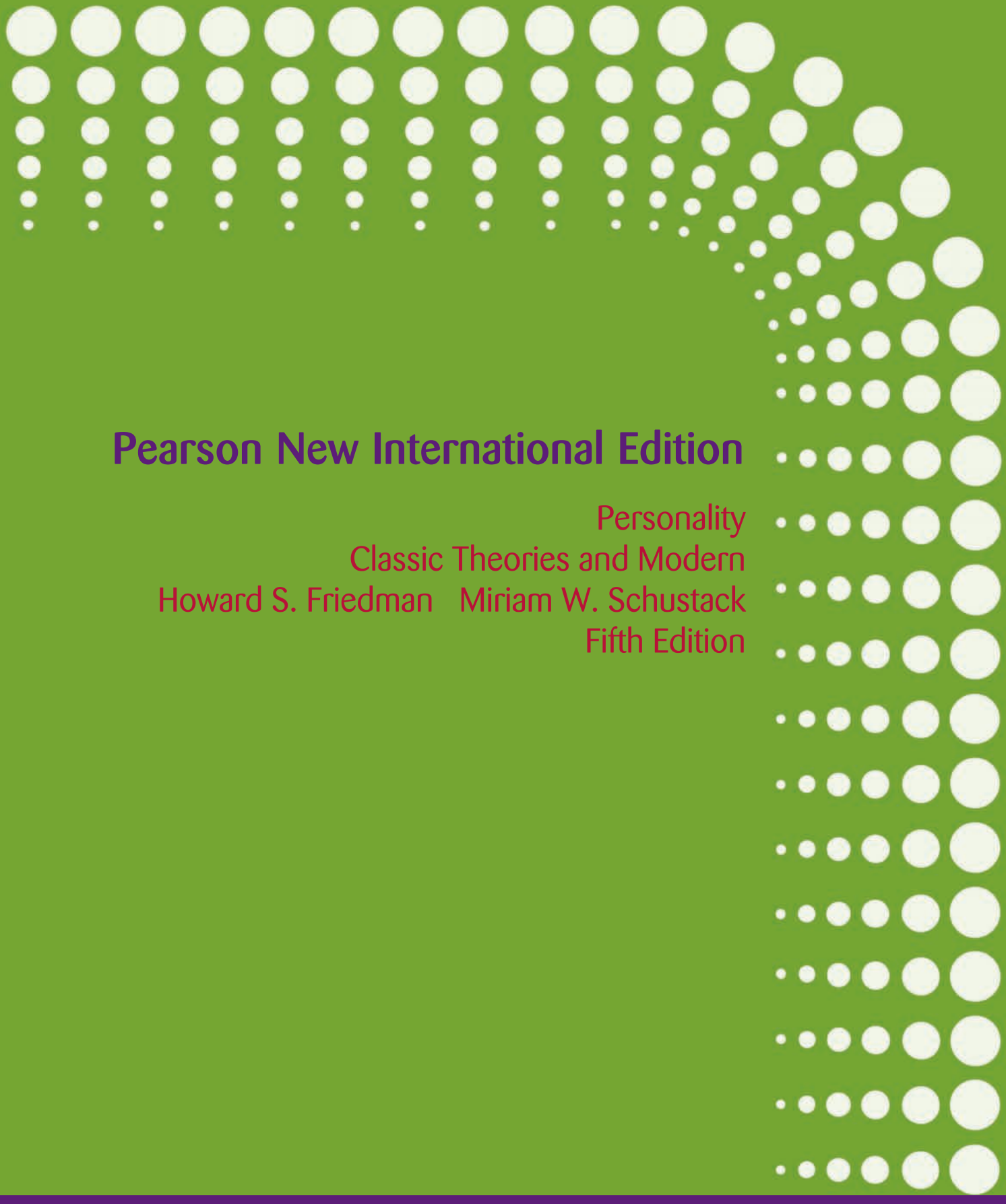

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the situation, the subculture, and similar factors, somewhat different results on basic temperament will emerge.

