THE LONG SHADOW OF TEMPERAMENT

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OVERVIEW

Over the past 25 years, we have been intrigued by two distinct categories of children who react to unfamiliar people, animals, and situations in different ways. Some stare for a few moments at a stranger and then continue with their activities. A smaller group remains subdued for a longer time or retreats to a parent. Mothers and fathers usually notice these traits by the second or third birthday, when their son or daughter meets unfamiliar children at the playground or in child care, and some conclude that their child is by nature shy or sociable.

American and European scientists who have studied such children longitudinally have discovered that a proportion of shy or sociable preschoolers retain their early disposition into adolescence and, in some cases, into the adult years. For example, middle-class men growing up in Berkeley, California, who as children had been very shy, established their careers, chose wives, and became fathers later in life than their more sociable peers. Eighteen-year-olds in New Zealand who had been categorized by observers as shy when they were 3 years old described themselves as cautious when facing new challenges or dangerous situations (Caspi and Silva, 1995; Caspi, Elder, and Bem, 1988).

The contrast between a cautious and a bold character can be found in many novels, in Shakespeare's plays, and in E. L. Thorndike's 1907 textbook, *The Elements of Psychology,* published almost a century ago. Thorndike called the traits *reflective* and *impulsive*. We use the terms *inhibited* and *uninhibited to the unfamiliar* to capture this opposed pair of behavioral tendencies, and we believe that they are the product of temperamental biases that can be detected in early infancy.

The concept of temperament, as we use it, implies an inherited physiology that is preferentially linked to an envelope of emotions and behaviors (though the nature of that link is still poorly understood). Almost all 1-year-olds will freeze in place for a few seconds when an unfamiliar adult wearing a mask comes into the room; almost all 10-year-olds will flee if a large dog runs toward them; and almost all adults will feel apprehensive as they board a plane at midnight in an ice storm. But some infants—a minority—remain immobile with the adult for a long time; some 10-year-olds will cry as they flee from the dog; and some adults will continue to worry throughout the flight. We believe, on the basis of the research described in this book, that inherited temperamental biases, combined with life experiences, create this variation in behavioral reaction to unfamiliar events.

We wish to be clear at the outset that an infant's temperament is only an initial potentiality for developing a coherent set of psychological characteristics. No temperamental bias determines a particular cluster of adult traits. Life experiences, acting in potent and unpredictable ways, select one profile from the envelope of possibilities. A young boy born with a temperament that favors bold, sociable behavior may become the head of a corporation, a politician, a trial lawyer, or a test pilot if raised by nurturing parents who socialize perseverance, control of aggression, and academic achievement. A child born with exactly the same temperament is at some risk for a criminal career if his socialization fails to create appropriate restraints on behaviors that violate community norms.

Each adult profile was influenced by the child's temperament, but neither was predetermined by it.

A study of plants illustrates the power of the environment to produce different observable profiles from genetically identical forms. Each of seven genetically different variants of an herb were cut into three pieces, and one piece from each genetic type was grown at one of three altitudes: sea level, 1,400 meters, and in high mountains. The height to which each of the seven variants grew depended on both its genotype and the place where it was planted. For example, one variant was the tallest of the seven types if grown at sea level, the shortest if planted at 1,400 meters, and of intermediate height if planted in the high mountains. It was impossible to predict the final height of the plant from knowledge either of its genetic pedigree or the place where it grew; both facts were necessary (Lewontin, 1995).

Origins

Our studies of inhibited and uninhibited children have many roots. The deepest originate about 50 years ago in a study of Caucasian adults born between 1929 and 1939 who, from infancy through adolescence, had participated in a study at the Fels Research Institute on the campus of Antioch College in Yellow Springs, Ohio. In 1957 Howard Moss analyzed the staff's descriptions of childhood behavior, while Jerome Kagan interviewed and tested these young adults, who were now in their third decade. The two psychologists then examined both sets of evidence to see whether any childhood behaviors persisted through the early adult years.

The most important discovery was that a small group of children who usually avoided unfamiliar people, objects, and events during the first 3 years preserved some derivatives of that bias as young adults. They were introverted, cautious, and dependent for emotional support on family, friends, or spouses. By contrast, the bolder, sociable children were extroverts who chose competitive, entrepreneurial vocations. A singularly unexpected finding was

that the adults who had been the timid children had high, minimally variable heart rates, suggesting higher sympathetic tone in the cardiovascular system. This evidence was the origin of the concepts of inhibited and uninhibited children (Kagan and Moss, 1962).

Fifteen years later, Kagan, Richard Kearsley, and Philip Zelazo were reflecting on their longitudinal observations of 53 Chinese-American and 63 Caucasian infants born in Boston who had been participating in a study on the effects of daycare. Some of the children had attended an experimental daycare center from 3 through 29 months of age; others had been reared only at home; but all infants were observed on five separate occasions. The Chinese-American infants, whether attending the daycare center or raised only at home, were more inhibited in the second year than the Caucasian children. The Chinese toddlers stayed closer to their mothers in unfamiliar places, cried more often when temporarily separated from their parent, and were unusually wary when playing with an unfamiliar peer (Kagan, Kearsley, and Zelazo, 1978). The results from the Ohio adults and the Boston children in daycare motivated more direct investigations of the temperamental properties of inhibited and uninhibited children.

The first investigation began in 1979 when Cynthia Garcia-Coll filmed 117 21-month-old Caucasian infants, both first- and later-born, as they encountered unfamiliar people, objects, and situations in a laboratory setting (Garcia-Coll, Kagan, and Reznick, 1984). Crying, withdrawal, and the absence of spontaneous behavior with the unfamiliar examiner, as well as prolonged hesitation in approaching unfamiliar objects or people, were regarded as signs of an inhibited response to unfamiliarity. The 33 children who were avoidant in a majority of unfamiliar contexts were categorized as inhibited. The 38 children who approached the unfamiliar people and objects were classified as uninhibited. The remaining 47 children who were inconsistent in their behavior were not observed again. When the inhibited and uninhibited children encoun-

tered the same set of unfamiliar events several weeks later, a majority retained the style they had displayed on the first evaluation.

