

The Answer
1/2/20

3/2/20

Alfred Binet and the Study of Intelligence

The following is a
summary of the work
of Alfred Binet and
his colleagues in
the study of intelligence.

The study of intelligence has a long history, but it was not until the late 19th and early 20th centuries that it became a serious scientific discipline. One of the pioneers in this field was Alfred Binet, a French psychologist who, along with his colleague Théodore Simon, developed the first practical intelligence test in 1905. This test, known as the Binet-Simon scale, was designed to identify children who were intellectually disabled and in need of special education. The test consisted of a series of tasks that measured various aspects of cognitive ability, such as memory, reasoning, and problem-solving. The scores on these tasks were used to determine the child's mental age, which was then compared to their chronological age. This concept of mental age was revolutionary, as it provided a way to quantify intelligence and track its development over time. Binet's work laid the foundation for the field of intelligence testing, and his ideas have influenced countless researchers and educators ever since.

The Developing Mind:
Alfred Binet, Jean Piaget,
and the Study of
Human Intelligence

In the late 1880s, the beleaguered young psychologist Alfred Binet (1857-1911) found instruction as well as welcome diversion by observing the behavior of his two little daughters, Madeleine and Alice. As an outspoken disciple of Jean Charcot and supporter of the fanciful theory of *grand hypnotisme* described in Chapter 10, Binet found himself under increasing professional attack at work. But at home he was enchanted by the growing abilities of his girls, and as an inveterate experimenter he could not resist trying out several new psychological tests he had read about. These home experiments yielded data for three scientific publications, and produced some important new attitudes in Binet about the nature and measurement of intelligence.¹

Some of the tests measured reaction time and sensory acuity, following the recent model of Francis Galton's Anthropometric Laboratory. As shown in Chapter 7, Galton hypothesized that innate and hereditary intelligence would be associated with powerful and efficient nervous systems. His tests were intended primarily

The Developing Mind

for young adults, but Binet tried them on his much younger daughters and was surprised at what he found.

When they attended to the task of reaction time, the girls responded just as quickly as normal adults. They did not always pay attention, however, and so had slower *average* reaction times than adults. But Binet thought this signified a difference between children and adults in *attention*, not in underlying neurological reactivity or sensitivity. Further, on tests of sensory acuity requiring the discrimination of variously sized angles or the matching of colors, three-year-old Alice did almost as well as normal adults and five-year-old Madeleine scored slightly *better*.

Tests that did show major differences between children and adults required skills largely untapped by Galton's measures. Binet's daughters could not *name* the colors printed on strips of paper as quickly as adults, for example, even though they could discriminate and match the same colors by sight just as well. And when asked to define simple everyday objects, the children did not offer formal "definitions" as adults would, but responded by describing immediate actions or purposes. For example, a knife "is to cut meat," a box "is to put candies in," and a snail was, simply and emphatically, "Squash it!"²

At this point in his career, Binet was not concerned with measuring degrees of intelligence as Galton and some others had been. But the experiments left him with a permanent distrust of Galton's whole general approach to testing. When young children with manifestly undeveloped intellects could approach or match the performance of adults, such measures hardly seemed promising discriminators of intelligence *between* adults or anyone else. Much more promising, it seemed, would be tests involving "higher" and more complex functions such as language and abstract reasoning. A decade and a half later, when Binet finally did turn his attention to the specific problems of developing an intelligence test, these attitudes would bear fruit and enable him to succeed where Galton and many others had failed.

Binet was not the only pioneer investigator of intelligence to learn from his children. Some thirty years after Binet's first experiments with Madeleine and Alice, the Swiss psychologist Jean Piaget

(1896-1980) systematically observed the behavior of his daughter Jacqueline and her cousin Gérard, in looking for lost objects. A chance observation of thirteen-month-old Gérard at play with a ball started things off. First the ball rolled under an armchair where Gérard could still see it; he crawled after it and retrieved it. Later the ball disappeared from his sight under a fringed sofa on the other side of the room. After just a cursory glance at the sofa, Gérard crossed the room to the *armchair* and searched for the lost ball in the place he had found it the time before.

From this "irrational" reaction, Piaget inferred that the baby Gérard lacked an adult's sense of the ball as a distinct "object," independent and separate from himself and his perception of it. Thus as Piaget's daughter Jacqueline passed through infancy, he carefully studied her developing grasp of what he called the object concept. During her earliest months, she acted as if objects ceased to exist as soon as they left her immediate sensory awareness. For example, when Piaget placed a toy in front of her she reached to get it, but immediately stopped when he blocked her view of it with his hand or a screen. When he placed a cloth over the toy, in full view, she made no attempt to remove the cloth and recover the toy. By eleven months she would search actively and successfully for such hidden objects, while still showing a limitation reminiscent of Gérard: When Piaget placed a toy parrot under bedcovers to Jacqueline's immediate left, she promptly retrieved it; but when he next ostentatiously hid it under covers on her right, she looked for it where she had been successful before, on the left. At twenty-one months, however, she was fully proficient at locating hidden objects, as Piaget documented in the following report:

