	65
Siblings	.24	203
Parent offspring	.24	720
REARED-TOGETHER NONBIOLOGICAL RELATIVES		
Siblings	.32	714
Parent offspring	.24	720

NOTE: MZ, monozygotic; DZ, dizygotic.
SOURCE: Adapted from "Familial Studies of Intelligence: A Review," by T. J. Bouchard and M. McGue, 1981, *Science, 250*, p. 1056. ©American Association for the Advancement of Science. Reprinted from McGue et al., 1993, p. 60.

Heritability Coefficient

How, exactly, does the behavioral geneticist determine the degree to which genetic variations determine variations among people in a personality characteristic? This usually is done by computing what is called a heritability coefficient, or h^2 (it is h "squared" because numbers are squared when computing variations around an average score). The heritability coefficient represents the proportion of observed variance in scores that can be attributed to genetic factors. In a study involving both MZ and DZ twins, h^2 is based on the difference between the MZ and DZ correlations. If MZ twins (who share all their genes) are no more similar to one another than are DZ twins (who share half their genes), then there is no genetic effect: h^2 is zero. If MZ twins differ greatly from DZ twins, h^2 is large; its upper limit is 1.0, or 100% of the total variance. To the extent that h^2 is less than 1.0, there exists variance that is not accounted for by genetic factors; this remaining variance is explained by environmental variation.

Note that the heritability coefficient refers to variation in the population examined in a given study. This point has two implications. First, different heritability coefficients, for the same psychological trait, may be observed in different populations; for example, if one is studying a population in which many people have been subjected to environmental effects that exert a particular large influence on them (e.g., stress from disease or war), then the environmental effects in this group will be relatively large and h^2 will be relatively small (Grigorenko, 2002). Second, the heritability coefficient does not indicate the degree to which genetics accounts for the fact that a particular individual has a particular characteristic. It is a measure of variation in the population. For some attributes (e.g., a biological feature or psychological capacity possessed by all humans), there may be no person-to-person variation. The h^2 would be zero even if genetics explains why all people have the attribute. For other attributes (e.g., your ability to read), the attribute may be explained by an interaction of genetic and social factors, and it may make little sense to say that genetics versus the environment each accounted for X percent of the attribute. The h^2 is an estimate associated with a population and not a definitive measure of the action of genes.

Heritability of Personality: Findings

We now consider additional behavioral genetic findings and the conclusions about personality to which they lead. An interesting feature of work in this area is that findings are often relatively consistent from study to study. This enables the behavioral geneticist to summarize results with confidence. Here are two quotes featuring key summaries: "It is difficult to find psychological traits that reliably show no genetic influence" (Plomin & Neiderhiser, 1992) and "For almost every behavioral trait so far investigated, from reaction time to religiosity, an important fraction of the variation among people turns out to be associated with genetic variation. This fact need no longer be subject to debate" (Bouchard et al., 1990). These quotes reflect findings from numerous twin and adoption studies. These studies have been conducted on a wide variety of personality variables, often with large samples of research participants, and with the work extending over significant periods of time. The evidence of genetic influence is sometimes startling, as when identical twins reared apart and brought together as adults are found not only to look and sound alike but to have the same attitudes and share the same hobbies and preferences for pets (Lykken, Bouchard, McGue, & Tellegen, 1993). But beyond such almost eerie observations is a pattern of results strongly suggesting an important role for heredity in almost all aspects of personality functioning (Plomin & Caspi, 1999). Recent estimates of the overall heritability of personality traits converge on roughly 40%. Table 9.2 presents heritability estimates for a wide variety of characteristics. For comparative purposes, heritability estimates for height and weight are included, as well as a few other characteristics that may be of interest.

A criticism made of behavior-genetic research on personality is that most studies are based on self-report questionnaire methods. A recent study is important in this regard in that two independent peer reports as well as self-reports on the NEO Five-Factor Inventory were collected on a sample of 660 MZ twins and 304 DZ twins (200 same sex and 104 opposite sex). The investigators found good evidence of reliability of ratings in terms of peer–peer rating agreement, good evidence of the accuracy of self-report in terms of self-peer rating agreement, and general support for earlier findings concerning genetic influence on all of the Big Five personality factors (Table 9.3) (Riemann, Angleitner, & Strelau, 1997).

Table 9.2 Heritability Estimates

The data indicate a strong genetic contribution to personality (overall estimate of 40% of the variance), a contribution not as large as that for height, weight, or IQ but larger than that for attitudes and behaviors such as TV viewing.

Trait	h^2 *estimate*
Weight	.60
IQ	.50
Specific cognitive ability	.40
School achievement	.40
BIG FIVE	
Extraversion	.36
Neuroticism	.31
Conscientiousness	.28
Agreeableness	.28
Openness to experience	.46
EASI TEMPERAMENT	
Emotionality	.40
Activity	.25
Sociability	.25
Impulsivity	.45
ATTITUDES	
Conservatism	.30
Religiosity	.16
Racial integration	.00
TV viewing	.20

NOTE: EASI = Four dimensions of temperament identified by Buss and Plomin (1984). E, Emotionality; A, Activity; S, Sociability; I, Impulsivity.
SOURCE: Bouchard et al., 1990; Dunn & Plomin, 1990; Loehlin, 1992; McGue et al., 1993; Pedersen et al., 1998; Pedersen et al., 1992; Plomin, 1990; Plomin et al., 1990; Plomin & Rende, 1991; Tellegen et al., 1998; Tesser, 1993; Zuckerman, 1991.

Some Caveats

Before concluding this section, we warn against two inappropriate conclusions that might otherwise be drawn from the behavioral genetic data. One is that heritability coefficients indicate the extent to which a characteristic is determined by heredity for a given individual. A heritability estimate of, for example, 40% for a personality trait does not mean that 40% of your own, individual personality trait is inherited. The heritability estimate is a population statistic; it describes variation *between* people in the overall population. At the level of the individual person, psychological traits commonly involve such an interplay of biology and experience that it is not meaningful to say that "X%" of an individual's trait is due

Table 9.3 Peer–Peer, Self–Peer, MZ and DZ (Self-Report), and MZ and DZ (Average Peer Report) Correlations on the NEO Five-Factor Inventory

	Peer–Peer	*Self–Peer*	*Self-Report*		*Averaged Peer Report*	
			MZ	DZ	MZ	DZ
N	.63	.55	.53	.13	.40	.01
E	.65	.60	.56	.28	.38	.22
O	.59	.57	.54	.34	.49	.30
A	.59	.49	.42	.19	.32	.21
C	.61	.54	.54	.18	.41	.17
Mean	.61	.55	.52	.23	.40	.18

NOTE: MZ, monozygotic; DZ, dizygotic.
SOURCE: Adapted from Riemann, Angleitner, & Strelau, 1997, pp. 460, 461, 462.

to one factor or another. (See discussions of gene–environment interaction and biological plasticity, below.)

A second inappropriate conclusion would be that, because a characteristic has an inherited component, it cannot change. In reality, environmental experiences can alter even highly heritable qualities. Height is significantly determined by genes, but can be influenced by environmental nutrition in childhood. Individual differences in weight are influenced by genes, yet your weight can vary greatly depending on your diet.