Sixty percent of this sample was observed again on two occasions when the children were 4 years old. The formerly inhibited, compared with the uninhibited, children were more subdued while interacting with an unfamiliar peer, had higher task-induced heart rates, and glanced frequently at the examiner. They were also described as shy and fearful by their mothers. When the inhibited children were shown a series of pictures, each illustrating a pair of people, they looked longer at the passive rather than the active member of the pair. When some children in this sample were observed during their first day in kindergarten, those classified as inhibited at 21 months were solitary and quiet and stared often at other children, while the uninhibited children showed the opposite behavior.

In a related study, Nancy Snidman (1989) filmed a large group of 31-month-old children as they played with another unfamiliar child of the same sex in a large room with both mothers present. At the end of the play session, a woman with a plastic cover over her head and torso entered the room and after a brief period of silence invited the two children to approach. The children who remained close to their mother and were reluctant to approach the adult stranger, initiate play with the unfamiliar child, or speak spontaneously were classified as inhibited. The children who showed the opposite set of traits were called uninhibited.

Twenty-six children (about 15 percent of Snidman's sample) were shy with the unfamiliar child and timid with the adult stranger; 23 children (14 percent) were sociable and bold. These two groups were assessed again when the children were 4, 5, 7, and 13 years old. Children classified originally as inhibited retained an inhibited behavioral style, while children who had been classified as uninhibited preserved a bold, sociable profile. When a stringent criterion for classification was applied, about one-third of

the children preserved their original temperamental bias, and only 3 of the 49 children changed from inhibited to uninhibited or from uninhibited to inhibited.

The inhibited and uninhibited children in the Garcia-Coll and Snidman samples were evaluated again when they were between 12 and 14 years old. Carl Schwartz, a child psychiatrist who interviewed these adolescents, discovered that those who had been inhibited were more likely to show signs of social anxiety (Schwartz, Snidman, and Kagan, 1999). During a subsequent testing session with an unfamiliar woman examiner, the formerly inhibited children failed to elaborate their answers or to ask the examiner questions, and they rarely smiled following success on various cognitive tasks. The formerly uninhibited children, by contrast, talked frequently and occasionally laughed after failing a difficult test item. Further, when asked to remember a long series of numbers and perform a motor coordination task as rapidly as possible, the inhibited children had either larger heart-rate accelerations or greater muscle tension. Finally, the inhibited youth were a little more likely to possess a tall, lean body build, narrow face, and light blue eyes.

The entire corpus of evidence convinced us of the significance of these two temperamental biases. In 1986 we designed an infant assessment to see whether we could detect in the behavior of 4-month-olds early signs of a future inhibited or uninhibited profile. We could not code avoidance of unfamiliar events because young infants are not capable of displaying the behaviors we call inhibited or uninhibited. Two psychological competences must develop before children will avoid or show caution in response to an unfamiliar person, object, or situation. First, the infant must relate her perception of the unfamiliar event to schematic representations of the familiar experiences encountered in the past. Second, the infant must be able to hold both representations in working memory long enough to compare the two. An inability to understand an unfa-

miliar event often results in crying or other actions reflecting uncertainty. The human brain at 3 to 4 months of age is not mature enough to perform these cognitive operations.

Reliable signs of timidity or avoidance in response to unfamiliar events first appear in human infants between 6 and 9 months of age, usually in the form of a fear reaction to strangers. An avoidant reaction to novelty appears in wolf cubs and kittens around 1 month, and at 3 months in infant monkeys, whose brains mature more slowly than wolf cubs' but faster than humans'. These facts suggest maturational constraints on this class of behavior. However, children overcome their timidity more quickly than monkeys. When a 4-month-old monkey confronts another unfamiliar monkey of the same age, the two wait a long time before one approaches the other. A pair of 12-month-old children who do not know each other may stare for a while, but within a minute or two most pairs begin to play. Humans conquer their initial restraint around the unfamiliar more quickly than monkeys.

The amygdala, a small almond-shaped organ lying beneath the convoluted cerebral cortex, contiguous to the hippocampus, influences a person's reaction to novelty. It is the only brain structure that detects change in both the outside environment and the body and, in addition, can instruct the body to flee, freeze, or fight. Every sensory modality sends information to one or more areas of the amygdala, and each area, in turn, sends projections to sites in the brain and body that mediate emotions and actions, including the cerebral cortex, brain stem, and autonomic nervous system. The amygdala can be likened to a central command post whose mission is first to detect and then, if necessary, to react to unfamiliar or unexpected events. Therein lies a clue to understanding the behavior of children when they encounter the unfamiliar.

The behavior of housecats affirms the significance of the amygdala in monitoring reaction to the unfamiliar. About 1 in 7 housecats behaves like an inhibited child. It fails to explore unfamiliar places, usually withdraws from unfamiliar objects, and does

not attack rats. This avoidant profile, which first appears at about 30 days of age, becomes a stable trait by 2 months, when the kitten's amygdala gains control of the circuits that mediate avoidant behavior. Timid kittens also show a larger increase in neural activity in the amygdala than bold kittens when they hear sounds that resemble the threat howl of another cat (Adamec, 1991).

It is probably not a coincidence that the basolateral area of the amygdala, which receives sensory information from many modalities, expanded as primates evolved. This growth is particularly clear in gregarious monkey and ape species that engage in complex social interactions with conspecifics. Their social organization relies on the ability to detect discrepant facial, vocal, and postural cues that might signal domination, attack, or the moment when it is safe to approach another member of the troop for nurture, play, or mating.

