Shitala P. Mishra

Cognitive Processes: Implications for Assessing Intelligence

Ever since the development of intelligence tests, numerous attempts have been made to explore the structure and content of mental abilities. Although attempts to elucidate the nature of human abilities have been divergent, the most frequent approach has been the study of relationships between patterns of individual differences in scores of psychometric ability tests. Using such an approach, intellectual ability has been described as a general factor comparable to mental energy as described by Spearman (1927). According to this view, general ability (as isolated by factor analytic means from psychometric test scores) primarily consists of the education of relations and correlates (Spearman, 1927), the complexity of a person's schemata (Vernon, 1960), and the hierarchy of reasoning and memory (Jensen, 1970; Burt, 1972). Although differential psychologists such as Thurstone (1947) and Guilford (1967) have recognized a need for an alternative model of human abilities, research on the nature of human intelligence during the first half of the century has blatantly ignored theoretical advances in related fields such as cognitive psychology and neuropsychology.

Despite impressive findings during the past two decades in the areas of cognitive psychology, learning theory, and neuropsychology, the use and interpretation of intelligence test results has remained virtually unchanged. The content and format of test items has not kept pace with the advances in related fields of psychology and neuropsychology. Piaget's theory (1971), for example, clearly indicates that children at different stages of development show a great deal of variation in their mental organization, suggesting that test content must vary with the cognitive stages of the child. Yet, intelligence tests, such as the Wechsler series, utilize the same subtests of items to measure intelligence across a broad age range. Similarly, Guilford's theory (1967) proposes five mental processes: cognition, memory, convergent-production, divergent-production, and evaluation. An examination of currently used ability tests would clearly reveal that the items of intelligence tests would have an underrepresentation of items tapping the intellectual functions of divergent-production and memory (Kaufman, 1973). Attempts have hardly been made to incorporate into intelligence tests comprehensive learning or concept-formation tasks such as Gagne's (1977) hierarchy for the determination of processes to predict learning ability. The inadequacy of general intelligence (referred to as the "g" factor), as measured by the Wechsler and the Stanford-Binet tests, becomes even more pertinent when considering a mounting body of evidence with respect to the specialization function of the cerebral hemispheres.

More recently, advances in the areas of cognitive psychology and neuropsychology seem to indicate a shift from the postulation of abilities to an inquiry into the information-processing mode. A mounting body of findings and theories generated from modern experimental psychology clearly suggests the incompleteness of the "g" factor and the Stanford-Binet and Wechsler as estimates of global

Shitala P. Mishra is associate professor of educational psychology at The University of Arizona.

intelligence. Information-processing (Das, Kirby, & Jarman, 1979) and componential models (Sternberg, 1979) of intelligence lend support for the examination of the nature of intelligence and other individual difference variables in the light of complex cognitive constructs. Ferguson (1954) and Cronbach (1957) have stressed the need for integrating the differential and information-processing approaches for developing more comprehensive and realistic models and theories of cognition and human intelligence.

The purpose of this paper is to examine the nature of human abilities in light of recent advances in information-processing and discuss implications of these developments for cognitive assessment of early adolescents. It should be noted that this is not an attempt to discredit current cognitive assessment practices, but to examine objectively the implications of current research for the development of assessment tools.

Historical Developments

The roots of the model pertaining to the processing of cognitive content can be traced back to the work of early theorists such as Thurstone (1947) who suggested that human abilities can be best comprehended in neurological, physiological, and psychological terms. However, the most direct roots of the model lie in Luria's contributions to understanding the neuropsychological bases of intelligence. Luria believed that the cortex is engaged in two types of integrative activity—simultaneous and successive. Relying extensively on a clinical research methodology, Luria examined persons with lesions in the left hemisphere of the cortex (Luria, 1966a, 1966b; Luria & Tzvetkova, 1967) and noticed that lesions in the occipital-parietal area caused a disturbance of the simultaneous mode of processing information, whereas lesions in the frontal-temporal area affected successive processing. In view of these different cognitive styles of the two hemispheres, it is believed that the left brain is especially adept at handling verbal and numerical stimuli while the right brain processes with relative ease information essentially nonverbal in nature.