Molecular Genetic Paradigms

Researchers have moved beyond the traditional behavior-genetic paradigm. Instead of merely comparing different types of twins, they have turned to a direct examination of the underlying biology. This work employs molecular genetic techniques in an effort to identify specific genes that are linked with personality traits (Plomin & Caspi, 1999). By examining the genetic material of different individuals, researchers hope to show how genetic variations, or alleles, relate to individual differences in personality functioning. Ideally, one might be able to show how a genetic variation codes for alternative forms of a biological substance or system that, in turn, has psychological effects.

Initial research reported the discovery of a gene linked to the trait of novelty seeking, similar to Eysenck's P factor, and to low C on the Big Five (Benjamin et al., 1996; Ebstein et al., 1996). However, this finding has not been replicated uniformly in follow-up studies (Grigorenko, 2002). Perhaps more promising, researchers recently have identified an interaction between a specific genetic mechanism and the social environment. This research studied the effects of maltreatment in childhood on the development of antisocial behavior later in life (Caspi et al., 2002). Despite such unfortunate maltreatment, some children have good developmental outcomes; they seem to be resilient in the face of early life stress. The question, then, was whether there might be a genetic basis to this resilience.

To answer this question, the researchers identified a subset of the study's population of participants who possessed a gene that has an important property: It codes for an enzyme that lowers the activity of certain neurotransmitters in the brain that are linked to aggressive behavior. Among those who had experienced maltreatment in childhood, people with this genetic variation were found to differ from others (Figure 9.6). Specifically, people who experienced severe maltreatment but who had the gene that produced high levels of the enzyme were less likely to display antisocial behavior in adulthood. The genetic variation, in other words, seemed to lower the negative impact of maltreatment. This exciting finding requires replication. However, it suggests a promising feature for molecular genetic research on personality.

Subsequent work by this same research team has discovered molecular genetic factors that make individuals more or less vulnerable to becoming depressed (Caspi et al., 2003). The genetic factor that was studied is one that influences levels of serotonin in the brain. Specifically, the researchers studied a naturally occurring genetic variation that involves two different versions of a gene that affects serotonergic activity. The researchers' expectation was not that possessing a particular genetic background would lead inevitably to the experience of depression. Instead, they again expected an interaction: Genes should predict the onset of depression only in people who have certain types of environmental experiences. The environmental experiences they investigated were those that involve high levels of stress. Adults were surveyed to determine the degree to which they recently had experienced stressful life events involving factors such as finances, health, employment, and interpersonal relationships. The expectation of a gene X–environment interaction was confirmed. Individuals who were genetically predisposed to have lower levels of serotonergic activity and who experienced numerous stressful life events were much more likely to become depressed than

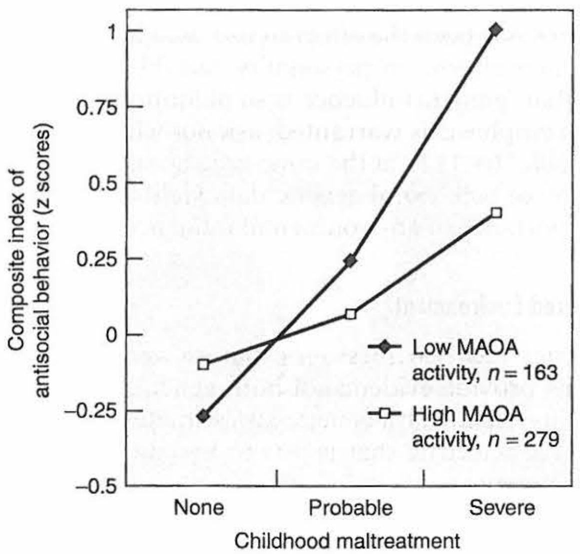


Figure 9.6 *Relations between antisocial behavior and both levels of childhood maltreatment and MAOA activity, which varies as a result of varying alleles of a particular gene.*

From Caspi et al., 2002.

were other individuals (Caspi et al., 2003). Again, then, molecular genetic research indicates that genes affect psychological outcomes in interaction with environmental experiences.

ENVIRONMENTS AND GENE–ENVIRONMENT INTERACTIONS

Genetic researchers realized early on that genetic and environmental influences are inextricably linked and interact in their influence on personality and behavior in adulthood. A classic study by Cooper and Zubek (1958) nicely illustrates such gene–environment interactions using the selective breeding research. In previous research, strains of maze-bright and maze-dull rats had been bred so that the strain of "bright" ones were much more likely to learn how to navigate a maze than were the "dull" ones. The researchers wanted to study how early environment experiences would influence the adult problem-solving capacity of these genetically different rats. Thus, they raised one group of each strain in an enriched, stimulating environment and another group of each strain in an impoverished environment. What happened? Compared to the normal lab environment, the enriched environment improved later learning ability in the dull rats but did not help the bright ones. Conversely, the impoverished environment markedly handicapped the bright rats but did not impair the dull group. Thus, even though these rats were not "prisoners" of their genetic predispositions, the environment interacted with their genes in a crucial way, modifying the way these predispositions were expressed.

For human personality, if the behavioral genetic data indicate that roughly 40 to 50% of the variance for single personality characteristics and personality overall are determined by genetic factors, then the rest of the population variance is made up of some combination of environmental effects and measurement error. Indeed, one interesting aspect of recent developments in behavioral genetics has been the effort to use twin and adoption data to determine environmental effects on personality variables. Thus, although Plomin (1990) suggests that "genetic influence is so ubiquitous and pervasive in behavior that a shift in emphasis is warranted: ask not what is heritable; ask instead what is not heritable" (p. 112), at the same time he suggests that the "other message is that the same behavioral genetic data yield the strongest available evidence for the importance of environmental influence" (p. 115).

Shared and Nonshared Environment

Behavioral genetics has two messages: nature and nurture (Plomin, 1990). Research findings provide evidence of both genetic and environmental influence on personality. Behavioral geneticists estimate not only the proportion of variability in a characteristic that is due to heredity, but also the proportion due to the environments.

Behavioral genetic research identifies environmental influences of two types: *shared* and *nonshared*. Shared environments are environmental influences that make siblings more alike (e.g., experiencing similar events while growing up in the same family). Nonshared environments are ones that create differences among siblings who grow up in the same family (e.g., siblings may be treated differently by parents or may develop different friendship patterns that affect their social development).

Robert Plomin.

Behavioral geneticists compute numerical estimates of genetic, shared-environmental, and nonshared-environmental influences on individual differences. They most commonly do so by studying the similarity of identical and fraternal twins. Their studies yield a surprising finding about environments. Shared environmental effects on personality are negligible; nonshared effects are large. Put differently, the unique experiences siblings have inside and outside the family appear to be far more important for personality development than the shared experiences resulting from being in the same family. Literature reviews indicate that roughly 40% of the variability in personality trait is due to environmental factors that cause people—even people who grow up in the same household—to differ (Dunn & Plomin, 1990; Plomin & Daniels, 1987).

Loehlin, McCrae, Costa, and John (1998) examined genetic and environmental effects in three different measures of the Big Five, with results generally


Corbis Stock Market.

Why Children from the Same Family Are So Different: Each sibling experiences a different, unique family environment.

consistent with the above conclusions. Three findings stood out. First, all five of the Big Five dimensions showed substantial genetic influences of the same magnitude; that is, individual differences in A, C, and O were just as heritable as individual differences in E and N, which had been studied extensively in the context of Eysenck's model of these two superfactors (see Chapter 7). Second, these findings were independent of the effects of intellectual ability, which had also been measured and were controlled in the behavior-genetic analyses; that is, Openness was found to be a personality dimension independent of intelligence, with its own genetic basis. Third, from a methodological perspective, having available three measures for each Big Five factor made it possible to test generalizability across instruments and to estimate error separately, rather than including it with the estimate of nonshared environment as in some previous research.