I put a coin in my hand, then put my hand under a coverlet. I withdraw my hand closed; Jacqueline opens it [and finds nothing], then searches under the coverlet until she finds the object. I take back the coin at once, put it in my hand and then slip my closed hand under a cushion situated on the other side (on her left and no longer on her right); Jacqueline immediately searches for the object under the cushion.³

Now Jacqueline could conceive of objects as entities in their own right, having an existence apart from her own immediate experience of them. And only now, Piaget reasoned, could she logically be

expected to attach *names* to stable and meaningful object-concepts, and to begin the sort of verbal discourse and thought that characterizes mature intelligence. This reinforced his hypothesis, already established on other grounds, that the mind or "intelligence" of a child is *not* simply a miniature replica of the adult's, but something that grows and develops through a series of stages that originally bear little obvious similarity to the finished result.

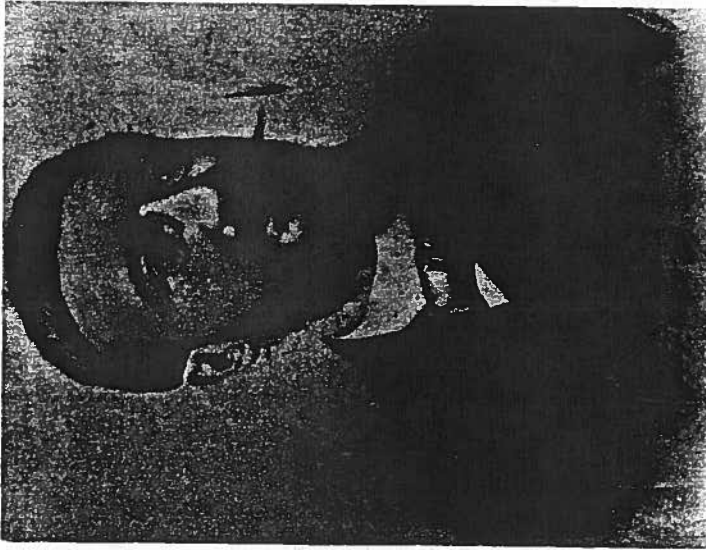
Binet's and Piaget's observations of their children constituted small but important parts of their overall investigations, which established the fact that a full understanding of the adult mind requires prior understanding of the child's. In moving now to the fuller stories of these two psychologist-fathers, we shall see the foundations of two different but equally influential approaches to the study of human intelligence.

Binet's Early Life and Career

Alfred Binet's wealthy parents separated soon after his birth on 11 July 1857 in Nice, France. He was raised in Nice and Paris mainly by his amateur artist mother, although his physician father figured in at least one crucial childhood experience. To cure Alfred's timidity, Dr. Binet forced him to touch a cadaver. The "treatment" served only to increase the boy's anxieties, and its memory haunted him thereafter.

After a creditable if unspectacular secondary school career, Binet took a degree in law but decided against practice. Then he tried medical school, where the horrors of the operating theater evidently exacerbated emotional scars from his childhood trauma. He suffered a severe breakdown and withdrew without a degree. At twenty-two — dispirited, emotionally exhausted, and vocationless — he began passing time by reading extensively in Paris's great library, the Bibliothèque Nationale. Apparently by accident, he discovered books on the new experimental psychology, became fascinated, and realized that he had at last found his vocation.

He plunged untutored into this new field, with more enthusiasm than discretion. He read a few studies of the "two-point threshold," showing that when two points are simultaneously pressed against



Alfred Binet (1857-1911). Archives of the History of American Psychology, University of Akron.

the skin, they must be separated by some minimum distance that varies both with individuals and with the parts of the body stimulated if they are to be correctly perceived as two rather than one. After experimenting briefly on himself and some friends, he wrote an article proposing a "new" theory of this phenomenon, which appeared in 1880 as Binet's first scientific publication. His pleasure at seeing his work in print quickly changed to embarrassment, as the Belgian physiologist Joseph Delboeuf (1831-1896) published a critical reply: Binet's experiments had flaws, and the "new" theory had already been published years before by Delboeuf himself.

Undaunted, Binet next became enthusiastic about the association-

istic psychology of John Stuart Mill, one of Locke's most important successors in stressing the importance of experience and education in shaping human character. In a second published article, Binet made the extreme claim that "the operations of the intelligence are nothing but diverse forms of the laws of association: all psychological phenomena revert to these forms, be they apparently simple, or recognized as complex."⁴ Although associationism clearly had merits (and Binet's appreciation of them would eventually help him to succeed where the arch-hereditarian Galton had failed in devising a workable intelligence test), this statement went much too far. Work in "dynamic psychology" had already clearly demonstrated that ideas can become *dissociated* or *disconnected* from each other, and that a given stimulus can lead to totally different trains of association under different motivational conditions. Laws of association could not easily account for these phenomena, and Binet was fortunate to escape a second public rebuke.