Luria (1971) conceptualized the working brain as divided into three major components which he referred to as "the blocks of the brain." The first block, located in the upper brain stem, is primarily responsible for regulating arousal and attention levels. The second block is involved in sorting, organizing, recording, and storing incoming sensory input. Located in the occipital, parietal, and frontal-temporal regions, as well as in their underlying structures, this is where most of the cognitive information processing occurs. The third block of the brain which comprises the frontal lobes is responsible for the "formation of intentions and programs for behavior" (Luria, 1970, p. 68). Intellectual functioning, according to Luria, is the product of the dynamic interaction of the three units of the brain, and the processing of the cognitive content by the brain is done by the use of a series of analyzers that can be of two types, simultaneous and successive. These processes are neither modality nor stimulus-specific.

Simultaneous integration involves synthesis of separate elements into groups. As described by Das et al. (1979), "the essential nature of this sort of processing is that any portion of the result is surveyable without dependence upon its position in the whole" (p. 49). Luria postulated that three processes are involved in simultaneous synthesis: (1) direct perception which assists in the formation of a synthesis of the input in the brain, (2) mnestic processes which are involved in the organization of stimulus traces from earlier experiences, and (3) the determination of relationships among components in order for the system to be readily surveyable.

Successive processing refers to the processing of information in a sequential or serial order. This type of processing differs from the simultaneous mode of information processing in the sense that in successive processing the system is not totally surveyable at any point in time. Thus, this type of processing is done by the brain in a linear fashion with information being handled in an interdependent serial order. An example of tasks relevant for simultaneous processing would include digit span tests, sequential visual short-term memory tests, and a wide variety of tests requiring serial recall of information.

Hemisphere Specialization and Mode of Processing Information

Stemming from the split-brain surgery performed on epileptics, a number of researchers have pointed to the differential functioning of the right and left hemispheres of the brain (Gazzaniga, 1970; Sperry, 1968, 1970). A review of the literature dealing with hemispheric specialization suggests that for a vast majority of individuals, the left cerebral hemisphere appears to be specialized for linguistic, analytic, propositional, and serial tasks. In contrast, the right hemisphere is adept at processing more nonverbal, spatial, oppositional, holistic, and creative functions (Bever, 1975; Bogen, 1969; Bogen, DeZure, Tenhouten, & Marsh, 1972; Nebes, 1974). Using the Wechsler scales, a substantial number of studies have examined the relationship of Verbal-Performance IQ differences to brain damage (Matarazzo, 1972, pp. 385-399). One of the earlier studies conducted by Reitan (1955) reported depressed Verbal IQs for patients with left hemispheric lesions and lowered Performance IQs for patients with lesions in the right hemisphere.

It is important to note, however, that cerebral hemispheric asymmetries are process-specific and not stimulus-specific. Bever (1975), emphasizing this key distinction between the hemispheres, suggests that lateralization of two processes occurs because these two modes of information processing are incompatible and cannot coexist in the same physical space. The left hemisphere specializes in sequential processing whereas simultaneous or multiple processing is lateralized, in most individuals, to the right hemisphere. Bogen (1975) points out that each hemisphere is capable of functioning independently and utilizes its own rules for processing information. The nature of the distinction between the two hemispheres has been defined differently by different researchers. For example, the scientific method is considered to be the speciality of the left brain whereas holistic and creative insight is the specialized function of the right hemisphere. Kimura (1966), however, considers that the left hemisphere processes information on the basis of conceptual similarity, whereas the right hemisphere uses the principle of structural similarity.