In an analysis of the data from the self-peer ratings of MZ and DZ twins on the NEO scale (Riemann, Angleitner, & Strelau, 1997), Plomin calculated the percentage of the variance due to genetic factors, shared environments, and nonshared environments (including measurement error) for both self and peer ratings on the Big Five. The resulting percentages closely approximate those reported earlier, although the percentages for genetic factors tend to be lower for peer ratings than for self-ratings (Figure 9.7) (Plomin & Caspi, 1999, p. 253).

Understanding Nonshared Environment Effects

These findings suggest that differences among families seem to matter less for the development of children than do differences within families. Recent research (Reiss, 1997; Reiss, Neiderhiser, Hetherington, & Plomin, 1999) has begun to focus on the particular processes linking genetic, family, and social influences on personality development during the important years of adolescence. This work focuses on the unique relationship between the parent and each adolescent sibling in terms of conflict and negativity, warmth and support, and so forth. In

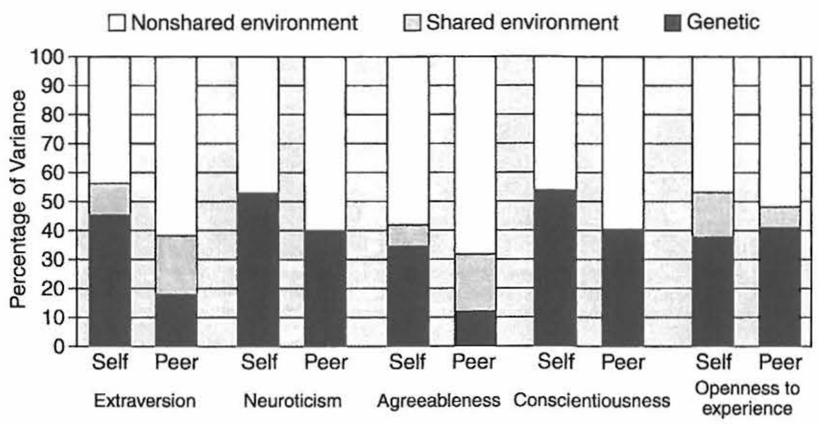


Figure 9.7 *Genetic (blue), shared environment (gray), and nonshared environment (white) components of variance for self-report ratings and peer ratings for the Big Five personality traits. Nonshared environment effects include error of measurement.*

(Plomin & Caspi, 1999, p. 253.) Copyright © Guilford Press. Reprinted by permission.

other words, the research seeks to separate out the effects of parenting common to siblings in a family from the effects of parenting unique to each sibling. The evidence to date shows substantial differences in the way siblings are treated by their parents. What is striking, however, is that much of the parenting unique to each child seems to be due to the genetic characteristics of that child. That is, differences in the way parents treat each child seem to be due to different behaviors evoked in the parent by that child, in line with earlier suggestions that children from the same family grow up to be different in part because of genetic differences that lead them to be treated differently by the parents. Most students with siblings can readily testify to such differences in parental treatment!

Does the finding that children from the same family differ due to nonshared environments mean that family experiences are unimportant? Not necessarily. Family influences may be very important, but may also be unique to each child rather than shared by children in the same family. Rather than the family unit being the sole focus of study, researchers must focus on the potentially unique experiences of each child in the family.

Three Kinds of Nature–Nurture Interactions

Until now we have considered the effects of genes and environment on personality separately. However, nature and nurture always are interacting with one another: "The critical point to remember in all of this is that in the dance of life, genes and environment are absolutely inextricable partners" (Hyman, 1999, p. 27). Along with the continuous unfolding of the effects of genes and experience, three particular forms of gene–environment interactions have been distinguished (Plomin, 1990; Plomin & Neiderhiser, 1992). First, the same environmental experiences may have different effects on individuals with different genetic constitutions. For example, the same behavior on the part of an anxious parent may have different effects on an irritable, unresponsive child than on a calm, responsive child. Rather than a straightforward effect of parental anxiety that is the same for both kinds of children, there is an interaction between parental behavior and child characteristic. In this case the individual is a passive recipient of environmental events. Genetic factors are interacting with environmental factors but only in a passive, reactive sense.

In a second kind of nature–nurture interaction, individuals with different genetic constitutions may evoke different responses from the environment. For example, the irritable, withdrawn child may evoke a different response from the parent than will a calm, responsive child. Within the same family, siblings can evoke different parental behaviors that then set in motion two completely different patterns of parent–child interaction. Such differences were indicated in the research considered earlier on differential parental treatment of siblings associated with genetic differences in the children. Beyond this, differences in inherited characteristics lead to different responses from peers and others in the environment outside the family. Attractive children call forth different peer responses than do less attractive children. Athletic children call forth different responses than do unathletic children. In each case, a genetically determined characteristic evokes a differential response from the environment.

In the third form of gene–environment interaction, individuals with different constitutions select and create different environments. Once the individual is able to take an active form of interaction with the environment, which occurs at a fairly early age, genetic factors influence the selection and creation of environments. The extravert seeks out different environments than does the introvert, the athletic individual different environments than the unathletic individual, and the musically gifted individual different environments than the individual gifted in visual imagery. These effects increase over the course of time as individuals become increasingly able to select their own environments. By a certain point in time, it is impossible to determine the extent to which the individual has been the "recipient" as opposed to the "creator" of the environmental effect.

In sum, individuals can be relatively passive recipients of environments, they can play a role in environmental events through the responses they evoke, and they can play an active role in selecting and creating environments. In each case, there is a nature–nurture, gene–environment interaction. In considering the nature and nurture of personality, we must keep in mind that the development of personality is always a function of the interaction of genes with environments, that there is no nature without nurture and no nurture without nature. We can separate the two for purposes of discussion and analysis, but the two never operate independently of one another. Indeed, genetic factors and environmental experiences are so intertwined that the usual formulation "nature versus nurture" may not even make sense any more. Instead, it may be better to think of "via nurture" (Ridley, 2003). The basic nature of genetic material, in other words, is that it "creates now possibilities for the organism" (Ridley, 2003, p. 250) that are realized only if the organism encounters particular environments—that is, only if it is nurtured in a particular way.

MOOD, EMOTION, AND THE BRAIN

All personality theorists are interested in mood and emotion. Freudians view emotional life as an expression of basic bodily instincts. Trait theorists see individual differences in mood as being at the heart of many personality traits. In the chapters ahead, you will see that behaviorists alter emotional responses through learning experiences, and that cognitive and social-cognitive theorists, like humanistic theorists, posit that people's beliefs about themselves and the world shape their emotional life.

Here, in our chapter on biological foundation, we ask: What are the neural and biochemical bases of individual differences in emotional experience?

LEFT AND RIGHT HEMISPHERIC DOMINANCE

If you look at a brain, its most obvious anatomical feature is that it is comprised of two halves, or hemispheres. Research pioneered by the psychologist Richard Davidson (1994, 1995, 1998) reveals *hemispheric dominance* in emotion. The left and right hemispheres are active to different degrees in different emotional states, with the left (right) hemisphere dominating in activation during positive (negative) emotional states.

Evidence of this finding comes from EEG methods (see Chapter 2). In one study, EEG recordings of hemispheric activity were taken before and during the showing of film clips designed to elicit positive or negative emotion. Participants also rated their moods during the films. EEG measures of hemispheric dominance related closely to the psychological experience of mood.