Evidently finding this out on his own, Binet next sought training in the new dynamic psychology from one of its most famous proponents. The eminent Jean Charcot, just then developing his theories of *grand hystérie* and *grand hypnotisme* at Paris's Salpêtrière Hospital, accepted the enthusiastic and independently wealthy young Binet as an unpaid assistant and trainee. Binet remained with Charcot for nearly eight years, becoming one of the most prolific researchers of the "Salpêtrière school." He published three books and more than twenty papers on varied topics ranging from mental imagery to sexual "fetishism" (a term he originated, to denote cases in which patients invest inappropriate objects or body parts with sexual significance).

Binet's most spectacular work at the Salpêtrière involved the hypnotic reactions of Charcot's prized "major hysterics." He and his colleague Charles Féré produced astonishing results in deeply hypnotized subjects merely by reversing the polarity of a horseshoe magnet in their presence: Symptoms moved from one side of the body to the other, for example, and emotions turned into their opposites. As recounted in Chapter 10 (pages 344-346), these implausible results aroused the skepticism of Binet's old nemesis Delboeuf, who visited the Salpêtrière and saw the young experimenters' carelessness

in openly expressing their expectations to the hypnotized subject. Delboeuf's consequent exposé helped turn the tide of informed opinion against Charcot's entire theory of *grand hypnotisme* in favor of the less flamboyant Nancy school.

At first, Binet tried to defend himself and Charcot by arguing that Delboeuf and the Nancy school could not reproduce the Salpêtrière findings only because they lacked access to the crucial cases of "major hysteria"—found more easily in the big city than in the provinces. Delboeuf responded sarcastically:

What has the school of the Salpêtrière replied to [my] deductions, so strongly upheld by facts? That my subjects and those of Nancy were only "common-place *somnambules*," that Paris alone had access to "profound hypnotism," while we—we had only "*le petit hypnotisme*," a hypnotism of the provinces! It would be difficult to find in the history of the sciences another [such] example of an aberration perpetuating itself . . . by pure overweening pride.⁵

Finally in 1891 Binet himself recognized the terrible truth that he had placed too much faith in Charcot's name and prestige and had accepted the master's theories too uncritically. Humbled, he admitted publicly that his earlier hypnotic studies "present a great many loopholes for error. . . . One of the chief and constant causes of mistakes, we know, is found in suggestion—that is to say, in the influence the operator exerts by his words, gestures, attitudes, even by his silences, on the subtle and alert intelligence of the person he has put in the somnambulistic state."⁶ From this school of hard knocks, Binet learned an invaluable lesson about how psychological experiments ought *not* to be conducted. Never again would he trust unauthenticated authority or go out on a limb for a position he had not tested thoroughly himself.

Further, just as the hypnosis debacle was coming to a climax, Binet began his series of experiments at home with his daughters. Besides suggesting to him the weakness of the Galtonian approach to mental testing, his observations of Madeleine and Alice reinforced one *positive* lesson from Charcot and the Salpêtrière. In conducting intensive studies of relatively few cases, Charcot had inevitably emphasized the essential *individuality* of all subjects in psychological

study. Binet found ample further evidence of individuality in his two daughters.

A proud and doting father, he saw both his girls as bright and able. But from earliest childhood onward they *showed* their intelligence in characteristically different ways—the elder Madeleine always proceeding cautiously and deliberately, while the younger Alice behaved with greater enthusiasm and imagination. Thus in learning to walk, Madeleine held on to a chair or table for support, and "risked abandoning that support only when she had visually selected another object a short distance away which would offer new support; she directed herself very slowly towards the second object, . . . with great seriousness and in perfect silence." Alice, by contrast, was "a laughing and turbulent child" who "never anticipated which object could furnish support, because she advanced without the slightest hesitation to the middle of an empty part of the room. She cried out, she gestured, she was very amusing to watch; she advanced staggering like a drunken man, and could not take four or five steps without falling."⁷

Such stylistic differences recurred in countless other situations, leading Binet to characterize the sensible and down-to-earth Madeleine as "the observer" ("*l'observateur*"), and the ever more impulsive and fanciful Alice as "the imaginer" ("*l'imaginatif*"). And for the rest of his career Binet would also respect the great individuality of every person's intelligence, lending his mature psychology a particular sensibleness and power.

Individual Psychology By 1891, the thirty-four-year-old Binet had learned enough positive and negative lessons at the Salpêtrière and at home to become a first-rate experimental psychologist. He lacked only a position, for he understandably did not wish to remain at the Salpêtrière after his humiliation, and other institutions—just as understandably—did not beat down his door with offers.

Finally in late 1891 Binet had a chance meeting in a railroad station with Henri Beaunis, a physiological psychologist and the director of the newly created Laboratory for Physiological Psychology at the Sorbonne in Paris. Beaunis had favored the Nancy school against Binet and

Charcot in the hypnosis controversy, and must have seemed an unlikely ally. Nevertheless, Binet summoned his courage and offered to work without pay in the new laboratory. With a meager budget, Beauvis perhaps felt he had little to lose. In any case, he appointed Binet as his unpaid assistant and got a wonderful bargain. Binet soon gained recognition as France's leading experimental psychologist, and succeeded Beauvis as director of the laboratory in 1894. The following year he founded *L'Année Psychologique*, the first French journal explicitly devoted to experimental psychology. He remained at the Sorbonne, always without pay, until the end of his life.