Brain Functioning and Ability Tests

From the vantage point of neuropsychological research, the verbal and numerical items of currently used ability tests are predominantly in the domain of the left hemisphere. Thus, a child's verbal IQ primarily reflects left hemisphere processing. In contrast to the verbal and mathematical items, however, performance subtests on the test like the *Wechsler Intelligence Scale for Children - Revised (WISC-R)* may be grouped into two categories. One set of subtests such as *Picture Completion* and *Object Assembly* seem to require right-brain functioning, while the other subtests (*Picture Arrangement*, *Block Design*, *Coding*, and *Mazes*) depend on integrated processing of the two hemispheres (Kaufman, 1979a). Similarly, the *Stanford-Binet Intelligence Scale* would primarily be considered a left-brain test for most elementary and junior high subjects since the items included in the test for these grade levels are primarily verbal and quantitative in nature. However, for most of the preschool children, the Stanford-Binet would primarily measure right-brain functions. Apart from the heavy emphasis on left-brain learning as tapped by the Stanford-Binet items for children and adolescents, the items disproportionately tap right and left brain functions (Kaufman, 1979b). Consequently, different processing demands make it difficult to compare Stanford-Binet IQs earned by the same child at different age levels. Similarly, the Wechsler scales, in spite of the dichotomy of content into verbal and performance scales, do not reflect a one-to-one relationship between cerebral hemisphere and the verbal and performance scales.

It should also be noted that some tasks included in currently available ability tests may not be strictly right or left brain tasks. An integration between right and left hemispheric functions might be required for successful performance on items of many subtests, such as *Block Design*. Support for such an integration comes from a study by Zaidel and Sperry (1973) in which it was observed that split-brain patients performed much lower than normal controls on *Raven's Colored Matrices Test*. The importance of integration in intellectual functioning has been stressed by Piaget (1971), as exemplified by many of his tasks (e.g., those measuring conservation), which would require children to identify visual concrete characteristics of the objects (right brain) and then to offer explanations for their responses (left brain). Similarly, techniques employed by Montessori may suggest the need for integration in intellectual development. In spite of the importance of interhemispheric integration, most of the ability tests tend to dichotomize content, with the dichotomy based on the subject matter of each task, not the processes required to answer items correctly. Additionally, the measurement of integration in the intellectual assessment domain has been ignored.

Mode of Information Processing: An Alternative View

Although rooted in Luria's (1966b) research findings, a somewhat alternative to the neurological model of information processing has been proposed by Das and his colleagues (Das et al., 1979), who distinguish between successive and simultaneous modes of processing. This approach differs from the neuropsychological viewpoint in that it is assumed that the type of stimulus is independent of process. Verbal stimulus, thus, may not necessarily require successive processing, and nonverbal item-content (visual-spatial stimuli) does not automatically demand the simultaneous mode of processing. It is assumed that both processing strategies can be involved in all forms of responding, irrespective of the method of input presentation. Using the factor analytic approach, Das et al. (1979) have shown that successive and simultaneous processing factors seem to remain invariant across cultural groups, age groups, achievement levels, and socioeconomic strata.

Kirby and Das (1977) have additionally demonstrated that the two modes of processing correlated significantly with verbal and nonverbal intelligence and with measures of academic achievement. In their extensive search for the evidence of a simultaneous-successive processing model, the Das-Kirby team (Das et al., 1979) has used tests like the *Raven's Progressive Matrices* (Raven, 1956), *Figure Copying* (Ilg & Ames, 1964), and *Memory for Designs* (Graham & Kendall, 1960). The measures used for the assessment of successive processes include tests like *Digit Span*, *Visual Short-term Memory*, and *Serial* or *Free Recall*. Such tests require a subject to serially reproduce item input. It should be noted that Das et al. (1979) have dismissed hemispheric specialization research as being content oriented (verbal vs. nonverbal). As a consequence, research studies dealing with Das's model concerning successive-simultaneous dichotomy has excluded Wechsler type verbal subtests which make it difficult to gain a comprehensive understanding of the processing component of the Wechsler test from the vantage point of Das's model.