CURRENT APPLICATIONS

CAUSES OF INDIVIDUAL DIFFERENCES: GENES, SOCIAL EXPERIENCE—OR SOMETHING ELSE?

Psychology's most famous question—"Nature or Nurture?"—suggests that there are two causes of behavior: (1) information encoded into the genes from the moment of conception, and (2) information acquired via social experience after one is born. Much of psychology's inquiry into the determinants of individual differences rests on this dichotomy between biological/genetic/nature factors and social/learned/nurture factors.

However, there is something else to consider: the prenatal environment, that is, the environment experienced after conception and before birth. Startling findings document a role for prenatal factors in determining a psychological quality of great interest, namely, sexual orientation.

One correlate of sexual orientation among males is the number of older brothers he has. Males who have more older brothers are, on average, somewhat more likely to have a homosexual rather than heterosexual orientation. (Note that this statement only holds on average: that is, it is a probabilistic statement that describes a pattern of results found only when one studies large numbers of men.)

This basic finding, in fact, characterizes most of the research that Anthony Bogaert and his colleagues (1996) conducted over many years on sexual orientation and the FBO hypothesis (i.e., fraternal birth order). The early studies also revealed that the FBO effect alone might characterize the sexual orientation of men with *older brothers*: that is, men's sexual orientation does not seem to be affected by the number of *older sisters*, nor is *sisters' sexual orientation* affected by the number or type of older siblings (being the brothers or sisters).

A question, then, is why this might be the case. What might link sexual orientation to the number of older brothers one has? One possibility is social experience: maybe social interactions with large numbers of older males somehow influences sexual orientation. This, however, is *not* what research findings suggest.

In an additional and critical piece of research (Bogaert, 2006), the sexual orientation of males who were raised with varying numbers of older brothers living in their homes was compared against the sexual orientation of a key comparison group: males who had the same number of older brothers, but whose brothers did *not* live in their households (e.g., people who were adopted or some of whose siblings were adopted). The findings revealed that sexual orientation was predicted by the number of older siblings one had *whether or not* those siblings grew up in one's own household! Males with more older brothers were, probabilistically, more likely to have a homosexual orientation even in cases in where they were not raised with those older brothers.

How can this be? Bogaert and his colleagues suggest that the FBO effect on male homosexual orientation operates during prenatal life (i.e., the prenatal environment), rather than during childhood or adolescence. Note that this hypothesis implies a biological explanation that partly interacts with environmental prenatal conditions or contingences. There is indirect evidence of this hypothesis. The FBO effect seems to primarily characterize *right-handed* men's sexual orientation (2007). Since hand preference is a marker of prenatal development, the evidence of an FBO–hand preference relation is consistent with the hypothesis that the FBO effect operates prenatally.

What are the exact prenatal environment's mechanisms or processes regulating the FBO effect on the sexual orientation of males with varying numbers of older brothers? In a recent review (2011), Bogaert & Skorska clarify the terms of their "Maternal Immune Hypothesis (MIH)" of male sexual orientation development. According to these researchers, the FBO effect arises because some mothers develop an immune response to a substance important to male fetus development. Furthermore, this immune effect would increase in likelihood with each male fetus mothers have to gestate, thus accounting for the heightened likelihood of the FBO effect at relatively higher numbers of older brothers.

The MIH hypothesis rests on the possibility that, prenatally, mothers and male fetuses are both agents and targets of a biochemical process that eventually affects the male fetuses' brain development and sexual orientation. Presumably, the process would begin when cells/biochemical substances from a male fetus enter a mother's circulation during pregnancy or childbirth. Being from a male fetus, these cells are antigenic to the mother who, eventually, develops antibodies to these substances. These antibodies are anti-male and they, in turn, may enter into a male fetus's circulation and blood/brain barriers, altering the typical development of brain areas and structures that are partly responsible for male sexual orientation. The MIH hypothesis also argues that this immune response process significantly increases its likelihood with increases in the number of male pregnancies the maternal immune system has had to face, thus accounting for the heightened FBO effect in young males with a relatively high numbers of older brothers.

Although the MIH hypothesis and research findings are partly speculative and require further research, this work does indicate a significant influence of prenatal factors on sexual orientation. In so doing, it has expanded the scope of factors that must be considered in analysis of personality development.

SOURCE: Blanchard & Bogaert (1996); Bogaert (2007, 2006); Bogaert & Skorska (2011).

"Those individuals with more left-sided prefrontal activation at baseline reported more positive affect to the positive film clips and those with more right-sided prefrontal activation reported more negative affect to the negative film clips. These findings support the idea that individual differences in electrophysiological measures of prefrontal activation asymmetry mark some aspect of vulnerability to positive and negative emotion elicitors" (Davidson, 1998, p. 316).

What about stable individual differences in the experience of positive and negative mood? Currently depressed and previously depressed individuals are found to have decreased left-anterior cortical activity relative to nondepressed individuals (Allen, Iacono, Depue, & Arbisi, 1993). Individuals with damage to the left-anterior brain region are likely to become depressed, whereas those with damage to the right-anterior brain region are likely to become manic (Robinson & Downhill, 1995). Research on infants suggests a relation between individual differences in measures of prefrontal activation and affective reactivity, with infants experiencing greater distress upon separation from their mothers showing greater right-sided prefrontal activation and less left-sided prefrontal activation than infants who showed little distress in this situation (Davidson & Fox, 1989).

EEG measures can differentiate between two different aspects of emotional experience that are both negative: anxious arousal during a task and worrying prior to a task (Heller, Schmidtke, Nitschke, Koven, & Miller, 2002). Worrying is associated with stronger left-frontal brain activation than is anxious arousal (e.g., Hofmann et al., 2005). Worrying, then, is "a unique emotional state" (Hofmann et al., 2005, p. 472) and not just a variation on the state of anxious arousal during a task. This finding from neuroscience has interesting implications for the personality trait theories. The five-factor trait of neuroticism combines different aspects of anxiety into one factor, whereas this neuroscientific evidence indicates the existence of different types of negative emotion that truly are distinct.

Research on the emotion of anger has caused psychologists to modify the original idea that left/right hemispheric dominance is associated with variations in the valence of mood, that is, its positivity/negativity. Anger is a negative emotion. It arises in response to negative events, and people feel that it is an aversive state (compared to, e.g., calmness or happiness). But higher levels of anger are associated with *left* hemisphere activation (Harmon-Jones, 2003), the hemisphere previously associated with positive moods. This finding suggests that hemispheric dominance relates most closely to approach and avoidance motivation, that is, the motivation to move toward (approach) or away from (avoid) a stimulus. Both positive states such as happiness and the negative state of anger entail a behavioral approach: When happy, you approach an object to enjoy an interaction with it; when angry, you approach it to confront it.

NEUROTRANSMITTERS AND TEMPERAMENT: DOPAMINE AND SEROTONIN

The brain's neurons communicate using neurotransmitters. Much research links variations in neurotransmitter activity to individual differences in mood. Of the brain's various neurotransmitters, the two that have received most attention in the study of mood and personality are dopamine and serotonin.