Prominent among the multitude of topics Binet studied from his Sorbonne base was **suggestibility**—the phenomenon that had ruined his hypnotic experiments and that he now acidly called the “cholera of psychology.” He began by developing a simple test of memory for schoolchildren, in which subjects were briefly shown a single straight line and asked to remember its length before being asked to choose its match from a pair of unequal lines. After establishing average accuracy levels on this task under “neutral” conditions, Binet tried to manipulate responses by suggestion. Sometimes he established “preconceived ideas” by making the top (or bottom) line of the pair correct for several consecutive trials and then deliberately switching. Other times he instructed subjects previously identified as “leaders” to make their choices publicly, before the others made theirs.* In still other experiments he made leading comments, such as “Are you sure? Mightn't it be the other line?” All of these manipulations had an effect, somewhat greater on younger subjects than older ones, and with substantial individual differences. Binet observed that these results raised serious doubts about the veracity of children's testimony in judicial proceedings, particularly when elicited by “leading questions” from lawyers.

Binet summarized these experimental results statistically, giving average numbers of correct and incorrect responses for groups of subjects under the various conditions. But as he did so he also recalled the lesson of individuality he had learned from Charcot and

*Students of social psychology will recognize that these experiments closely anticipated the classic studies of conformity conducted by Solomon Asch in the 1950s.

his daughters. “Mere numbers cannot bring out . . . the intimate essence of the experiment,” he warned. He felt uneasy about expressing “all the oscillations of thought in a simple, *brutal* number, which can have only a deceptive precision. . . . It is necessary to complete this number by a description of all the little facts that complete the physiognomy of the experiment.”⁸

Binet also now looked zealously for signs of suggestibility in *himself* whenever he conducted an experiment. When he found it he reported it, as in a study from the late 1890s involving head measurements from several hundred subjects. Following Galton, he had hypothesized a positive relationship between head circumference and mental ability. To his chagrin, however, he found that when he *expected* heads to be small, his measurements averaged some three millimeters less than when he reexamined the same heads under more neutral expectations. This discrepancy exceeded the disappointingly small *real* difference he found between the average head circumferences of schoolchildren classified by their teachers as either very bright or very dull. Besides illustrating the experimental dangers of suggestibility, these findings further convinced Binet of the inadequacy of the Galtonian theory of mental testing.

In other work during the 1890s, Binet conducted in-depth case studies of unusually talented people, including several of France's most famous authors and two “lightning calculators”—men who could quickly and accurately perform complicated mathematical operations entirely in their heads. He learned from these studies that sharers of the same special ability often go about it in entirely different ways. One calculator always *saw* the numbers in his imagination as he worked, for example, while the other always *heard* them instead. Some authors worked best during intense, intermittent periods of “spontaneous inspiration,” while others—with equally good results—wrote methodically and systematically every day. Thus different people used different intellectual strategies to arrive at similar extraordinary results.

So impressed was Binet by this fact of individuality that he and his younger colleague Victor Henri (1872–1940) launched a program called **Individual Psychology** in 1895. They sought a series of short tests, administerable to one person in less than two hours,

that could provide information comparable in richness, complexity, and comprehensiveness to that obtained from the many hours of observations and interviews traditionally devoted to individual case studies. Ideally, a short summary of these test results would serve as an adequate substitute for the sort of extended case reports Binet had written of his extraordinary subjects.

In trying to develop such tests, Binet continued to experiment with his daughters Madeleine and Alice. Throughout their adolescence they served as subjects on scores of tasks designed to test their memory, judgment, imagination, and general personality. Some of these tasks required word associations, the interpretation of ink-blot, or the telling of stories about "neutral" stimuli; thus Binet anticipated several "projective tests" that would much later come into vogue with clinical psychologists. Binet summarized the results of twenty such tests in his 1903 book, *L'Étude Expérimentale de l'Intelligence* (*The Experimental Study of Intelligence*)—regarded by some psychologists as Binet's most creative work. This book repeatedly showed how the two girls had continued to manifest their "intelligence" in characteristically different ways—Madeleine as the down-to-earth "observer," and Alice as the "imagineur." Consider, for example, the two teenaged girls' contrasting responses when their father asked them to write something about a chestnut tree leaf:

Madeline: "The leaf [was] gathered in the autumn, because the folioles are all almost yellow except for two, and one is half green and yellow. . . . The folioles are not of the same size; out of the 7, 4 are much smaller than the three others. The chestnut tree is a dicotyledon, as one can tell by looking at the leaf, which has ramified nervures."