Humans, like their primate relatives, are exquisitely sensitive to changes in facial expression, voice, and posture that signify anger, empathy, fear, seduction, delight, or disapproval from another person. If the variation in behavior to unfamiliarity is partly due to amygdalar excitability, it follows that coding the reactions which accompany arousal of the amygdala in infants might provide an index of a temperamental bias. Projections from the amygdala to motor centers enable infants to pump or thrash their limbs, arch their back, and cry when aroused by unfamiliarity. Thus, we hypothesized that infants born with a neurochemistry that rendered the amygdala unusually excitable would display vigorous motor activity and crying when presented with unfamiliar stimuli. Conversely, infants born with a higher threshold of reactivity in the amygdala due to a different chemistry would show minimal motor activity and distress in reaction to the same unfamiliar events.

The Infant Assessments

The central assumption behind our assessments of 4-month-old infants was that those who displayed frequent motor activity and

crying when presented with unfamiliar visual, auditory, and olfactory stimuli had inherited a distinct neurochemistry that rendered the amygdala excitable. These infants should be biased to become inhibited children in the second year. The infants who showed minimal motor activity and little or no distress, because of a different neurochemistry, were likely to become uninhibited children.

This assumption was supported by LaGasse and colleagues (1989), who found that when the water newborn infants were sucking through a nipple suddenly turned sweet, some showed an immediate and large increase in rate of sucking. The unexpected change in taste sensation should have activated the amygdalae of all infants. Thus, those who showed a higher increase in sucking rate in response to the change in taste probably had a lower threshold of excitability in this structure. Two years later, these same children displayed shy and timid behavior in response to unfamiliar events. This finding implied an association between threshold of excitability in the amygdala and a temperamental bias to become inhibited.

In order to eliminate other conditions that might produce variation in infant behaviors, we recruited only infants born to mothers who had followed sound prenatal guidelines and had given birth at term to healthy infants without complications during pregnancy or delivery. In collaboration with Doreen Arcus (1991), we evaluated over 500 healthy Caucasian infants born to middle-class women, most of whom had college degrees. We selected 4 months as the time for the first assessment because by that age the amygdala and its projections are prepared to produce vigorous motor activity and distress when events fail to match the knowledge the infants had already acquired about the world.

FOUR-MONTH-OLD ASSESSMENTS

The 4-month evaluation, which lasted about 45 minutes, contained seven episodes that were discrepant from the infant's past experience. Initially, the mother looked down at her infant, smiling

but not talking, for one minute. She then went to a chair behind the infant to be outside his field of vision. The examiner placed a speaker baffle to the right of the infant and turned on a tape recording that played 8 short sentences read by female voices. Most infants became quiet and remained alert during the presentation. However, some began to thrash their arms and legs, and a small number cried.

The speaker baffle was removed and the examiner, standing in back of the infant, presented a set of mobiles composed of 1, 3, or 7 unfamiliar colorful toys that moved back and forth in front of the infant's face for nine 20-second trials. Most infants were more active in response to the mobiles than to the taped sentences; some became increasingly aroused over the nine trials, as reflected in vigorous limb movements and crying. The examiner then dipped a cotton swab into very dilute butyl alcohol and presented it close to the infant's nostrils for 8 trials (the first and last trials were water rather than alcohol). The speaker baffle was replaced and the infant heard a female voice speaking three nonsense syllables *(ma, pa, ga)* at three different loudness levels. As before, most infants were quiet, but a small proportion thrashed and cried. The examiner then popped a balloon in back of the infant; most were unperturbed by this event. Finally, the mother returned to gaze at her infant for the final minute.

About 20 percent of infants showed crying and vigorous pumping of the legs and arms, sometimes with arching of the back, on at least 40 percent of the trials. These infants were called high-reactive. Because the motor activity and crying usually ceased when the stimulus was removed, it was reasonable to conclude that these reactions were caused by the unfamiliar stimulation rather than by hunger, transient pain, or sleepiness. The 40 percent who showed the opposite pattern—minimal motor activity and minimal distress—were called low-reactive. Occasionally these infants moved an arm or a leg, but they showed little crying or motor tension and appeared minimally aroused. About 25 percent showed low levels

of motor activity but were very irritable during the stimulus presentations; these infants were called distressed. Finally, the smallest group, 10 percent, showed vigorous motor activity, usually pumping of arms and legs but no arching of the back, and rarely cried—they were called aroused. The remaining 5 percent of the sample were difficult to classify. We studied the developmental paths of these four groups over the next 10 to 12 years (see Kagan, 1994, for details of the initial assessments).

TWO-YEAR-OLD ASSESSMENTS

More than 300 infants from our original sample of 500 returned to our laboratory at 14 and 21 months, where they encountered a large number of unfamiliar events, including people, objects, procedures, and rooms. We coded the display of a fearful reaction to each unfamiliar stimulus. For example, we noted the child's resistance when the examiner placed heart-rate electrodes on her chest and a blood pressure cuff around her arm, and whether the child refused to put her finger into a small glass containing black fluid or refused to allow a drop of water to be placed on her tongue.

In another procedure, the examiner uncovered a rotating toy on the first two trials, smiled and uttered a nonsense phrase followed by the child's name (for example, *tat bubl, Marie*) in a friendly voice. On the second two trials she frowned while speaking the same words in a stern voice, and we noted whether the child cried following this change in the examiner's face and voice.

We coded the child's reaction to an unfamiliar woman dressed in a white laboratory coat wearing a gas mask, and we noted whether the child avoided a large metal robot that the examiner asked the child to approach. We also recorded whether the child was reluctant to approach a person dressed in a clown costume wearing a red and white mask, or a radio-controlled robot that moved while making sounds, despite invitations from the examiner to do so. Although all children recognized that these experiences were unfamiliar, only some showed the crying or avoidance

that we regarded as behavioral signs of fear in response to the unfamiliar.