An excess in the neurotransmitter dopamine is implicated in schizophrenia, while an underproduction of dopamine is implicated in Parkinson's disease. Dopamine also is associated with pleasure, being described as a "feel good" chemical (Hamer, 1997). Animals will perform responses that lead to administration of dopamine (Wise, 1996). Thus, dopamine appears to be central to the functioning of the reward system: "One way of characterizing the job of this dopamine circuit is that it's a reward system. It says, in effect, "That was good, let's do it again, and let's remember exactly how we did it" (Hyman, 1999, p. 25). Addictive drugs such as cocaine are viewed as "masquerading" as the neurotransmitter dopamine, leading to the experience of pleasure upon taking the drug but also to the experience of a low as the cocaine stops coming and the dopamine level drops.

The neurotransmitter serotonin also is involved in regulation of mood. Modern drugs, known as SSRIs (selective serotonin reuptake inhibitors), are thought to alleviate depression by prolonging the action of serotonin at the synapses of neurons. SSRIs administered to normal individuals have been found both to reduce negative affective experience and to increase social, affiliative behavior (Knutson et al., 1998). Finally, we know that the hormone cortisol is associated with the stress response. Again returning to Kagan's (1994) research, inhibited children at the age of five were found to be high in reactivity to threat, as measured by cortisol response, although this was not as true at age seven.

The fact that neurotransmitters contribute to mood suggests that an analysis of brain chemistry can illuminate the topic with which we began this chapter: individual differences in temperament. Numerous investigators have explored the potential biochemical bases of temperament (Cloninger, Svrakic, & Przybeck, 1993; Depue, 1995, 1996; Depue & Collins, 1999; Eysenck, 1990; Gray, 1987; Pickering & Gray, 1999; Tellegen, 1985; Zuckerman, 1991, 1996). Although similarities appear among almost all of these models, and many are similar to the five-factor model described in Chapter 8, they do not always overlap in clear ways with one another. Thus, rather than exploring a number of such models, we will follow the lead of Lee Anna Clark and David Watson (1999; Watson, 2000) in their analysis of personality temperament.

Three Dimensions of Temperament: PE, NE, and DvC

According to Clark and Watson's (1999) model, individual differences in temperament can be summarized in terms of three big superfactors similar to those suggested by Eysenck and also corresponding, roughly, to three of the Big Five dimensions: NE (Negative Emotionality), PE (Positive Emotionality), and DvC (Disinhibition versus Constraint). Individuals high on the NE factor experience elevated levels of negative emotions and see the world as threatening, problematic, and distressing, whereas those low on the trait are calm, emotionally stable, and self-satisfied. The PE factor relates to the individual's willingness to engage the environment, with high scorers (like extraverts) enjoying the company of others and approaching life actively, with energy, cheerfulness, and enthusiasm, whereas low scorers (like introverts) are reserved, socially aloof, and low in energy and confidence. It is important to note that although NE and PE have opposite-sounding qualities, they are independent of one another; that is, an individual can be high or low on each (Watson & Tellegen, 1999; Watson, Wiese, Vaidya, & Tellegen, 1999). This is because they are under the control of different internal biological systems. The third factor, DvC, does not involve affective tone, as was true for the first two factors, but rather relates to style of affective regulation, with high DvC scorers being impulsive, reckless, and oriented toward feelings and sensations of the moment, whereas low scorers are careful, controlled by long-term implications of their behavior, and avoiding risk or danger.

The question, then, is whether one can identify biological correlates of the three factors. Building on work by Depue (1996; Depue & Collins, 1999), Clark and Watson suggest that PE is associated with the action of dopamine, the "feel good" chemical. In animal research, high dopamine levels are associated with approach behaviors, whereas deficits in this neurotransmitter are associated with deficits in incentive motivation. In all, Clark and Watson suggest that "individual differences in the sensitivity of this biological system to the signals of reward that activate incentive motivation and positive affect, and supportive cognitive processes, form the basis of the PE dimension of temperament" (1999, p. 414). Differences in hemispheric lateralization, with high PE scores being associated with left hemispheric dominance, may also be involved (Davidson, 1994, 1998).

Turning to DvC, Clark and Watson suggest that the biological basis of this factor is serotonin. According to them, humans low in this neurotransmitter tend to be aggressive and to show increased use of dopamine-activating drugs such as alcohol. Alcoholism also is associated with reduced serotonin functioning. Hamer (1997) also associates the neurotransmitter dopamine with thrill seeking, impulsivity, and disinhibition. There also is evidence that high levels of the hormone testosterone are associated with competitiveness and aggressiveness, both linked with high scores on DvC.

Clark and Watson suggest that less is known about the neurobiology underlying NE. However, there is a relation between low serotonin levels at the neuron synapses and depression, anxiety, and obsessive-compulsive symptoms. Hamer and Copeland (1998) relate low serotonin levels to a dark view of the world, analogous to Galen's melancholic temperament. Depue (1995) reports that animals low in serotonin are excessively irritable, and Hamer (1997) describes serotonin as the "feel bad" chemical. In addition, there is the evidence noted of a relation between right hemispheric lateralization and the tendency to experience negative emotions. Finally, there is evidence that excessive sensitivity of the amygdala likely plays a role in the tendency to experience high levels of anxiety and distress (LeDoux, 1995, 1999).

In assessing this work, one must recall that there is no one-to-one correspondence between biological processes and personality traits. Rather, each biological component appears to be associated with the expression of more than one trait, and the expression of each trait is influenced by more than one biological factor: "Models of personality based on only one neurotransmitter are clearly too simplistic and will require the addition of other modifying factors" (Depue & Collins, 1999, p. 513). Thus, it is difficult to integrate all these neurobiological findings into the three-dimensional temperament model because we risk oversimplifying the neurobiology we know so far. The links between biology and temperament suggested in Table 9.4 are best described

Table 9.4 Suggested Links Between Biology and Personality

Amygdala Part of the primitive limbic system, the brain's emotional response center. Particularly important for aversive emotional learning.

Hemispheric Lateralization Dominance of the right frontal hemisphere associated with activation of negative emotions and personality traits of shyness and inhibition; dominance of the left frontal hemisphere associated with activation of positive emotions and personality traits of boldness and disinhibition.

Dopamine A neurotransmitter associated with reward, reinforcement, pleasure. High dopamine levels are associated with positive emotions, high energy, disinhibition, and impulsivity. Low dopamine levels are associated with lethargy, anxiety, and constriction. Animals and people will self-administer drugs that trigger the release of dopamine.

Serotonin A neurotransmitter involved in mood, irritability, and impulsivity. Low serotonin levels are associated with depression but also with violence and impulsivity. Drugs known as SSRIs (selective serotonin reuptake inhibitors) (e.g., Prozac, Zoloft, Paxil) are used to treat depression as well as phobias and obsessive-compulsive disorders. Exactly how they operate is not totally clear.

Cortisol A stress-related hormone secreted by the adrenal cortex that facilitates reactions to threat. Although adaptive in relation to short-term stress, responses to long-term, chronic stress can be associated with depression and memory loss.

Testosterone A hormone important in the development of secondary sex characteristics and also associated with dominance, competitiveness, and aggression.

SOURCE: Hamer & Copeland, 1998; Sapolsky, 1994; Zuckerman, 1995.

as initial hypotheses, as our best guesses of how things might hang together, to be tested further and revised as more data become available.

In addition, although brain localization of functions has advanced significantly, it is important to consider the brain as a total system. According to Damasio (1994), Gall was correct in suggesting that the brain consists of subsystem parts that are specialized in the functions they serve, as opposed to being one large, undifferentiated mass. However, not only was Gall not able to identify correctly the parts and functions, he was unaware of how the brain functions as a system. As Damasio puts it: "I am not falling into the phrenological trap. To put it simply: The mind results from the operation of each of the separate components, and from the concerted operation of the multiple systems constituted by those separate systems" (1994, p. 15). There is both differentiation–localization and organization–system. In sum, personality traits are linked with the functioning of the patterning of elements in the biological system rather than by single elements: "Psychobiology is not for seekers of simplicity" (Zuckerman, 1996, p. 128).

