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PRIMARY MENTAL ABILITIES

One of the earliest accomplishments of the science of psychology was the objective measurement of mental abilities.

In 1904, the British psychologist Charles Spearman argued that intelligence could be characterized as being composed of a general factor (g) common to all meaningful activity and of specific factors (s) that are unique to the different tasks used to measure intelligence. Test instruments that applied the concept of general intelligence were introduced by Binet and Simon in France and by Terman in the United States. American psychologists engaged in educational and occupational selection activities found the concept of general intelligence less useful for predicting success in specific jobs or other life roles. In addition, Thorndike's work on transfer of training had suggested that the notion of generalizability of a single ability dimension was not justified.

Efforts soon began, therefore, to determine whether human abilities could be described along a parsimonious number of distinct substantive dimensions. Initial work along these lines began with the publication of T. L. Kelley's *Crossroads in the Mind of Man* (1928), which advocated the determination of group factors representing distinct skills, such as facility with numbers, facility with verbal materials, spatial relationships, speed, and memory. These efforts were also aided by advances in the methods of factor analysis that allowed the determination of multiple factors, each representing a latent construct represented by sets of independently observed variables.

Most prominently associated with these developments was L. L. Thurstone (1935), who expressed the hope that a careful scrutiny of the relations among a wide array of assessment devices, developed to reflect a given construct as purely as possible, would yield a limited number of dimensions that would reflect "the building blocks of the mind." He administered a battery of 56 simple psychological tests to a large number of children in Chicago schools and applied factor analysis to determine the latent basic ability dimensions represented by these tests. Given the procedures available at the time, he was reasonably successful in showing that fewer than 10 latent constructs were required to explain most individual differences variance in his measures. The factors obtained in this work were consequently labeled the *primary mental abilities.*

Most of the factors identified by Thurstone have been replicated subsequently in work by others. The most important factors, in order of the proportion of individual differences explained, are the following:

Verbal comprehension (V). This factor represents the scope of a person's passive vocabulary, and is most often measured by multiple-choice recognition vocabulary tests.

Spatial Orientation (S). The ability to visualize and mentally rotate abstract figures in two- or three-dimensional space. This ability is thought to be involved in understanding maps and charts and in assembling objects that require manipulation of spatial configurations. This may be a complex factor involving both visualization and the perception of sp relationships.

Inductive Reasoning (R or I). This is the ability to de mine a rule or principle from individual instan probably involved in most human problem solvi The ability is generally measured using a number letter series that has several embedded rules; t subject is asked to complete the series correctly.

Number (N). This is the ability to engage rapidly an correctly in a variety of computational operations The most simple measure of this ability is a test checking sums for addition problems.

Word Fluency (W). This factor represents a person's active vocabulary and is generally measured by free recall of words according to a lexical rule.

Associative Memory (M). Found primarily in verbal tasks involving paired associates or list learning. It is not a general memory factor, evidence for which has not thus far been established.

Perceptual Speed (P). This ability involves the rapid and accurate identification of visual details, similarities, and differences. It is usually measured by letter canceling, simple stimulus, or number comparison tasks.

Other organizational schemes to characterize multiple abilities have been developed by G. H. Thompson (1948) and P. E. Vernon (1960) in England and by J. P. Guilford (1967) in the United States. The latter system actually classified tasks along a three-dimensional higher-order hierarchy in terms of content, product, and operations involved in each task, resulting in a taxonomy of as many as 120 factors, many of which remain to be operationalized.

For the purposes of educational application, L. L. Thurstone and T. G. Thurstone (1949) developed a series of tests at several difficulty levels suitable from kindergarten to high school designed to measure Thurstone's first five factors (V, S, R, N, and W). This battery was updated and revised by T. G. Thurstone in 1962. Measures of the other factors may be found in the kit of factor-referenced tests (1976) developed by the Educational Testing Service.

The primary mental abilities measures have had little use in educational practice in recent years. However, the primary abilities have experienced a revival as a useful measurement instrument for charting the course of abilities in studies of adult development (also see "Adult Intellectual Development"). A special version of the primary abilities tests particularly suitable for work with older adults has also been developed (STAMAT). Factorial invariance of six latent ability dimensions (Inductive Reasoning, Spatial Orientation, Verbal Ability, Numeric Ability, Perceptual Speed, and Verbal Memory) has been demonstrated in longitudinal samples across time and different birth cohorts (as well as across genders) (Schaie, 1996). The validity of the primary mental abilities in adults has also been examined with respect to its relation to measures of practical intelligence and subjective perception of competence, as well as to specific occupational outcomes.

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See also: **Testing Methods**

PRIMARY MOTOR CORTEX AND PRIMARY SOMATIC SENSORY CORTEX

The primary motor cortex and the primary somatic sensory cortex represent two principal components of sensory motor integration implemented in the brain. The fundamental function of motor cortex is to control voluntary movements, whereas somatic sensory cortex receives and analyzes tactile, joint, and muscle sensory inputs, sometimes in relation to voluntary movement. From classical perspectives, motor cortex functions as the final cortical output for already processed movement commands, relaying signals from premotor cerebral cortical sites to the spinal cord. Similarly, somatic sensory cortex has often been viewed as a pipe to relay subcortical inputs to higher order cortical sites for further processing. Recent evidence indicates more complex and crucial roles for primary motor cortex and primary somatic sensory cortex in processing motor and somatic sensory information.

Primary Motor Cortex

In the past two decades, new concepts have emerged to explain the function and role of motor cortex in movement control. Instead of resembling an automatic "piano player" superimposed upon spinal cord output, motor cortex appears to have significant functions related to movement planning and learning. The neural substrate for these higher order functions of motor cortex likely relates to the distributed and plastic anatomical and functional organization within motor cortex.

Motor Cortical Organization

Motor cortex has three functional subdivisions, one each for the upper limb, the lower limb, and the head and neck; output from these subdivisions yields the motor commands that elaborate voluntary movement. Previous principles of motor cortex organization indicated a somatotopic pattern resembling a distorted but recognizable body shape—the homunculus—represented upon the surface of the motor cortex. A functional consequence of the homuncular arrangement could be to imply dedication of specific neural elements, such as a cortical column, to controlling one body part, perhaps a finger.

Recent evidence suggests that motor cortex does not have a regular and organized somatotopic pattern. Instead, circuits in motor cortex exhibit a widely distributed, multiple and overlapping representation of the different body parts, though there remains separation between the leg, arm, and head representations. Thus, neural circuits in motor cortex related to finger movements are intermingled and may be shared with circuits for the more proximal movements. The distributed and shared functional organization of motor cortex can provide for flexibility and enormous storage capacity.

Motor Cortex Plasticity and Cognition

Motor function has nearly infinite flexibility, ranging from the capability to learn new simple or complex tasks to recovery from central nervous system damage that might come about through changes in motor cortex internal pro-