Eysenck's Model of Nervous System Temperament

The best way to clear up these discrepancies about basic temperaments would be to find the actual biological substrates of these observable patterns of emotional reactivity. That is, it would be helpful to track the nervous system and hormonal changes that accompany stable patterns of reactivity. Perhaps several patterns of physiological responsiveness could be identified.

Interesting research on the effects of biological temperament on personality was inspired by the work of the late British psychologist Hans Eysenck, particularly in the area of introversion–extroversion. Introverts are generally quiet, reserved, and thoughtful. Extroverts are active, sociable, and outgoing. Most people fall somewhere in between. The introversion–extroversion dimension thus combines elements of the activity dimension with the sociability dimension of temperament. Although notions of introversion–extroversion appear in many personality theories, Eysenck ties the dimension directly to the central nervous system.

The basic idea is that extroverts have a relatively low level of brain arousal, and so they seek stimulation. They want to get things "pumped up." Introverts, on the other hand, are thought to have a higher level of central nervous system arousal, and so they tend to shy away from stimulating social environments. In particular, Eysenck points to the part of the brain known as the ascending reticular activating system (Eysenck, 1967). There is as yet, however, little empirical evidence that this brain system is directly related to personality. The argument has also been extended by Eysenck and others to a neuroticism–emotionality dimension, with the point being that stable people are said to have a well-modulated nervous system, whereas neurotic people have a very reactive nervous system, which promotes emotional instability. The validity of this intriguing model is also still unknown (Gale, 1983; Zawadzki & Strelau, 2010).

There are many problems in trying to test a nervous system–based theory of temperament, which Eysenck himself acknowledged (Eysenck, 1990). First, it is difficult to define and measure nervous "arousal"; there is no impartial gauge like a thermometer and no single response like a fever. Second, many problems arise from the fact that the human body is a system that attempts to maintain equilibrium; responses rise and fall, varying in baseline, intensity, and duration.

There is, however, assorted evidence that extroverts do indeed differ physiologically from introverts (Corr, 2008; Pickering & Gray, 1999; Stelmack & Pivik, 1996). Some of this corroboration comes from studies using electrodermal measures—monitoring the electrical activity of the skin with electrodes. Other support comes from brain scans. There is also evidence that, as predicted, introverts are slower to habituate to (get used to) sensory stimuli such as unusual tones that are played (Crider & Lunn, 1971; Zuckerman, 1999). Stimulation bothers them. In colloquial terms, it "gets on their nerves." Overall, extroverts generally show less brain arousal at rest than introverts do. Although this approach is promising, it is likely that a more complex model of brain arousal and temperament needs to be developed, one that does not rely on only one aspect of nervous arousal (Eysenck, 1990; Gale, 1983; Pickering & Gray, 1999).

Approach and Inhibition: Gray's Reinforcement Sensitivity Theory

An extension of the physiological, brain-based model of personality to incorporate findings from modern neuroscience comes from Jeffrey Gray and colleagues (Kumari, Ffytche, Williams, & Gray, 2004; Leue & Beauducel, 2008; Pickering & Gray, 1999). This approach again begins with Pavlov's classic notion that animals' nervous systems have evolved to orient them to attractions and dangers, but also emphasizes the notion of the importance of reward or punishment for appropriate/inappropriate behaviors. In other words, observation *and* learning are key to survival.

This approach therefore postulates two relevant biological systems. The first is the *behavioral inhibition system (BIS)*. This system provides the orienting response to novel situations and also responds to things that are punishing. If this system is sensitive, then you are prone to anxiety, always alert and worrying that something bad will happen. Second, there is the *behavioral activation system* (sometimes called the *behavioral approach system*, or *BAS*), which regulates our response to rewards. It is how we learn to enjoy rewarding activities like good food and friends. If this physiological system is overly active, then you are impulsive and constantly seeking rewards. There is evidence that persons with an active behavioral approach system are more prone to drug addiction and overeating (Davis et al., 2007; Franken, Muris, & Georgieva, 2006).