Alice: "This . . . has just fallen languidly in the autumn wind. . . . Poor leaf, destined now to fly along the streets, then to rot, heaped up with the others. It is dead today, and it was alive yesterday! Yesterday, hanging from the branch it awaited the fatal flow of wind that would carry it off, like a dying person who awaits his final agony. But the leaf did not sense its danger, and it fell softly in the sun."⁹

But while Binet's attempts to realize the goals of Individual Psychology produced some interesting isolated results, he concluded in 1904 that the program as a whole had failed. No short combination of tests had emerged that could satisfactorily substitute for an

extended case study. Binet ruefully concluded: "It is premature to look for tests permitting a diagnosis during a very limited time (one or two hours), and . . . much to the contrary, it is necessary to study individual psychology without limiting the time—especially by studying outstanding personalities."¹⁰ The most significant concrete results of Individual Psychology remained his extended case studies of his daughters, and of a few prominent literary figures.

But while technically unsuccessful, Binet's testing experiments in Individual Psychology helped pave the way for his most famous achievement. He had gained valuable experience by trying out innumerable tests of varied functions such as memory, imagination, comprehension, attention, suggestibility, and the aesthetic and moral senses. He had confirmed his belief that only relatively direct tests of the higher, complex mental functions measured significant intellectual differences. When he began in 1905 to seek a test of "intelligence" in a narrower and more specific context than he had been concerned with before, these experiences helped him to succeed where Galton and his other predecessors had failed.

The Binet Intelligence Scales

During the first years of the twentieth century, Binet and many others became increasingly interested in the problem of mental *subnormality*. The recent passage of universal education laws in France had brought a new public visibility to mentally handicapped children. Previously, most such children had either dropped out of school at an early age or never attended at all. Now they were required by law to attend school—and since they usually could not keep up with an ordinary curriculum, they required special attention and special schools.

In 1904, Binet joined a government commission charged with investigating the state of the mentally subnormal in France, and soon concluded that accurate *diagnosis* of subnormality posed the most pressing problems. "It will never be a mark of distinction to have passed through a special school," he remarked, "and those who do not merit it must be spared the record."¹¹ Thus with Théodore Simon (1873–1961), a young physician who had come to study

psychology with him in 1899, Binet set out to develop a test to identify children whose mental handicap rendered them permanently unable to benefit from an ordinary education.

The 1905 Tests Binet and Simon started out with few theoretical predispositions regarding the "intelligence" whose deficiency they hoped to measure. Thus they proceeded empirically, identifying groups of children who had been unequivocally diagnosed as subnormal or normal by their teachers or doctors, and then testing them on many different specific measures. They avoided tests that relied heavily on reading, writing, and other clearly school-related skills, so as not to confuse lack of intelligence with mere lack of schooling. But they did not hesitate to try items that assumed a basic familiarity with everyday French life and culture—many of which Binet had already used in his earlier studies of his daughters and other children.

At first Binet and Simon were frustrated, because while the normal and subnormal groups showed differences in average performance on most items, no item came close to being a perfect discriminator. That is, at least some of the normal children failed on every test and/or some subnormal children passed. But soon a key insight dawned—one that seemed perfectly obvious once recognized, but that had eluded previous workers in the field. *Age* had to be considered: Normal and subnormal children might both learn to pass the same tests, but normal children invariably did so at a younger age. Binet and Simon summarized: "It was almost always possible to equate [subnormal children] with normal children very much younger."¹² Following this insight, it has become customary to describe the subnormal population as "mentally retarded."

Their idea enabled Binet and Simon in 1905 to construct the first test of intelligence that actually worked, comprising thirty separate items of increasing difficulty. The first item simply tested whether subjects could follow a lighted match with their eyes, demonstrating the elementary capacity for *attention* that is prerequisite for all intelligent behavior. Next, subjects had to grasp a small object placed in their hand, to unwrap and eat a piece of candy, to shake hands with the examiner, and to comply with a few simple spoken or ges-

tured requests. Normal children could do all of these things by the age of two, but the most profoundly retarded of any age could *never* do some of them. Intermediate problems, passable by normal five- or six-year-olds but by none of the moderately retarded, required them to state the differences between pairs of objects such as "paper and cardboard" and "a fly and a butterfly" and to memorize and repeat sentences such as "I get up in the morning, dine at noon, and go to bed at night." The more difficult items, which in effect defined the upper borderline of subnormality, required subjects to find rhymes for the French word *obéissance*; to construct a sentence containing the three given words "Paris," "river," and "fortune"; and to figure in their heads what time it would be if the hands of a clock were reversed (for example, twenty past six would become half past four). Most normal children of eleven or twelve could pass these, but few genuinely subnormal individuals of any age could.

