

Cognitive approaches to neuropsychological assessment

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Experimental and field studies in behavioral toxicology often report effects of solvent exposure on reaction time, perceptual speed, and psychomotor speed. General intellectual impairment has sometimes also been found. These effects emanate from measurements with traditional psychometric tests, and they indicate performance decrements which presumably originate from organic damage. However, it is not possible to establish which neuropsychological and cognitive mechanisms are affected or in what way. The reported effects may be the result of inferior or slower sensory or perceptual processes, response selection, or delayed motor responses, for example. All mental processes required between the presentation of the test item and the response may be slowed down. It is also possible that the mental processes are inferior in quality; such loss in the quality of content could reduce processing speed and, hence, performance. These are all, in a sense, validity problems.

Two main types of validity are of interest. For the determination of the *empirical validity* of a test the results should be correlated with other measurements which are known to measure effects of organic solvents. Such measurements could be neurophysiological, neurological, or neuroradiological. However, at present, these methods are even more ambiguous than the psychological tests with respect to solvent-induced organic effects. They are therefore unsatisfactory as criteria for validation.

The empirical validity can also be determined through correlation of the results with symptoms that are assumed to reflect neuropsychological disturbances. A possible problem could be that such symptoms are rarely specific for a certain state but are often diffuse and may emanate from several disturbances. The validation coefficient would therefore be less informative.

There appear at present to exist no good criteria for determining the empirical validity of psychological tests with respect to solvent-induced effects. An approach that has been tried with some success is the use of discriminant analysis to differentiate between

different populations with different degrees of exposure (3). This method however requires measurements from several populations with different degrees of exposure.

Another kind of validity is often called *construct validity*; it refers to the degree to which a test measures the theoretical construct it was designed to measure (4). The criterion, which may be a theory of the structure or function of the intellect, is only indirectly measurable. Determination of the validity requires that the test in question should or should not correlate with all other tests with which the theory predicts it should or should not correlate (4). Empirically developed global models have been proposed by Thurstone, Spearman, Guilford, and others. They have been the basis for developing the present tests, which have been carefully tried with respect to psychometric criteria of reliability and unidimensionality. In essence, it may be asserted with confidence that a spatial test measures the spatial function of the intellect with fairly good precision. However, it is not clear what this phenomenon means in terms of how mental subprocesses are involved during the solving of a spatial test or how these subprocesses are related to the processes required in, for example, a perceptual test. The models are essentially trait models (7) with no predictive value concerning mental processes and specific solvent effects. The predictions that can be made derive from clinical validation studies of the tests in psychiatric and pharmacological research. Such studies are often designed to compare the mean performance on different tests between groups of persons with lesions or with psychiatric illnesses and normal people.

Development of more powerful methods in behavioral toxicology would appear to call for new strategies that are less bound to the traditional factor analytical approach. One goal of psychometric investigations in behavioral toxicology may in the future be directed less towards determining whether in fact any adverse effects follow long-term solvent exposure and more towards determining *how* intellectual performance is affected. This shift in emphasis would be possible if the effects could be specified in terms of effects on processes that enhance or retard cognitive performance.

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During the past 20 years there has been growing interest among experimental cognitive psychologists towards identifying and modeling such mental processes. Much experimental research has been done on human information processing. It is assumed that the performance of a task involves the sequential action of a series of discrete mental events (figure 1). Through studies of individual differences in task performance attempts have been made to identify fundamental processes in perception, learning, memory, problem solving, etc. Early examples include studies on spatial ability by Shepard and his collaborators during the 1970s. Shepard & Metzler (6) discovered systematic relationships between the orientation of two drawings of a three-dimensional object and the time required to compare the drawings. They found that the time to decide that two drawings represent the same object varied in a linear fashion with the angular difference between the orientation of the first and the second drawing. They suggested that, once a characteristic feature of the stimulus has been located, its representation is mentally transformed through an iterative rotation-and-match cycle until a match is found between the transformed representation of one drawing and the other drawing. Similar results have been obtained with two-dimensional objects and their mirror images (2). Models have been suggested for the sequences of distinct mental operations required for such spatial visualization tasks [eg, that of Carpenter & Just (1)] and for other types of mental tasks. A drawback with the human information processing models is that they are task-specific and do not attempt to establish global models of intellectual functioning.