This conception fits the observation that impulsive people are mostly shaped by rewards, whereas anxious, obsessive people are mostly concerned with avoiding unknown situations and punishment. Would you go away on a weekend ski trip with a blind date? A person with an active biological approach system will be pulled by the potential for many rewards. A person controlled by a strong behavioral inhibition system, however, will shy away, worrying about everything from embarrassment to injury to sexually transmitted diseases.

Photo by Michelle Buckham, Arrowtown, New Zealand

■ Some individuals are more likely than others to seek out exciting (and potentially dangerous) activities. Possibly, they are seeking arousal from the environment to compensate for their lower levels of internal biological activation.

Sensation Seeking and Addiction-Proneness

A related nervous system approach to personality focuses directly on **sensation seeking** (Joseph, Liu, Jiang, Lynam, & Kelly, 2009; Zuckerman, 1999, 2007). Think about people who are always on the lookout for a new challenge or a new high. Sensation seekers have a consistent tendency to seek out highly stimulating activities, such as sky-diving, and they are also attracted to the unknown. Sensation seekers, however, have no consistent preference as to whether they enjoy being around others. Thus, they are not simply extroverts. But this theory similarly proposes that sensation seekers may have a low level of natural (internal biological) activation and so seek arousal from the environment. Consistent with Pavlov's original notions, sensation seekers seem

to have a strong, nervous system–based, orienting response. They seem biologically primed to seek out and engage their environments.

Understanding such natural inclinations depends on knowledge about the workings of the brain and the nerves, including **neurotransmitters**—the chemicals nerves use to communicate. One likely possibility involves the neurotransmitter dopamine, with evidence of genetic differences in dopamine availability and regulation (Klein et al., 2007; Zuckerman & Kuhlman, 2000). For example, why might sensation-seeking individuals be drawn to cocaine? Cocaine is a psychomotor stimulant that is an especially widespread and dangerous drug. Cocaine prevents the reabsorption of the neurotransmitter dopamine by binding to the dopamine uptake transporter, hence inhibiting dopamine reuptake and leaving more dopamine in the synapse (Bloom & Kupfer, 1995). When dopamine concentrations therefore rise (and nerve activity increases) due to cocaine, emotional highs are initially (and artificially) created. But the brain is severely disrupted as dopamine levels later crash.

It is likely that some people have natural defects or disease-caused weaknesses in their dopamine systems, and such people may be especially susceptible to cocaine addiction. Even in initially healthy people, chronic cocaine use tends to produce symptoms of paranoia, as the brain tries to adapt to the high dopamine levels. A nervous system–based model of individual differences in susceptibility to drug addiction is shown in Figure 1.

The neurotransmitter serotonin also is related to impulsivity (Carver, Johnson, & Joormann, 2008; Cyders & Smith, 2008). For example, there is an inverse correlation between impulsivity and serotonin levels in vervet monkeys (Fairbanks, Melega, Jorgensen, & Kaplan, 2001). Furthermore, the monkeys' impulsivity can be dramatically altered by giving them the drug fluoxetine (**Prozac**), which blocks the reabsorption of serotonin in the brain, thus enhancing mood. By the way, how do you tell if a vervet monkey is impulsive? (It will not take a Rorschach test.) In the case of captive monkeys, you bring an intruder monkey to the edge of the subject monkey's territory. Then you code responses. Impulsive monkeys recklessly rush the intruder, sniff it, and attempt to touch it (Fairbanks, 2001). Their cautious, unimpulsive peers, on the other hand, stay back and observe the monkey intruder for a while.

There are also larger structural differences. The human brain has two distinct halves—a left and a right hemisphere. One promising method of addressing biological differences in personality focuses on individual differences in **hemispheric activity**; that is, relative differences in activation between the right and left cerebral hemispheres in the brain (Biondi et al., 1993; Davidson & Fox, 1989; Maxwell & Davidson, 2007).