PLASTICITY: BIOLOGY AS BOTH CAUSE AND EFFECT

When thinking about biology and personality, two thoughts are common: (1) biology is fixed—determined by genes and unchanging over time, and (2) in cause-effect relationships involving biology and experience, biology is a cause and psychological experience is its effect.

These two thoughts are only partly correct. Biology can change, and it changes, in part, as a result of behavioral experience. The capacity of biological systems to change as a result of experience is called plasticity. Like plastic, biology can be shaped and molded.

FROM EXPERIENCE TO BIOLOGY

Both neural systems and neurotransmitter systems display plasticity (Gould, Reeves, Graziano, & Gross, 1999; Raleigh & McGuire, 1991). For example, although leadership in a monkey hierarchy is associated with high levels of serotonin, if the troop is reorganized so that leadership ranks are reversed, the new leaders develop higher levels of serotonin than when they were on the bottom (Raleigh & McGuire, 1991). Similarly, the relation between testosterone and aggression or competitiveness is bidirectional, with high testosterone facilitating greater aggression and competitiveness but competition and aggression also increasing testosterone levels (Dabbs, 2000). Not only does losing a competitive sports event lower testosterone levels, but rooting for a loser does, too (McCaul, Gladue, & Joppe, 1992). Merely winning in a coin toss can increase testosterone levels (Gladue, Boechler, & McCaul, 1989). Hamer and Copeland (1998) are led to conclude that "from song birds to squirrels, and mice to monkeys . . . winners get a blast of testosterone; losers get a drain. Humans are the same" (p. 112).

Experimental evidence showing the influence of experience on the brain comes from research employing a simple task: juggling (Draganski et al., 2004). After obtaining anatomical depictions of the brains of a group of research participants, Draganski and colleagues asked half, selected randomly, to learn how to juggle. These participants learned a simple three-ball juggling routine over a period of 3 months. At the end of this time period, both groups, jugglers and nonjugglers, returned to the lab for a second brain scan. Brain imaging revealed that the experience of juggling changed the anatomy of the brain. Jugglers experienced a significant expansion of gray matter in the brain, in particular in a brain region involved in the perception of motion. The results, the authors note, "contradict the traditionally held view that the anatomical structure of the adult human brain does not alter, except for changes in morphology caused by ageing or pathological conditions" (Draganski et al., 2004, p. 311).

In sum, advances in neuroscience are providing exciting evidence of the two-way-street that runs between biology and experience. Future years surely will expand our understanding of the biological bases of personality functioning, and of social and experiential contributions to the biology of the individual.

SOCIOECONOMIC STATUS OF COMMUNITIES AND SEROTONIN

Research on biological plasticity is important to society at large. Findings illustrate that biology is not a fixed feature of a person or group of persons. The biology of a group of people living in a particular environment may reflect not only inherent features of that group, but also the influence of the environment in which they happen to live. Consider the influence of socioeconomic status.

As we have stated, serotonin is a neurotransmitter important to emotional life. People's levels of serotonergic activity in the brain differ, and these differences are linked to emotional experience, including the experience of depression. An important question, then, is where do these differences come from?

Surely genetic factors play a role in producing the observed differences in serotonergic activity among people. Yet a recent research team (Manuck et al., 2005) looked at an entirely different factor. They speculated that differences in serotonin functioning could result from differences in socioeconomic status (SES). People in economically advantaged versus disadvantaged neighborhoods experience different factors in their daily lives (Gallo & Matthews, 2003). In economically poorer neighborhoods, people tend to experience higher levels of daily stress and may on average also experience lower levels of nutrition. Since the body responds to both nutrition and stress, these external environmental factors could affect internal biology, including serotonergic activity.

To test for this possibility, the researchers (Manuck et al., 2005) asked a large sample of adults to participate in a laboratory study. Participants were asked to ingest a serotonin agonist, an "agonist" being a substance that mimics the action of another substance. In this case, since the researchers were interested in serotonin, they used a substance that is a serotonin agonist. After this substance was administered, the researchers took a blood sample and measured levels of a hormone, prolactin. Prolactin is of interest because serotonin stimulates the release of prolactin in the body. The great advantage of this research paradigm is that it allowed the investigators to examine, very directly, the possibility that people living in different socioeconomic neighborhoods would have different biological functioning—specifically, that they would differ in peak prolactin levels, which are a direct indication of the body's responsivity to serotonin.

The findings provide remarkable evidence of socio-community variations in the functioning of a biological system with psychological importance. People who lived in lower socioeconomic neighborhoods displayed lower serotonergic responsivity; this finding held similarly for both women and men (Figure 9.8).

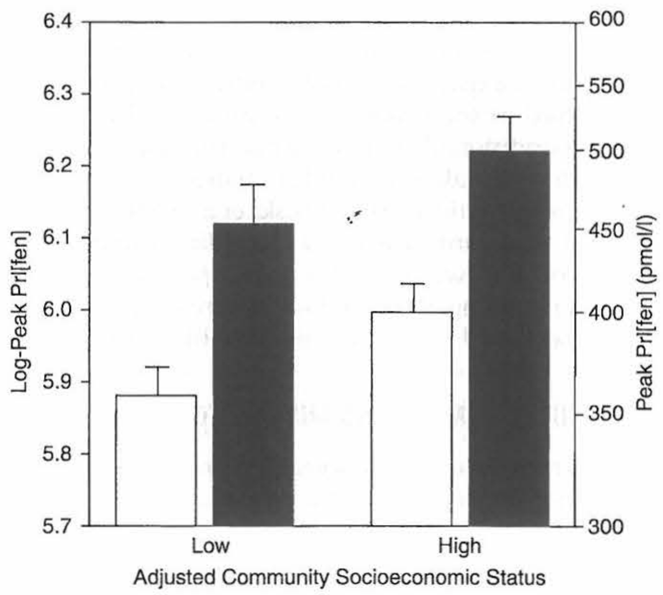


Figure 9.8 *Differences in biological functioning, specifically in peak prolactin levels, among men (white bars) and women (blue bars) living in communities of low and high socioeconomic status. Manuck et al., 2005.*

If you are thinking to yourself, "well, maybe the high-SES people differed on some personality traits from the low-SES people, and that explains the effect," then the news to report is that the researchers tested for this possibility, too. Measures of the five-factor traits, as well as a measure of IQ, were available. The differences between communities were *not* explained by any differences in five-factor traits of intelligence; the biological differences were observed even after statistically controlling for these factors (Manuck et al., 2005). Having ruled out these alternative possibilities, the authors conclude that "socio-economic inequalities among communities can, if perhaps modestly, affect even the neurobiology of their residents." This may help to explain "reported effects of low community SES on the prevalence of psychiatric disorders or behaviors associated with dysregulated central serotonergic function, such as depression, impulsive aggression, and suicide" (Manuck et al., 2005, p. 526).