About one-third of the children showed either no fear or, at the most, one sign of fear during the varied episodes. Another third were very fearful, displaying a fear reaction to 4 or more situations. And one-third showed intermediate levels of fear. The children who had been high-reactive infants were most fearful, the low-reactives least fearful; the other two groups had intermediate fear scores. These findings convinced us that a temperamental bias contributed to the variation in reactivity at 4 months and the subsequent tendency to approach or avoid unfamiliar incentives in the second year.

FOUR-YEAR-OLD ASSESSMENTS

A sample of 193 of these children returned to the laboratory at 4.5 years for two sessions. During the first, which took about an hour, an unfamiliar woman administered a variety of cognitive tests. The children who had been low-reactive infants were more spontaneous and sociable with the examiner than those who had been high-reactive. Each child returned several weeks later for a play session in a larger room with two other unfamiliar children of the same sex and age while the three parents sat on a couch in the room. Twice as many low-reactive as high-reactive children were extremely sociable and talkative during this play session with unfamiliar children. By contrast, 46 percent of those who had been high-reactive infants were shy, quiet, and timid, compared with only 10 percent of those who had been low-reactive infants.

SEVEN-YEAR-OLD ASSESSMENTS

A group of 164 children were evaluated at 7.5 years for the presence of anxious symptoms. Initially, the mothers were sent a questionnaire which asked them to rate their child on a three-point scale for descriptions of age-appropriate behavior. Twelve questions dealt with shyness and timidity (for example, "my child be-

comes quiet and subdued in unfamiliar places"; "my child is afraid of thunder and lightning"; "my child is afraid of animals"). These answers were used to select a group of potential members of a category one might call anxious children. The mothers of the children selected as potentially anxious were interviewed on the telephone and asked to provide specific examples to support their earlier descriptions. These interviews revealed that some mothers had exaggerated the seriousness of their child's behavior. For example, when asked to explain why they said their child was afraid, the mothers indicated that the children were not exceptionally fearful. These children were eliminated from the category of potentially anxious children.

The teachers of children in the remaining group were interviewed. Each teacher, with no knowledge of the child's prior laboratory behavior or the purpose of the interview, first described and then ranked the child with respect to all children of the same sex in that classroom for characteristics that reflected shyness and fearfulness. The maternal questionnaire and telephone interviews with the mother and teacher were studied by Kagan, Snidman, and Marcel Zentner. If all three agreed that the child met the criteria for anxious symptoms, the child was categorized as anxious.

A total of 42 children (26 percent of the sample) met these criteria. A group of 107 control children were selected who did not meet criteria for any psychological symptom. An additional 15 children had symptoms of hyperactivity or disobedience but no signs of anxiety. All 164 children came to the laboratory for a battery of procedures administered by an unfamiliar woman who did not know their prior behavior.

The 7-year-olds who had been high-reactive infants were most likely to have anxious symptoms. Forty-five percent of high-reactives but only 15 percent of low-reactives received this classification. The high-reactives who developed anxious features were the ones most likely to have screamed in fear during the 21-month-

assessment when a person dressed in a clown costume entered a room where they were playing. As at earlier ages, the high-reactives displayed fewer spontaneous comments and smiles while interacting with the examiner (Kagan and Snidman, 1999).

A total of 18 percent of the high-reactives were consistently inhibited at all four ages—14 and 21 months and 4.5 and 7.5 years—but not one high-reactive infant was consistently uninhibited across all four evaluations. Moreover, the high-reactives with anxious symptoms, compared with the non-anxious high-reactives, showed higher diastolic blood pressure and greater cooling of the temperature of the fingertips as they listened to a long series of numbers they had to remember. These latter two measurements imply a more reactive sympathetic nervous system in the presence of a cognitive challenge. And about one-fourth of the anxious high-reactives had a smaller body size and narrower face than the other children, as well as blue eyes.

ELEVEN-YEAR-OLD ASSESSMENTS

The results of the last assessment, which occurred when the children were between 10 and 12 years old, are the focus of the remaining chapters of this book. The sample of 237 children who returned to our laboratory contained 30 percent who had been high-reactive as infants and 39 percent who had been low-reactive; the remaining 31 percent belonged to the other two temperamental groups, originally called distressed or aroused. The laboratory evaluation, which took about 3.5 hours, measured a variety of biological variables, such as EEG power and asymmetry of activation, brain stem auditory-evoked potential, event-related potentials, and sympathetic reactivity in the cardiovascular system (changes in finger temperature, heart rate, and blood pressure and a spectral analysis of supine heart rate). These measures, described in detail in Chapter 4, were selected because each is potentially under the direct, or indirect, influence of the amygdala.

The evidence illuminates two questions:

- To what degree did the 11-year-old children from the temperamental groups display the behavioral and/or biological biases expected from their infant assessments?
- To what degree was their behavior (both past and present) yoked to their current biology?

The Behavioral Profile

We constructed different indexes of each preadolescent's behavior. One was based on social interaction with the examiner. We knew from past work that high-reactive children talked and smiled less frequently than low-reactives in unfamiliar social situations. All children should have been maximally uncertain during the initial part of the interview because both the examiner and the setting were new. Thus, we counted the number of times the child made a spontaneous comment or smiled at the examiner (who knew nothing of the child's past behavior) during the first 18 minutes of her interaction. A spontaneous comment was defined as an elaboration of an answer required by the examiner's question or an unprovoked comment or question made by the child. (We restricted the coding of comments and smiles to the first 18 minutes because the biological measures, gathered after that time, required the child to be still and quiet.)