Attempts are however made to measure individual differences in test performance within the framework of an experimentally based theory of human cognition. A common task in psychometric tests of reasoning is the analogy problem, eg, hand-foot, finger-?. Sternberg (7) has proposed a componential analysis of analogical reasoning which aims at bringing together information processing and factor analytical techniques and may apply across all analogy problems and possibly also other types of tasks. The component processes that are specified for analogy tasks are (i) encoding the terms of the analogy, (ii) inferring the relationship between the first two terms (ie, hand-foot), (iii) mapping the relationship between the first and third terms (ie, hand-finger), and

(iv) applying the results of the influence and mapping processes to the third term (ie, finger) to generate an ideal fourth term (ie, toe). If several alternative answers are given, (v) an optional justification process is used to select among alternative answers preceding (vi) the response process which indicates the choice of an answer.

Sternberg has related latency measures for the various component processes to general reasoning scores derived from standardized test batteries. Processing speed for the different components was not uniformly positively related to general reasoning ability. It appears from these and other studies that individuals with high general reasoning scores, ie, good problem solvers, spend relatively more time on the encoding process than do individuals with low reasoning scores. This phenomenon may indicate that good reasoners, by spending more time on encoding, obtain a better or more elaborate quality of the encoded information, which may improve the speed and accuracy in the consecutive component processes.

Experimental studies on human reasoning have begun to throw light on the nature of the skill involved in this type of task. Of importance is the ability to structure the problems by extracting relations among elements of a problem and assembling these relations into a rule governing the entire problem. Pellegrino & Glaser (5) further conclude that the necessity to maintain and update in working memory the accumulated results of ongoing analyses is important for all inductive reasoning tasks. Their conclusion implies that the capacity and efficiency of working memory can affect or interact with individual differences in other processes and performance in psychometric tasks. High-ranking performers on psychometric tests may have more elaborate memory structures, enabling them to encode a larger number of features and to spend more time on this process, which presumably facilitates the structuring of the problem and the efficiency of subsequent processes.

Several specific processes may be supposed to be affected by long-term solvent exposure. In present-day testing a general deterioration of memory or learning is expected from several cross-sectional studies. However, little is known about how memory is affected; possible mechanisms would be the way knowledge is organized in memory or impairment of mnemonic strategies or other memory-related processes. Many memory and problem-solving tasks

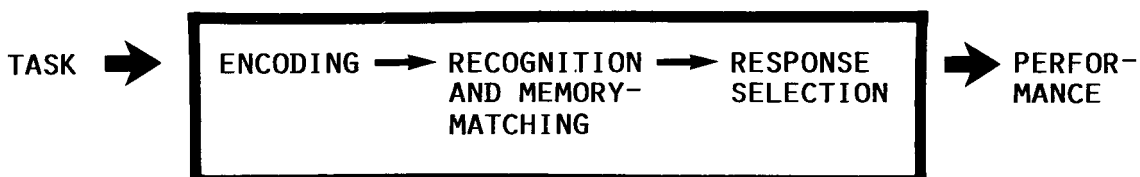


Figure 1. Schematic figure of the human information processing approach.

depend on the use of higher-level executive strategies that facilitate and direct the sequencing of basic processing activities and the activation and manipulation of memory codes (5). Individual differences in such executive routines may be an important source of individual differences and could be vulnerable to effects of solvent exposure. For example, the spontaneous implementation of mnemonic strategies changes with age; this phenomenon has been ascribed to the development of more task-appropriate and flexible executive routines (5). It is conceivable that these routines regress to become less adaptive as an effect of solvent exposure.

Many approaches other than those described are used. Much attention is being devoted to metatheoretical frameworks of cognition.

Metacognition may be defined as the control an individual has over his or her own cognitive processes (8). Metatheoretical concepts concern higher-order control processes for planning courses of action, for making decisions regarding alternative courses of action, and for monitoring the success of the chosen course of action (8).

Attempts to conceptualize individual differences in intellectual ability in terms of theories of human cognition may make it possible to find development strategies that can yield data at a level which can be used in validation studies. Identifying intellectual components may enable psychologists to do more than determine whether or not there are indeed any

effects of solvent exposure. The goal will be to find *how* the intellect is affected and to pick up early signs of adverse effects.

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