NEUROSCIENTIFIC INVESTIGATIONS OF "HIGHER-LEVEL" PSYCHOLOGICAL FUNCTIONS

Much of the work we have just reviewed primarily addressed emotional and motivational processes. Investigators have related biological systems to psychological phenomena involving moods, basic impulses, and emotions such as fear. But what about the rest of personality functioning, including "higher-level" psychological functions (e.g., self-concept, morality, etc.)? Those psychological functions also require a biological brain. In principle, then, neuroscience can shed light on these complex psychological functions. We now turn to some recent research that attempts to do just that.

CURRENT QUESTIONS

STRESS AND AGING: HOW DOES IT WORK?

Intuition tells us that one of the most important factors linking personality to biology involves the experience of stress. People who live calm, stress-free lives appear younger. Chronic psychological stress, in contrast, seems to speed up aging. But are these intuitions correct? And if so, how does it work—how is psychological stress linked to biological aging?

A remarkable study of middle-aged women who experienced varying degrees of stress provides concrete answers to these questions (Epel et al., 2004). The key feature of this study was that it included a measure of a biological mechanism that is fundamental to cellular aging. One part of cells are telomeres, which are strands of DNA that form a kind of "cap" at the end of every chromosome. The telomere shortens slightly every time a cell replicates. With age, then, the telomere gets smaller. When the telomere becomes too short, the cell no longer can divide. Telomere length thus is "a bookmarker of a cell's biological (versus chronological) 'age'" (Epel et al., 2004, p. 17312).

What does this fact have to do with stress and personality functioning? The experience of stress affects the body's internal chemistry, including the cellular environment in which telomeres reside. People who are of the same chronological age but who experience different levels of daily stress, then, may have cells with telomeres of different lengths. Epel et al. (2004) hypothesized that stress would have a negative effect on telomere length. It was predicted, in other words, that people who experience high amounts of stress would have shorter telomeres. At a cellular level, they would be biologically older.

How can one test this hypothesis? One challenge is to identify how much stress people are experiencing. The experimenters did this in two ways. First, they included a

Left: Henry Groskinsky/Stringer/ GettyImages; Right: George Tames/ Getty Images.

Photos depict former U.S. president Richard M. Nixon at the inauguration (left photo) and conclusion (right photo) of his presidency, which ended in his resignation from office after the Watergate scandal. At the time of his resignation, Nixon looked decades older than he had at the time of his inauguration, although the events actually were only about six years apart. Research suggests that the stresses of the office may have been responsible for Nixon's rapid biological aging.

measure of perceived stress, that is, a self-report of how much stress one is experiencing. Second, they included in their study groups who differed on an objective life event that is stressful. Some of the women in the study were mothers of children with a chronic illness; thus, day-to-day child care for these women was particularly stressful. A second, "control" group consisted of mothers of healthy children.

The other research challenge is to measure telomere length. This was done through standard biological procedures. Blood samples were taken and analyzed to determine average telomere length for each participant.

The findings revealed a remarkably strong link between stress and telomere length (Figure 9.9). The figure plots telomere length as a function of perceived stress for two groups: the low-stress (white dots) and high-stress (blue dots) mothers. In both groups, higher stress predicted shorter-length telomeres. The highest levels of stress, and many of the shortest telomere lengths, were found in the group of mothers who were caring for a chronically ill child. When telomere lengths were translated into years (i.e., by relating telomere lengths found in the people in this study to data for the population at large), it was found that the effects of stress on aging are huge! High-stress persons showed a cellular age 9 to 17 years older than those who experienced low stress. (You might want to remember this research result the next time a friend suggests that you "chill out.")

In summary, research on environmental stress and telomere length expands psychology's understanding of the ways in which biological systems are "plastic" in response to experience.

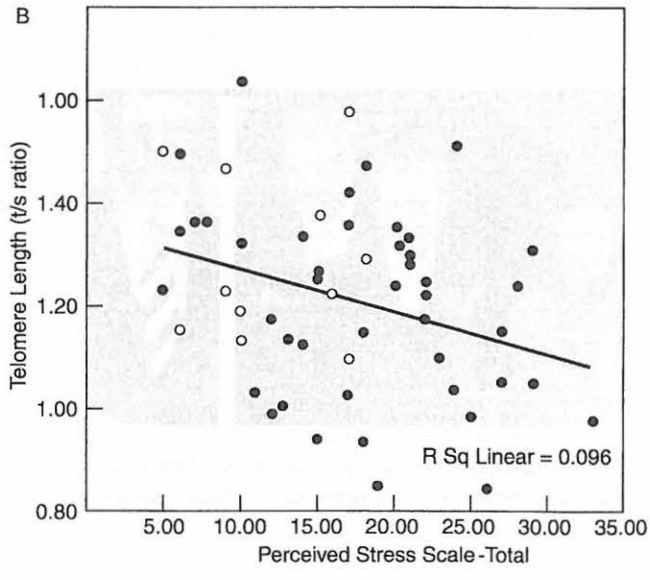


Figure 9.9 *The figure plots telomere length as a function of perceived stress for two groups: the low-stress (white dots) and high-stress (blue dots) mothers.*

BRAIN AND SELF

A uniquely human capacity is the ability to reflect on the self: one's features, potentials, appearance to others, and so forth. A question of basic research interest concerns the nature of this capacity. Does it reflect people's overall cognitive capabilities; in other words, is the self just "one of those things we happen to think about?" Or is it unique? Might there be functionally distinct systems in the brain that come into play when we are thinking about ourselves as opposed to thinking about other people or things?

Recent work (Kelley et al., 2002) has investigated this question by using a brain-imaging technique, fMRI. An fMRI (or functional magnetic resonance imaging) enables researchers to identify specific regions of the brain that are active when people perform a given task. This technique involves analyzing changes in blood flow during task performance. If there is a particularly large change in blood flow in a given brain region during task performance, this provides evidence that the brain region is somehow involved in the performance of that task.

The task that participants performed in the Kelley et al. study (2002) involved the rating of trait adjectives (dependable, polite, etc.). Participants were asked to make three types of ratings about the words. They judged (1) whether the adjective (when presented to them) was in uppercase letters, (2) whether the adjective described George W. Bush, and (3) whether the adjective described themselves. The idea, then, is that some brain regions might be uniquely active when people think about themselves ("am I dependable?") as opposed to another person ("is Bush dependable?") or cues unrelated to a person ("is the word 'dependable' in uppercase type?"). An alternative possibility is that thinking about the self is no different than thinking about other people.

Kelley and colleagues (2002) found that, yes, there are regions of the brain that appear to be uniquely involved in judgments about the self. An area near the front of the brain, specifically the medial prefrontal cortex, or PFC was "selectively engaged during self-referential judgments" (p. 790). Compared to baseline recordings, fMRI recordings during task performance indicated that when participants were not performing the trait-rating task, the PFC was more involved in judgments about the self than about Bush or the typeface of the letters.

Such findings, of course, do not demonstrate that this particular region of the frontal cortex is the biological "home of the self." Judging oneself with respect to trait adjectives is only one aspect of self-concept, and multiple brain regions surely come into play when people engage in any complex mental activity involving self-reflection. Yet, the findings provide intriguing initial evidence that neuroscientific research can inform complex questions about personality functioning. Future years are sure to see growing interest, and scientific evidence, on the question of the neural foundations of self-concept (see, e.g., Churchland, 2002).