A second behavioral index of inhibited and uninhibited behavior, more inferential, was an observer's judgment, on a 4-point scale, of the child's degree of inhibition over the first 18 minutes. The rating was based on infrequent comments and smiles, a soft voice, excessive muscle tension, nervous motor movements, gazing away from the examiner, and questions that reflected concern or worry over the procedures. A rating of 1 described a maximally uninhibited child who was relaxed, sociable, and spontaneous. A rating of 2 described a child who, although he did not smile and talk frequently, showed no other signs of uncertainty. A rating of 3

described a child who talked and smiled but showed other signs of uncertainty. A rating of 4 described a maximally inhibited child who rarely smiled or spoke, was tense, and displayed other signs of uncertainty.

A third source of evidence came from independent descriptions of the child provided by the mother and the child in the familiar home setting. Each was given different sets of cards with printed statements descriptive of the child. The mother was given 28 descriptions; the child was given 20. The mother and child, sitting in different rooms, arranged these descriptions from most to least characteristic of the child.

As anticipated, more children who had been high-reactive infants were quiet and serious while interacting with the examiner; more low-reactives were talkative and relaxed and smiled frequently. About 33 percent of the high- and low-reactives displayed a style of social behavior that was in accord with their infant temperament, while 16 percent of each group behaved in ways that were inconsistent with expectations—a ratio of 2 to 1. The number of spontaneous smiles was a particularly sensitive sign of infant temperament. More high-reactives preserved a serious, nonsmiling facial expression at every assessment, from 14 months to 11 years. More low-reactives smiled and laughed frequently at every age. Many low-reactives, but very few high-reactives, smiled and laughed within the first minute of entering the laboratory at 11 years of age.

The mother's description of her child's usual behavior with strangers bore a modest relation both to infant temperament and to behavior with the examiner. About one-third of high-reactives were described by their mother as very shy around adult and child strangers; one-third of low-reactives were described as very sociable. However, the children's descriptions of their own shyness or sociability bore little relation to their early temperament, their behavior with the examiner, or their mother's evaluation. Many high-reactives who were quiet with the examiner and were described by

their mothers as shy denied this quality in their self-descriptions. Many low-reactives who were sociable with the examiner and were described by their mothers as sociable reported being shy.

However, the children's descriptions of their usual moods and preference for novelty were linked to their infant temperaments. The low-reactives were most likely to report that they enjoyed new places to visit and novel experiences. One item in the child's self-descriptions was especially revealing. The low-reactives were more likely than high-reactives to report that they were "happy most of the time." We will see that most of these "happy" children had been low-reactive infants and had a distinct biology at 11 years of age.

To our surprise, the level of fear in response to unfamiliar events during the second year did not predict the child's behavior at age 11. That is, children who were very fearful at 14 and 21 months, across all temperaments, were not very different at age 11 from those who were minimally fearful. The infant's behavior at 4 months was a better predictor of their behavior and biology at age 11 than variation in fear at 1 and 2 years of age.

Smiling was the single exception to this generalization. Frequency of smiles in the second year did predict 11-year-old behavior. This fact suggests that moment-to-moment changes in emotion are more reliable indexes of high and low reactivity than avoiding or approaching unfamiliar events in the second year.

Yoking Current Biology to Behavior

Our selection of biological measures was guided by the hypothesis that high-reactives and low-reactives differ in amygdalar excitability. We chose a varied set of measures of cortical, brain stem, and autonomic reactivity that other research had implicated as potential signs of this property (see Chapter 4). Most of our expectations were confirmed. The biological measures that we regard as indirect signs of amygdalar excitability were more frequent among the 11-year-olds who had been high-reactive infants than among

those who had been low-reactive. For example, the former showed greater activation of the right rather than the left hemisphere and a larger increase in cortical arousal in the EEG when the examiner asked them to reflect on their thoughts as they drove to the laboratory and then to stand up and recite them. They also displayed a larger evoked potential from the inferior colliculus (a target of projections from the amygdala), greater sympathetic tone in the cardiovascular system, and a larger negative waveform in the event-related potential in response to discrepant scenes.

The earlier observation that high-reactive children were more likely to have a thin body build, narrow face, and blue eyes was also affirmed in the 11-year-olds. A slightly shorter stature, lighter weight, and blue eyes were more common among the high-reactives, while more low-reactives were taller, heavier, and more often brown-eyed. The smaller body size of the high-reactive group could not be attributed to malnutrition or chronic disease because all children were well-fed and healthy. One possible explanation is that the genes contributing to infant reactivity, body size, and eye color are contiguous on a chromosome and travel together from one generation to the next during meiosis (the process which produces egg and sperm cells). A second, more likely possibility is that the genes that contribute to high or low reactivity are pleiotropic—that is, they influence many traits, some of which include body size, eye color, and timid or bold behavior in the face of unfamiliarity.

A study of silver foxes illustrates pleiotropy at work. A group of tame silver foxes, representing less than 10 percent of all the animals housed on a Siberian fox farm, were bred with one another—tame males were bred only with tame females. As a result of this selective breeding, changes in body form and fur pigmentation occurred as the mated animals produced increasingly large numbers of tame offspring. The offspring of the twentieth generation of the selective matings were not only tame but also displayed depigmented white spots in their fur and more flexible ears and

tails, suggesting that the genes that contribute to tameness were pleiotropic. These changes in pigmentation and flexibility of ears and tail are characteristic of domesticated mammals, including goats, horses, and cows (Trut, 1999).