How is all this relevant to personality? The idea is that relatively greater activation of the right hemisphere is associated with greater reactions of fear and distress to a stressful situation; that is, individuals who have a relatively more active right hemisphere are more likely to overreact to a negative stimulus.

Sensation Seeking
A tendency to seek out highly stimulating activities and novelty

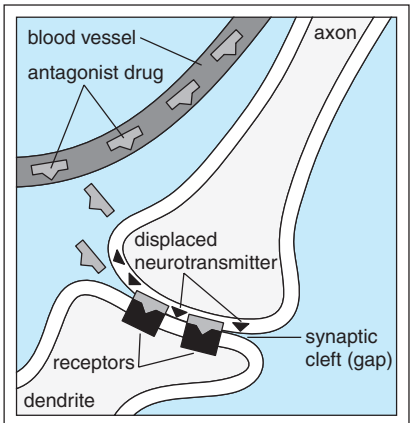
Neurotransmitter
A chemical used by nerves to communicate

Prozac
A drug that blocks reabsorption of the neurotransmitter serotonin in the brain and thus elevates moods and alters emotional reaction patterns

Hemispheric Activity
The level of activity within one cerebral hemisphere (left or right)

Why Does It Matter?

In addition to helping understand susceptibility to addiction, knowledge of biological influences on individual differences can help in uncovering the best treatments for depression. For example, brain-derived neurotrophic factor (BDNF) is an important substance involved in the health and growth of nerve cells and is relevant to depression. Variations (polymorphisms) in the gene that influences BDNF production are being studied to understand optimal drug treatments. There is evidence that certain variations are not responsive to fluoxetine (Prozac). For depressed people with such a genetic variation, Prozac may not work, and the psychiatrist may want to look instead to other antidepressant drugs. In other words, with genetic testing, doctors may have to rely less on trial-and-error therapeutics for people with serious mood disorders and instead could target prescriptions at the likely problem for a particular individual (Chen et al., 2006).



Cocaine prevents dopamine reuptake, leaving more dopamine in the synapse.

A person with biological weaknesses in dopamine regulation in the brain, who may be an impulsive or anxious person, seeks out wild parties.

↓

Under peer pressure and seeking stimulation (perhaps an insecure teenager at a party), this person ingests an opiate or euphoric such as heroin or cocaine.

↓

The drug travels to the brain, where it affects the pathways that normally make us feel pleasure in response to rewarding experiences. It thus creates artificial or purely biological pleasure. Neurotransmitters, especially dopamine, are affected.

↓

In the case of drugs like cocaine, normal dopamine reuptake is hindered, keeping dopamine levels high, and pleasure intense. The person feels better and less "out of sorts."

↓

Over time, the brain senses that homeostasis (internal balance) has been disrupted and too much neurostimulation is occurring. The body responds by decreasing the amounts of neurotransmitters available or decreasing their effects (such as by decreasing the numbers of dopamine receptors).

↓

The person becomes even more tense, unhappy, or driven, as normally pleasant activities are no longer sufficient to produce a sense of well-being. Reinforcement turns from being provided by the social environment to being provided by the drug.

↓

The person seeks higher or more frequent drug doses to compensate. The brain further adapts. The usual social environment, in turn, becomes increasingly unrewarding. The person is addicted.

■ FIGURE 1

A Nervous System–Based Model of Individual Differences in Susceptibility to Drug Addiction

All in all, if certain aspects of personality are indeed based on biologically induced temperament, then we should expect to see such differences in all cultures. Indeed, the introversion–extroversion dimension does seem to appear worldwide (Eysenck, 1990). Also of interest, studies of brain development and brain activity

reveal that the brain reaches its maximum number of synaptic connections and its greatest metabolic activity around age 3 or 4, thus supporting the psychoanalytic observation that the basis of personality is formed by around this age. The brain does, however, continue to alter its organization to some extent throughout life.