The 1908 and 1911 Scales The Binet-Simon test of 1905 marked a turning point in the history of psychology, for it truly made useful discriminations among lower degrees of intelligence. But it focused primarily on the very retarded and the very young, while many of the most difficult educational decisions involved older children close to the borderline of "normality." Accordingly, Binet and Simon extended and refined their pool of items, producing revised intelligence tests in 1908 and 1911. On these, each item was specifically designated according to the age at which a sample of normal children had first been able to pass it. Thus each item at the six-year level had been passed by a minority of normal five-year-olds, about half of the six-year-olds, and a majority of older children. The 1908 revision contained fifty-eight items located at age levels between three and thirteen; its 1911 counterpart had five questions for each age between five and fifteen, and five more in an "adult" category. Here are a few examples:

At the *three-year level*, children had to name common objects in a picture, correctly repeat a six-syllable sentence, and point to their eyes, noses, or mouths upon request. At *six*, they were expected to state the difference between morning and evening, and count thirteen coins. At *ten*, they normally could reproduce several line

drawings from memory; answer questions involving social judgment such as why people should be judged by their acts rather than their words; and detect and describe the logical absurdities in statements such as: "The body of an unfortunate girl was found cut into 18 pieces; it is thought that she killed herself." Items at the *fifteen-year level* asked subjects to recall correctly seven digits, and to deal with problems such as: "My neighbor has been receiving strange visitors. He has received in turn a doctor, a lawyer, and then a priest. What is taking place?"

With age-standardized items such as these, Binet had a genuine "scale" of intelligence, capable of providing a single score or intellectual level for each child who took it. Questions were always asked in ascending order of difficulty, until five in a row were missed. Then the examiner took the highest year for which all five items had been successfully passed as the base, and added one-fifth of a year for each subsequent correct answer to compute the child's intellectual level. For example, a child who answered all of the questions at the age-seven level, four at age-eight, and two at age-nine would be assigned an overall intellectual level of 8.2 years.

In diagnosing mental subnormality, Binet compared each child's tested intellectual level with his or her actual age. He collected statistics suggesting that children whose intellectual levels trailed their ages by less than two years could usually manage in the regular school system, while those who showed greater discrepancies (about seven percent of the population) usually had trouble. Accordingly, he proposed a rule of thumb that children with intellectual levels more than two years behind their actual ages be seriously considered for special education.

Even as he suggested this rule, however, Binet also counseled caution. He still denied the ability of "brutal" numbers adequately to summarize any complex quality, and emphasized that different children could achieve identical intellectual levels by correctly answering widely varying patterns of specific questions. He also recognized that no score could be valid for a child poorly motivated to take the test, or who had been reared in a culture other than that of the sample of children he had used to standardize his questions. And the early proponent of Mill's associationism still emphatically

believed that the "intelligence" measured by his test was not a fixed quantity, but something that grows naturally with time, and that—at least for retarded children and within limits—may be increased by training. He developed a program he called *mental orthopedics*, with exercises like the games of "Statue," in which children had to freeze in position upon hearing a signal, and "Concentration," where they had to remember several objects that were briefly removed from a box and then rehidden. Children whose deficits stemmed from an inability to sit still and to concentrate often benefited from these exercises, increasing not only their "intellectual levels" as measured by Binet's tests, but also their intelligent behavior in real life.

The Rise of Intelligence Testing

At the height of his powers when he developed mental orthopedics and his revised intelligence scales, Binet had little time to enjoy his accomplishments. His wife suffered from an ill-defined malady that inhibited social life, and Binet himself seemed susceptible to gloomy thoughts, reflected in a series of plays he co-authored with André de Lorde, a popular dramatist known as the "Price of Terror." Protagonists in these plays included a released psychiatric patient who murders his brother, a deranged father who kills his infant son after being denied admission to an asylum, and another father who performs ghoulish experiments trying to restore his dead daughter to life.¹³ And all too soon the ultimate tragedy occurred in real life, as Binet himself suffered a stroke and died in 1911, at the early age of fifty-four.

As his most enduring legacy, Binet left behind the basic technology that still underlies modern intelligence tests. Although some psychologists still hope ultimately to find measures of innate intelligence that are "culture free" and closely tied to direct neurophysiological functions, all of the most practically useful tests developed to date still rely on items basically like Binet's—questions directly entailing a variety of higher and complex functions such as memory, reasoning, verbal facility, and practical judgment. But while Binet might feel comfortable about the item content of most modern intelligence tests, he probably would have reservations about some

other developments in their interpretation and use—developments that began to occur almost immediately after his death.

One concerned the general conception of "intelligence" presumably measured by the items. Binet himself had adopted a flexible and pragmatic definition of intelligence, seeing it as a rather loose collection of separate capacities for memory, attention, reasoning, and the like, all tied together by a faculty he simply called "judgment" or "good sense." A rival view, the theory of general intelligence, or "g," was effectively promoted by the English psychologist Charles Spearman (1863-1945) soon after Binet's death.

Spearman first observed and emphasized a fact that has been repeatedly confirmed ever since—namely, that when correlation coefficients (see pages 230-235) are computed between them, all of the various items and submeasures used on intelligence tests tend to be positively and hierarchically intercorrelated with each other. People who do well on vocabulary tests, for example, tend also to score high on arithmetic problems, the detection of similarities, the assembling of painted blocks into specified patterns, the memory for digits, or any of the other items. Further, while all of the subtests tend to intercorrelate positively, some of them achieve generally higher levels of correlation than others. Subtests involving abstract reasoning (such as similarities), for example, intercorrelate more strongly than do measures of rote memory with other items across the board.