The modest relation between eye color and temperament in our young subjects is not an original discovery. Other psychologists have reported that shy school-age Caucasian children are more likely to be blue-eyed rather than brown-eyed. When teachers in 133 different classrooms nominated the Caucasian child in their class who was most shy and the Caucasian child who was least shy, 60 percent of the most shy children were blue-eyed and 58 percent of the least shy children were brown-eyed. A collaborative study with psychiatrists at the Massachusetts General Hospital revealed that among 148 Caucasian middle-class children with a parent who had panic disorder, panic disorder with depression, or no psychiatric condition, 10 girls born to a parent with panic disorder, usually the mother, were extremely shy with the examiner and had a very high heart rate—and all 10 girls had very light blue eyes.

An association between eye color and temperament lies quietly in the unconscious of the artists who have drawn figures for Walt Disney's animated films. Doreen Arcus (1989) discovered that the eye colors first given to characters portrayed as psychologically vulnerable—for example, Alice, Cinderella, and Dopey (one of the dwarfs in *Snow White*)—were blue. By contrast, the characters portrayed as aggressive or dominating—for example, the evil queen in *Snow White,* Grumpy (one of the dwarfs), the Queen of Hearts, Captain Hook, and Merlin—were drawn with dark eyes.

A number of implications flow from this rich set of evidence. The most interesting, and perhaps most significant, is that a 45-minute observation of the behavior of 4-month-old infants reveals a subset of children whose behavioral and biological characteristics could be anticipated to some degree over a decade later. This prediction was possible, we believe, because high- and low-reactive

infants inherit different neurochemistries in the amygdala and its projections.

One-fourth of the preadolescents categorized at 4 months as high-reactives developed an expected pattern of behavior and biology. These 11-year-olds were described as shy by their parents, were quiet and subdued with the examiner, and displayed several of the biological signs that imply an excitable amygdala. And one-fourth of low-reactives preserved their expected behavioral and biological profile. But because 11-year-olds have considerable control over their public behavior, only a modest proportion of high-reactive preadolescents behaved in ways an observer would characterize as extremely shy, fearful, or timid, even though some of these non-shy youth showed physiological properties indicative of higher amygdalar activity.

In other words, the biology of the high-reactives had not prevented them from learning ways to cope with strangers and new challenges, but it did prevent them from displaying the relaxed spontaneity and low level of cortical and autonomic arousal characteristic of many low-reactive children. The fact that more than twice as many high-reactives as low-reactives had values on some of the physiological variables that imply an excitable amygdala, whether these adolescents were shy or bold, implies preservation of a biological property over the course of childhood.

The more important fact is that very few high-reactives became exuberant, sociable, minimally aroused preadolescents, and very few low-reactives became fearful, quiet introverts with high levels of biological arousal. Less than 5 percent of the children from each of these temperamental groups developed the behavioral and biological features characteristic of the other type. Most children who did not conform to expectation were neither extremely shy nor extremely exuberant, and few possessed more than one sign of amygdalar excitability.

The power of each infant temperamental bias lay in its ability to prevent the development of a contrasting profile. Put differently,

the probability that a high-reactive infant would not become an ebullient, sociable, fearless child, with the appropriate biological profile, is very high. But the probability that a high-reactive infant would be extremely shy and show biological arousal at age 11 was much lower. The complementary pair of claims held for the low-reactives. An infant's temperament, therefore, constrains the acquisition of certain profiles more effectively than it determines the development of a particular personality.

Because variation in fear of the unfamiliar during the second year was less predictive of the 11-year profiles than was infant reactivity at 4 months, it appears that life experience had already begun to build a retaining wall around the young child's biology, constraining its influence on behavior. The environments in which children develop can create different personas in those who began life with the same temperamental bias. This process resembles the way that variation in climate, food supply, and predators can create, over time, different species from an original ancestor population. The fact that behavior at age 2 had already become a less transparent window into the child's temperament frustrates observers who would like to be able to predict the early temperaments of adolescents and adults from their current behavior.

Environmental Influences on Temperament

Many environmental conditions affect the future development of high- or low-reactive infants. Family socialization styles and values operate first. Parents who encourage boldness and sociability and gently discourage timidity motivate their high-reactive children toward a less inhibited profile. Doreen Arcus discovered that the mothers of high-reactive infants who showed minimal fear in the second year did not protect their infants from all uncertainty because they believed that their child had to learn to deal with unfamiliar challenges. The mothers of high-reactives who, out of equally loving concern, were reluctant to cause them distress and protected them from new experiences had the most fearful 2-year-olds.

Excessive parental criticism is also formative. Regular parental criticism can generate high levels of uncertainty in high-reactives, who are more vulnerable than low-reactives to feelings of anxiety or guilt following violation of family standards. Parental behaviors as role models are also influential. Most children identify with their parents; that is, they believe that some of the adult properties belong to them, and they experience vicarious emotion. Hence, a high-reactive girl with a bold, sociable parent is tempted to believe that she too has an outgoing persona. The high-reactive girl with a highly anxious mother comes to the opposite conclusion and might assume that her timidity is an inherent trait.

Actual success and failure, with people or with tasks, modulate development. A child with several satisfying friendships will have less doubt over her sociability than one with no close friends. Success in school, athletics, music, art, or other activities can persuade a highly reactive child that he has some basis for resisting a private judgment of inadequacy.

The specific group the child selects to compare himself to is critical for development. Shy children in contemporary American society would feel less uncertainty if they did not encounter so many sociable children. The mind/brain is exquisitely sensitive to infrequent events. Because extreme shyness is less common than sociability in the United States (but not necessarily in all societies), children and adults exaggerate the significance of this trait, and some view it as undesirable. The automatic attention paid to infrequent events is one reason why questionnaire measures of temperament are less valid than extensive behavioral observations. Parents of a shy child will attribute less shyness to that child if he possesses another even less common trait—for example, extreme aggression or impulsivity. By contrast, parents of a child for whom shyness is the only salient quality are tempted to exaggerate the seriousness of this trait.