BRAIN AND MORAL JUDGMENT

Personality theorists have long been interested in moral judgment. As you have learned, Freud proposed an entire structure of personality, the superego, to explain people's tendency to evaluate the actions of themselves and others according to moral and ethical standards. Moral judgments seem unique not only to the professional personality theorist, but probably also to you, the intuitive personality theorist. Suppose someone says the following two things: "5 + 5 = 11" and "poor people who need emergency medical care should be denied care unless they can pay for it." Both statements seem "wrong." But they seem wrong in different ways. The second statement seems wrong in a deep, emotional way. Your sense that this opinion is morally wrong seems to engage emotional processes in a way that your knowledge that "11" was the wrong answer to "5 + 5" does not.

If moral judgments are, in fact, different from other kinds of judgments, then it might be possible to identify specific brain regions that come into play specifically when people engage in moral reasoning tasks. This possibility was pursued in a study by Greene, Somerville, Nystrom, Darley, and Cohen (2001). Like Kelley and colleagues (2002), these researchers used fMRI to investigate the possible link between brain functioning and an aspect of personality functioning. In the work of Greene and colleagues, research participants were asked to consider a series of difficult choices, or dilemmas. Some of the choices were moral dilemmas; they involved issues such as the correctness of keeping money that one has found or harming someone if the harm would result in a benefit to a large number of other people. Other choices were nonmoral; they involved decisions such as whether to take a bus versus a train to get to a given location. Participants were asked to judge whether or not a given course of action was appropriate as a response to each moral and nonmoral problem. The question, then, was whether different brain regions would be involved when people thought about moral versus non-moral tasks.

The researchers did indeed find different involvement of brain regions in moral versus nonmoral reasoning. Of particular interest is that the brain regions involved in moral reasoning were those that, in previous research, had been shown to also be involved in generating emotional experiences (Greene et al., 2001). The fMRI data, in other words, confirmed the intuition stated above: The difference between moral and nonmoral reasoning is that moral reasoning is not "cold" factual thinking; instead, it involves emotional responses that directly influence people's decision-making capabilities. These findings are part of a wide range of recent data demonstrating the role of the brain's emotional systems in psychological functions that previously had been thought of as purely "cognitive" (Bechara, Damasio, & Damasio, 2000; Sanfrey et al., 2003). More generally, they demonstrate the power of neuroscientific research to inform questions about social thinking processes and personality that are a primary focus of theories we will consider later in this text (Chapters 11 to 13).

In sum, in this chapter we have reviewed an array of findings that are potentially "dizzying." They involve deep questions about personality and, simultaneously, complex techniques from the biological sciences. Yet some simple themes emerge from this complexity. On the one hand, contemporary research in personality psychology has succeeded in identifying specific neural and biochemical systems that contribute to personality functioning and to significant differences among persons. On the other hand, research on biology and personality has, to a surprising degree, highlighted the influence of the environment. Identical twins are not identical in their personalities. Similar people who encounter different social settings and experiences differ biologically. In the broad context of the theories of personality, the research results we have reviewed do confirm the intuitions of trait theorists that biology is fundamental to personality and individual differences. Yet they also support the intuitions of the theorists you will learn about in the chapters ahead, who commonly explore not only biology, but the environment, society, and culture, in their efforts to understand persons.

MAJOR CONCEPTS

Adoption studies An approach to establishing genetic-behavior relationships through the comparison of biological siblings reared together with biological siblings reared apart through adoption. Generally combined with twin studies.

Behavioral genetics The study of genetic contributions to behaviors of interest to psychologists, mainly through the comparison of degrees of similarity among individuals of varying degrees of biological-genetic similarity.

Effortful control A quality of temperament involving the capacity to control one's actions by stopping one activity (a dominant response) in order to do another.

Evolved psychological mechanisms In evolutionary psychology, psychological mechanisms that are the result of evolution by selection; that is, they exist and have endured because they have been adaptive to survival and reproductive success.

fMRI (functional magnetic resonance imaging) A brain-imaging technique that identifies specific regions of the brain that are involved in the processing of a given stimulus or the performance of a given task; the technique relies on recordings of changes in blood flow in the brain.

Heritability The proportion of observed variance in scores in a specific population that can be attributed to genetic factors.

Inhibited-uninhibited temperaments Relative to the uninhibited child, the inhibited child reacts to unfamiliar persons or events with restraint, avoidance, and distress, takes a longer time to relax in new situations, and has more unusual fears and phobias. The uninhibited child seems to enjoy these very same situations that seem so stressful to the inhibited child. The uninhibited child responds with spontaneity in novel situations, laughing and smiling easily.

Neurotransmitters Chemical substances that transmit information from one neuron to another (e.g., dopamine and serotonin).

Parental investment theory The view that women have a greater parental investment in offspring than do men because women pass their genes on to fewer offspring.

Phrenology The early 19th-century attempt to locate areas of the brain responsible for various aspects of emotional and behavioral functioning. Developed by Gall, it was discredited as quackery and superstition.

Plasticity The ability of parts of the neurobiological system to change, temporarily and for extended periods of time, within limits set by genes, to meet current adaptive demands and as a result of experience.

Proximate causes Explanations for behavior associated with current biological processes in the organism.

Selective breeding An approach to establishing genetic-behavior relationships through the breeding of successive generations with a particular characteristic.

Shared and nonshared environments The comparison in behavioral genetics research of the effects of siblings growing up in the same or different environments. Particular attention is given to whether siblings reared in the same family share the same family environment.

Three-dimensional temperament model The three superfactors describing individual differences in temperament: Positive Emotionality (PE), Negative Emotionality (NE), and Disinhibition versus Constraint (DvC).

Twin studies An approach to establishing genetic-behavior relationships through comparison of degree of similarity among identical twins, fraternal twins, and nontwin siblings. Generally combined with adoption studies.

REVIEW

1. Psychologists have long been interested in individual differences in temperament, relating such differences to constitutional factors. Advances in temperament research have come in the form of longitudinal studies and objective measures of behavior and constitutional-biological variables. Kagan's research on inhibited and uninhibited children is illustrative of such developments.
2. Evolutionary theory concerns ultimate causes of behavior—that is, why the behavior of interest evolved and the adaptive function it served. Work in the area of male-female mate preferences, emphasizing sex differences in parental investment and parenthood probability, and in male-female differences in causes of jealousy illustrate research associated with evolutionary interpretations of human behavioral characteristics.
3. Three methods used to establish genetic-behavior relationships are selective breeding, twin studies, and adoption studies. Twin and adoption studies lead to significant heritability estimates for intelligence and most personality characteristics. The overall heritability for personality has been estimated to be .4 to .5; that is, 40 to 50% of the variance in personality characteristics is due to genetic factors. However, there is evidence that heritability estimates are influenced by the population studied, personality characteristics studied, and measures used.
4. Associations between findings in neuroscience and personality have focused on the functioning of neurotransmitters such as dopamine and serotonin, on individual differences in hemispheric lateralization and emotional style, demonstrated in the work of Davidson, and on the functioning of parts of the brain such as the amygdala in relation to the processing of emotional stimuli and emotional memories. The three-dimensional temperament model proposed by Clark and Watson represents one attempt to systematize relations between the findings in neuroscience and personality. Many such links are suggested, although at this time a comprehensive model of biological processes and personality traits remains to be formulated.
5. In recent years, researchers in neuroscience have begun to identify specific brain regions that are involved in complex aspects of personality functioning, such as judgments about the self and judgments of the morality of actions. This work generally relies on brain-imaging techniques, particularly fMRI.
6. Although there is a tendency to think of biological processes as fixed, there is considerable evidence of plasticity or potential for change in neurobiological systems as a result of experience. Research on the biological foundations of personality, then, provides information not only about the role of genetics in personality, but also about the role of the environment.