To explain these findings, Spearman theorized that all intellectual tasks must entail the exercise of a single common "factor" he called "general intelligence" and abbreviated as "g." He further proposed that each individual type of item required an ability specific to itself, an "s" factor; his theory is accordingly called the two-factor theory of intelligence. Writing metaphorically, Spearman went on to liken each person's "g" capacity to an overall supply of mental energy or power, capable of driving any number of specific neurological "engines" required for performing different specific tasks (and thus constituting the material basis for the individual "s" factors). Thus a person's performance on any task was theoretically a joint function of the overall energy or "g" available, as well as the efficiency of the particular "s" engine involved. The hierarchical nature

of the correlations suggested that some tasks, such as abstract reasoning, depended relatively much on "g" and relatively little on "s"; for rote learning the proportions were reversed. But even tasks relatively "unsaturated" with "g"—like rote learning—required some degree of mental energy. Thus for Spearman the single most important fact to know about any person's intelligence was his or her general intelligence level, or overall mental power.

Although not the only possible explanation for the observed hierarchies of positive intercorrelations, Spearman's theory has held considerable support from its inception. Suggesting that "intelligence" is not so much a loose collection of varying functions and aptitudes as a network of engines all driven by a common energy source, it has fostered attitudes toward testing very different from Binet's. While Binet believed different intelligence levels could be represented only approximately and inadequately by numbers, Spearman's theory suggested that a single figure representing each person's "g" level, or overall "mental horsepower," would be the most important thing to know about that person's intelligence.

A means of calculating such single numbers from Binet's intelligence tests was proposed in 1912 by the German psychologist William Stern (1871-1938), with his concept of the intelligence quotient. Stern had worried over experimental findings showing that the discrepancy between a child's real or "chronological age" and the tested intellectual level or "mental age" (as Binet's term was usually translated) often increased over time. When re-tested after exactly one year, children whose scores were below par the first time usually gained less than one year in mental age, while those who had been above average gained more than a year. Thus Binet's suggestion to adopt a two-year discrepancy between chronological and mental age as diagnostic of subnormality seemed suspect, because it implied different standards for different age groups. Many children's discrepancies inevitably grew from less than two at an early age to more than two later on, making diagnoses of subnormality relatively more frequent at later ages.

To remedy this inequality, Stern suggested taking not the absolute discrepancy between mental and chronological age as the measure of retardation, but rather the ratio of mental age to chronological

age — a fraction Stern called the “intelligence quotient.” Thus a five-year-old with a mental age of four would have an intelligence quotient of 4 divided by 5, or 0.80; to achieve the same quotient, a ten-year-old would have to get a mental age of eight, two years rather than one behind the chronological age.

While perhaps simplifying the problem of diagnosis, Stern’s innovation had one effect that Binet would certainly have deplored. As a final, summary score of test results, the intelligence quotient was much further removed from the actual “physiognomy of the experiment” than the simple mental age or intellectual level. Binet had complained because the same mental age could be produced by different patterns of specific answers; now the problem was compounded because the same intelligence quotients could be produced by different combinations of mental and chronological ages.

For many psychologists, however, this simplification of results carried a major benefit. The intelligence quotient was potentially interpretable as an index of a unitary, quantifiable intellectual power like Spearman’s “*g*.” All that remained was to demonstrate that *high* quotients were indicative of *superior* intellectual power. In 1920 this was not a foregone conclusion. Binet himself had experimented briefly on children with advanced mental ages, been disappointed with the results, and concluded that “the most valuable applications of our scale will not be for the normal subject, but instead for the inferior degrees of intelligence.”¹⁴ That is, he saw his tests as primarily useful in detecting the *lack* of intelligence in subnormal children, and doubted their usefulness in measuring *positive* intelligence.

The first major attempt to demonstrate otherwise occurred during World War I, when tests adapted for group administration were given to nearly two million U.S. Army recruits. The results were used not only to screen out mental defectives, but also to select high-scoring individuals for advanced training. But while this program represented a spectacular organizational accomplishment for psychologists, and helped place intelligence testing “on the map” of public consciousness, the war ended before the tests’ validity in predicting positive performance could be accurately or fully evaluated. In fact, there were many glaring deficiencies and inequalities in the way the testing program was run.¹⁵

First to argue *persuasively* for the usefulness of Binet tests in diag-

nosing superior intelligence was Lewis M. Terman (1877–1956), a Stanford University psychologist who had worked on the army program. Terman in 1916 had introduced “The Stanford Revision of the Binet-Simon Scale,” an extensive reworking of Binet’s test adapted for American subjects and standardized on a considerably larger sample of children. The “Stanford-Binet” quickly became the most widely used individual intelligence test in North America. When introducing this test, Terman had endorsed Stern’s intelligence quotient concept, and further suggested that the fraction be multiplied by 100 to eliminate decimals, with the result being abbreviated as the *IQ*. Ever since, an exactly average level of intelligence has been denoted by an IQ of 100.