The influences of temperament, past history, and current context are not additive. Each comes online at different times, and it is

impossible to assign a weight to any one of these factors that reflects its unique contribution to the adolescent character. The temperamental bias is the first to exert its force, but the social environment begins to sculpt infants with varied temperaments into different profiles during the first year. And each child adjusts her psychological profile as settings of action change from home to playground to school to college to workplace. That is why it is difficult, at least at the present time, to discern an adult's early temperament by examining her current behavior or biology.

Unpredictable or chance events, too, have potency to change a life, or the lives of a group, just as a hurricane can eliminate a perfectly well-adapted population of mussels while enhancing the prospects of a competitive variety. Being first or later born in a family, growing up in a small town or big city, having competent or indifferent teachers at a critical age, or losing a parent in early childhood can alter the life course. Some unpredictable events, like war, civil unrest, or economic depression, can affect the ideas of millions of adolescents in a society and, in so doing, impact an entire generation. Two obvious examples for American youth were the Depression between 1930 and 1940 and the protest against the Vietnam War and racism in the late 1960s.

Yet, despite these facts, some temperamental biases can persist. Hox genes, which determine an animal's body architecture, offer an illuminating analogy. This small group of genes, which contributes to the bilateral body symmetry of worms, mosquitoes, frogs, lizards, hawks, mice, and humans, has been preserved for over 500 million years, while the genes for body size, type of skin covering, and shape of the limbs have been altered more drastically by natural selection working in concert with mutations and recombinations. We believe that the physiologies that are the foundation of high and low reactivity are more likely to be preserved over the life span than cognitive talents, political beliefs, or coping strategies. A person watching silent films of the first 20 minutes

of interviews with these adolescents, and who understood the facts we have summarized, would, we believe, do better than chance in deciding which ones were high- and which ones low-reactive. But the viewer would be unable to predict that child's school grades, popularity with friends, emotional relation to parents, or athletic talents. The tell-tale signs would be the degree of muscle tension in the trunk and limbs and the frequency of smiling and laughter.

Advice for Parents

Most parents worry over the development of their children and implement practices they hope will protect their sons and daughters against undesirable outcomes. Educated parents in Westernized cultures are prone to believe that scientific facts should guide their rearing behavior. Although some suggestions of psychologists, pediatricians, and psychiatrists are no more valid than the superstitions of the ancient Greeks, we believe that some potentially useful advice flows from the evidence gathered on the high- and low-reactive temperaments.

First, parents should appreciate that some children inherit a temperamental bias to be cautious in unfamiliar situations. Parents should not assume that their parenting behavior is the sole source of this trait in their child's personality. An acceptance of that fact should alleviate some of the guilt felt by parents who misinterpret their child's timidity as a sign that they must have done something wrong. Conversely, proud parents of an ebullient and confident child should not assume full credit for their wise parenting skills. This suggestion does not mean that parents do not affect their child's personality—they do.

Parents should not overprotect high-reactive infants from all novelty or challenge, even though some loving parents are tempted to do so. Parents who gradually expose their high-reactive infants to feared targets can help them overcome their initial tendency to

avoid the unfamiliar. Many of the inhibited children in our study gained control over outward signs of their uncertainty. One high-reactive inhibited boy wrote an essay for his teacher describing his eventual success in dealing with his temperamental bias.

> I've always been more of an anxious person than some other people. There is a tendency for some people to be more shy and most of all more anxious. It took me a very long time to learn how to cope with this heightened state of nervousness. Until recently, I've been very scared of shots. One dentist refused to work with me. I finally found a dentist who I really trusted and then my fears ebbed away. I was also afraid to swim for a very long time because I was afraid of getting water on my face. I could not actually jump in until the day my sister did. When she jumped in the pool, I couldn't stand the feeling of inferiority. That made me jump in. From that day on, I could go under water. I used to have to talk to my parents all the time to calm down after a bad dream. However, I got over all those things. I sleep fine in the dark and have no problems with bad dreams.
>
> I was able to get over my fears. These inner struggles pulled at me for years until I was able to just let go and calm myself. I have also found that the manifestation of my anxiety can be overcome by using simple mind-over-matter techniques. A good example of this was when I was 8 after learning about asthma, I started to feel like I was having trouble breathing. In a heightened state of anxiety, I subconsciously forced myself into believing that I had asthma. Besides just general fears, it was a struggle to overcome this anxiety manifestation. I overcame these problems. I know how to deal with them when they occur. For example, when I first heard about the anthrax in Washington, I began to have an upset stomach. I realized it was simply because of my anxiety that I was feeling sick. As soon as I realized that, the stomachache

went away. Because I now understand my predisposition towards anxiety, I can talk myself out of simple fears.

PARENTING A HIGH-REACTIVE CHILD

Consider, as a thought experiment, three types of American families who bring a highly aroused, easily distressed infant home from the hospital. One class of parents feels empathic for this apparently unhappy infant and becomes overly solicitous. Mothers are likely to pick their infants up as soon as they cry and try to soothe the distress. This routine strengthens an infant's predisposition to cry at the first sign of novelty and, later, to avoid unfamiliar events. A reluctance to make their children unhappy motivates nurturing parents to accept a retreat from novelty, even though the acceptance increases the likelihood that, as they become older, their children will be cautious in new situations. Continued acceptance of inhibited behavior can lead, in time, to shy, restrained, timid 6-year-olds. We estimate that about one-third of high-reactive American infants experience this form of child-rearing.

A second group of equally loving parents holds a different philosophy. These families believe, often tacitly, that they must prepare their children for a competitive society in which retreat from challenge is maladaptive. These parents refrain from comforting their infants every time they cry and wait for the children to regulate their own distress. Rather than accept retreat from unfamiliarity, these parents encourage their children to greet adult strangers and approach unfamiliar children on a playground, and they praise their sons and daughters when they overcome their caution. Children reared this way are less likely to be avoidant when it is time to begin first grade. Such children often display a high energy level, talk too much, and ask too many questions. This script is more common in sons than in daughters because of a sex-role bias in our culture that regards retreat from challenge as less acceptable in boys than girls. We suspect that this group, too, comprise about one-third of high-reactive infants.