TIME LINE

The History of Biological Approaches to Personality

The major developments in the biological approach can be seen here in historical relation to one another and in relation to their broader societal and cultural contexts.

Developments in Biological Aspects		Societal and Scientific Context
Charles Darwin publishes *On the Origin of Species by Means of Natural Selection*, the first formal statement about evolution (1859)	1850s–1880s	Biology adopts evolutionary paradigm
Francis Galton studies families and twins, beginning the biological study of individual differences, and he launches the eugenics movement	1860s–1890s	Development of the field of genetics, but Social Darwinism misappropriates ideas to provide a pseudoscientific basis for fascism
Studies of temperament and individual constitution begin, focused on body types and emotional patterns	1940s–1960s	Psychology is dominated by behaviorist and other nonbiological approaches; fascism is defeated and democracy spreads throughout the West
Hans Eysenck proposes brain-based model of personality	1960s–1970s	Hormones, temperament, and brain neurotransmitters begin to receive significant attention
Studies of effects on the brain of drug abuse, pollution, and genetic diseases begin in earnest	1980s	Fields of environmental toxicology and psychopharmacology develop
Evolutionary personality psychology takes root, as evolved predispositions toward sex, love, hate, jealousy, and aggression are studied	1990s	More sophisticated views of genetics and evolution develop, as the complex interactions of biology and behavior are uncovered
Personality psychology begins serious study of the genetic bases of individual behavioral patterns	2000s–	Human genome is unraveled, new ethical challenges arise

Twins as a Source of Data

We should be able to detect systematic biological influences on personality by studying twins. Twin research is indeed now one of the most active areas of research in the study of the biological aspects of personality, with many intriguing studies comparing identical twins to fraternal twins. Identical twins share the same genetic makeup (share 100 percent of their DNA), but fraternal twins (who develop from separate fertilized eggs) have a comparable genetic overlap to ordinary brothers and sisters (sharing 50 percent of their DNA). On various key dimensions—including emotional stability, conscientiousness, intelligence, and extroversion—identical twins are indeed more similar than fraternal twins (Bouchard & McGue, 2003; Heath, Eaves, & Martin, 1989; Rose, Koskenvuo, Kaprio, Sarna, & Langinvainio, 1988; see also Loehlin, 1992).

Does this prove a biological basis? Not necessarily, because identical twins may be treated more similarly than fraternal twins. Identical twins look more alike, and their parents may dress them alike, and so on. Or identical twins may consciously try to act more similarly than fraternal twins. For these reasons, it is much more informative to compare twins who have been adopted and raised apart from each other.

Sir Francis Galton

In the latter half of the nineteenth century, the British scientist Sir Francis Galton began the study of genetic influences on personality (Galton, 1869). He was inspired by the work of his cousin Charles Darwin. Galton drew family trees of blood relatives of famous and eminent people. Sure enough, he found that eminence seemed to run in families. For example, a son might succeed his father as a professor at a university chair (professorship). Galton also noticed that among the lower classes in nineteenth-century Britain, hardly anyone achieved eminence.

Parents may draw attention to the similarity of identical twins by dressing them in the same clothing, providing matching hairstyles, and treating them identically. If identical twins are treated more similarly to each other than fraternal twins are, then we cannot conclude that greater similarity in personality among the identical twins is of purely genetic origin. So, psychologists have turned to studying twins raised apart.

Although one of the most brilliant and well-intentioned men of his time, in retrospect Galton was what we would today call a benign racist. He endeavored to be scientific, but he began from the supposition that upper-class Englishmen were a superior population. It is hardly surprising that the son of a wealthy, well-educated professor would be more likely to achieve prominence in a hierarchical society than would the son of poor, illiterate parents. To his credit (given the tenor of the times), Galton recognized this possibility, and he suggested that adopted children be studied, including adoptive twins. So it was Galton who began this type of study. But Galton did not worry that too much would come of such studies; he was convinced of his own natural superiority (and that of his relatives and friends).