Terman’s major interest, however, lay in children with IQs *higher* than average. Perhaps partly because he had himself been a precocious student who passed through school much faster than most, he suspected that “advanced” children in general tended to grow up as unusually capable adults. To test his hypothesis, he followed two complementary strategies. First, he and his graduate student Catherine Cox examined the childhood biographies of more than three hundred eminent historical “geniuses.”¹⁶ Although data were often scanty, virtually every case showed *some* evidence of childhood accomplishment in advance of one’s years — often quite spectacular accomplishment. (Included in Terman-Cox’s list of documented child prodigies were several pioneers from earlier chapters of the present book, including Descartes, Leibniz, Kant, Darwin, and Galton.) Terman and Cox accordingly argued that *if* Binet-type intelligence tests had been available in the past, most people who turned out intellectually great in adulthood would also have achieved high IQs as children.

Terman’s second attempt to relate childhood precocity to adult achievement followed a complementary strategy, and led to his most extensive and famous research program. In the early 1920s his students tested more than 250,000 California schoolchildren, to identify a group of 1,528 “gifted children” with IQs above 140. He then proceeded to investigate all aspects of these children’s lives at regular intervals as they grew up. Terman’s successors still continue to study the survivors of this group, now well into their seventies.¹⁷

And how did they fare? Statistically speaking, the answer is that

they did very well indeed. Compared to a random sample, a high proportion entered the professions, with many earning national or international reputations. More than thirty became eminent enough to be listed in *Who's Who*. Taken as a whole, the group attained more education, earned more money, and in general led healthier and apparently happier lives than the national average.

At the same time, the study showed that high IQ alone does not guarantee success, for a significant minority failed to lead objectively successful lives. Moreover, the group contained surprisingly few individuals successful in the creative arts (as opposed to the professions), and none who have won the Nobel Prize or become celebrated "geniuses." In countless other studies since Terman's, IQ scores in the general population have been found to correlate moderately but far from absolutely with variables such as academic grades, years of education finally completed, and salary levels in adulthood. Thus, in general, high IQs have turned out to be good but far from perfect predictors of intellectual success. In spite of the widespread tendency to equate high IQs with "genius," the evidence suggests that the tests still work relatively better for their original purpose—the diagnosis of retardation.

Still, Terman and other advocates made IQ scores into common intellectual currency, and a vast testing industry developed. New tests were subsequently designed for adults, calculating IQ scores not by the traditional mental age to chronological age ratio, but according to the distributions of result within each age group. Thus a twenty-five-year-old and a sixty-year-old, each with an IQ of 100, stand at the exact average of people in their age groups. IQs of 80, 110, and 135 always stand respectively at about the 9th, 74th, and 99th percentiles for the age group in question.

In sum, modifications of Binet's testing procedures became applied to all segments of the population, with results summarized by a single score for each subject. Inevitably, these scores were also interpreted by some—particularly those who accepted Spearman's conception of intelligence as dominated by a biologically given general factor—as Galton's long-sought measure of *hereditary* natural ability. Others have disputed this contention, seeing IQ as a variable primarily determined by environment and education, rather than

heredity. Indeed there remains great controversy today over the exact meaning of IQ scores. Were he alive today, Binet himself would undoubtedly regret all of the fuss about these issues, but be pleased to see that his testing techniques have retained their usefulness for individual educational and clinical diagnoses.

One further development would probably please him as well. In 1920, the young Swiss psychologist Jean Piaget came to work in one of Binet's old laboratories, under the direction of his colleague Simon. Using a clinical interview method much like that endorsed by Binet, Piaget arrived at a new conception of exactly *how* children's intelligence normally develops with age. Concerned with qualitative rather than quantitative intellectual developments, Piaget revolutionized the field of child psychology.

Piaget's Early Life and Career

Jean Piaget was born on 9 August 1896 in Neuchâtel, Switzerland, the son of an academic who wrote prolifically about medieval literature and local history. Piaget recalled his mother as intelligent and kindly, but also prone to emotional disorders that often made the domestic atmosphere uncomfortably tumultuous. To cope with the tumult, he said he identified with his father and buried himself in serious intellectual work. Even as a child he wrote prodigiously, and he continued throughout his life to publish at a rate not far short of Wundt's. When asked as an adult how he could write so much, Piaget frankly replied, "Fundamentally I am a worrier whom only work can relieve."¹⁸

Piaget's boyhood works included a pamphlet describing his invention of a combination wagon-locomotive, and a small handwritten book entitled *Our Birds*. His ornithological knowledge was real, for at age ten his essay describing a partly albino sparrow appeared in a local journal of natural history—his first scientific publication. Shortly thereafter, young Piaget became a volunteer assistant to the director of Neuchâtel's natural history museum, a man who specialized in malacology, the study of mollusks. Piaget learned this field too, and between the ages of fifteen and nineteen published twenty-one malacological papers in assorted international journals.