Information Processing Mode and General Mental Ability

In light of recent research findings in the area of neuropsychology and cognitive information processing, a strong argument can be made for the limited utility of the concept of global mental ability. The componential model of intelligence, as proposed by Sternberg (1979), similarly dismisses the notion of "g" and proposes organization of mental abilities into four levels—composite tasks, subtasks, information processing component, and information metacomponents. Kaufman (1979b), in his extensive review of recent research on cerebral specialization, has reached the same conclusion about the inadequacy and incompleteness of the "g" factor and conventional IQs in the estimation of global intelligence. He suggests that "global intelligence of an individual should not be inferred by an IQ of any sort unless that IQ reflects systematic measurement of left-brain processing, right-brain processing, and integration of the two hemispheres" (Kaufman, 1979b, p. 98).

Aside from an impressive body of research supporting the presence of the cognitive processing element in ability, one advantage of considering processes is their direct relevance to performance. The understanding of processes helps in describing an individual's functioning in a test situation. Additionally, one of the major difficulties with the concept of IQ is that it often leads people to consider IQ as the only index of intelligence. Such a view is highly questionable since mental functioning involves information-processing components used in the acquisition, as well as creation, of new knowledge and relationships. The components used in mental activities are simply processes (Das et al., 1979). Consequently, an intelligent act consists of many interacting processes and components. However, intelligence tests have resisted change in their structure as well as content, remaining inconsistent with recent theoretical advances.

Mode of Cognitive Processing and Implications for Assessment

It seems abundantly clear that research findings and theoretical developments regarding modes of information processing are making their mark in both assessment and practice. In the area of educational practice, a study by Krashen, Seliga, and Hartnett (1973) has demonstrated that the learning of the Spanish language was found to be more effective by a logical, rule-governed method for left-brained individuals whereas right-brained students seemed to derive maximum benefit from a more holistic approach. Similar advantages of the successive-simultaneous approach to educational practices have been noted by Biggs (1978). In another study conducted by Pask and Scott (1972), subjects classified as "serialists" on the basis of their performance on a classification task learned new content better by serial rather than by the holistic method as contrasted with "holists," who learned when taught by a method consistent with their processing mode.

In the field of psychoeducational assessment involving youngsters and preadolescents, there seem to be multifaceted reasons for focusing on the mode of information processing. It is obvious that a comprehensive theory of intelligence must account for the method and components of processing cognitive content. Consequently, new instruments with appropriate stress on hemispheric specializations and cognitive processing strategies are very much needed. For the results to be of maximum practical value, the IQ test must include tasks such as Torrance's (1974) measure of figural creativity, Street's (1931) *Gestalt Completion Test*, and Kagan and Klein's (1973) basic cognitive competencies. Based on Cronback and Snow's (1977) aptitude-treatment interaction approaches, children with the same problems and performance patterns may require differential remedial and intervention procedures based on their preferred mode of processing information. Thus, understanding of processing mode should enhance the effective interpretations of children's WISC-R profiles in the light of existing research data.

Recent developments in cognitive information fields may also be of special value for psychoeducational assessment of youngsters from minority cultures. Bogen et al. (1972), for example, noticed that blacks performed better on right-brained figure completion tests. Findings of Pines's (1973) study similarly indicated higher performance of blacks as compared to their white counterparts on some visual spatial tasks such as pattern recognition. Evidence of creative potential was observed by Torrance (1977) in black youngsters, many with low IQ scores. Since there might be a variance among individuals across cultures with respect to their hemispheric dominance and preference for different cognitive strategies, the validity of assessed traits can be tremendously enhanced by including test items appropriate for measuring preferred processing strategies. It is therefore essential that new techniques and tools be developed based on current theories of intelligence in order to maximize their use for instructional and psychoeducational assessment purposes.

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