A much smaller proportion of high-reactives are born to parents who misinterpret their irritability as willful. These parents often become angry with their children and punish what they regard as misbehavior or disobedience. This regimen exacerbates an already high level of limbic excitability. Because these children cannot always control their emotions, they can become more irritable or, depending on the severity of the parental behavior, withdraw as experimental animals do when they cannot avoid electric shock. Fortunately, this developmental course is far less common than the first two.

PARENTING A LOW-REACTIVE CHILD

Families with a low-reactive infant also vary in parenting styles. Low-reactive infants smile frequently, sleep well, and are easy to care for most of the time. However, when the first signs of self-awareness emerge during the second year, these children may resist parental demands for control of mild aggression, tantrums, disobedience, and destruction of property because parental chastisement does not generate as much uncertainty as it does in most 2-year-olds. At this point two developmental itineraries become possible.

In the most common, derived from the value Americans place on autonomy and freedom from anxiety, parents adopt a laissez-faire approach and permit disobedience to all but the most serious infractions. These children are likely to become relatively exuberant and sociable as long as their parents are consistent in socializing serious violations of community norms on aggression, domination, and destruction. However, if parents are inconsistent in their punishment and if, during later childhood, there are peer temptations for asocial acts, these children—especially boys—are at a higher than normal risk for developing an asocial personality.

A different course is likely if parents are unwilling to brook opposition to their demands and punish most disobedience. Children raised this way are likely to react with angry tantrums, and contin-

uation of this cycle can create a rebellious posture toward parents and later toward the authority of teachers and employers.

The mothers' descriptions of their 11-year-olds affirm these hypothetical predictions. Fifteen percent of high-reactives, but only one low-reactive, were described as very shy with strangers; 30 percent of high-reactive boys, but only 15 percent of low-reactive boys, were described as having high energy and talking all the time. By contrast, 30 percent of low-reactives were described as exuberant, compared with only 5 percent of high-reactives, and 10 percent of low-reactive boys, but not one high-reactive boy, was described as rebellious.

A BALANCED PERSPECTIVE

Although many parents may assume that low-reactives represent the more desirable type of infant, each temperamental type has both advantages and disadvantages in our society. A technological economy requires a college education. Students with higher grade-point averages in high school tend to be accepted at better colleges and have a higher probability of attaining a gratifying, economically productive career. In middle-class homes, high-reactive children are more concerned with academic failure and therefore more likely to have an academic record that will gain admission to a good college. After college, this type of person will have many occupational options, because our society needs adults who like to work in environments where they can titer the level of uncertainty. Adolescents who were high-reactive infants often choose intellectual vocations because this work allows some control over each day's events in settings where unanticipated interactions with strangers can be held to a minimum. Our society needs these vocational roles, and those who fill them are rewarded with respect and financial security. I suspect that T. S. Eliot would have replied "no" if, after attaining international fame, he was asked whether he would have wanted his mother to take him to a therapist to treat

his inhibited personality. Had Eliot conquered his extreme introversion, he might not have become a poet and playwright.

Contemporary adolescents are confronted with many temptations that promise pleasure, peer acceptance, and self-enhancement if they are willing to assume some risk. Driving at high speeds, experimenting with drugs, engaging in sex at an early age or unprotected sex at any age, and cheating on examinations are four common temptations with undesirable consequences; some decisions can change a life permanently. The adolescent who experiences uncertainty as he thinks about engaging in these behaviors—a more likely response among high-reactives—will tend to avoid the risk. It is not a coincidence that introverts live longer than extraverts. Guppies with a bold temperament approach large predator fish, while timid guppies stay away. The former have a shorter life span than the latter.

The low-reactive, uninhibited child enjoys her share of advantages. Sociability and a willingness to take career and economic risks are adaptive in contemporary American society. The 17-year-old willing to leave home in order to attend a better school or accept a more interesting job is likely to gain a more challenging position and greater economic return than one who stays close to home because of a reluctance to confront the uncertainties of a distant place. Had the parents of Lyndon Johnson and Bill Clinton tried to mute their sons' extreme extraversion, those men might not have become President.

The island of Cayo Santiago, close to mainland Puerto Rico, contains over 1,000 rhesus macaques and no human residents. Observers visit the small island each day to make notes on the animals' behavior. The consistently timid monkeys are likely to die of starvation because, when food is put out each day, they wait for the other monkeys to feed first. If a timid monkey waits too long on too many days, he will starve to death. On the other hand, the bold monkeys get sufficient food, but they are at a higher risk of

dying from wounds that follow an impulsive attack on a stronger animal.

When scientists eventually discover drugs that can reduce the uncertainty of the inhibited child or rein in the fearlessness of the uninhibited, parents will have to decide whether to use these pills. Their decision will depend on the values of our society. If American culture 50 years hence is not very different from its present form, most parents of inhibited children will probably use the drug, while parents of uninhibited children will not. Should historical events place the uninhibited child at higher risk for adaptive failure, parents will make the opposite decision.

We end this overview with three suggestions for parents:

1. Acknowledge your child's temperamental bias and do not assume that either your rearing practices or the child's willfulness is the only reason for his or her behavior.
2. Acknowledge your child's malleability and capacity for change. An infant's biology does not determine what she will become 10 or 20 years later. Temperament is not destiny.
3. Accommodate parenting goals to the child's own wishes. A regimen of rearing that takes account of both the parent's hopes and the child's desires can be found, if parents are willing to search for it.