A Better Look at Intelligence

J.P. Das[1]

Developmental Disabilities Centre, University of Alberta, Edmonton, Alberta, Canada

Abstract

The Planning, Attention, Simultaneous, and Successive (PASS) model is offered as an alternative to the unidimensional conceptualization of intelligence as a general ability. The unidimensional conceptualization has not helped researchers and clinicians understand variations of cognitive functions within special populations such as individuals with learning disabilities, disorders of attention, or mental retardation. Neither has this conceptualization aided in program planning for these individuals. PASS is a model of cognitive function based on contemporary research in both cognition and neuropsychology and provides a theory for both assessment and intervention. This article reviews concepts and examples of PASS theory and its application to reading disabilities and mental retardation. For example, the article links dyslexia with a deficit in successive processing. It also identifies the major difficulties of individuals with Down syndrome in phonological memory and articulation. Further research on successive processing, and planning as it relates to language, is suggested.

Keywords

intelligence; PASS theory; reading disability

> The brain consists of a great many modules that process information more or less independently of each other. It seems likely that it will be easier to discover how one of those modules works than to explain the functioning of the brain as a whole. (Frith, 1997, p. 5)

This quotation questions the validity of the notion that there is a general factor of intelligence. Much as the organs of the body are specific and diverse in their functions, the brain, although admittedly working as a whole, cannot be conceived to have one general intelligence function. Arguments against a general factor of intelligence arise both from logical considerations and from clinical observations. Clinically, in cases of brain damage, specific cognitive functions are often spared while others remain impaired. In addition, individuals who have significantly damaged frontal lobe functions may have normal IQs, despite the fact that the frontal lobes are essential for higher cognitive processes. Similarly, some dyslexic children have high IQs despite their significant difficulties in reading.

Examples such as these challenge the usefulness of a one-dimensional notion of general intelligence, be it conceptualized as mental energy or speed. A general-ability view leads to different questions and measures of ability than a view that intelligence is made up of multiple and interdependent cognitive processes. Multidimensional views of intelligence are suggested by the seven modules of intelligence posited by Gardner (1983), the triarchic theory of Sternberg (1985), and the Planning, Attention, Simultaneous, and Successive (PASS) theory my colleagues and I have proposed.

As its name suggests, the PASS theory refers to four kinds of competence. First, planning processes are required when an individual makes decisions about how to solve a problem, carry out an activity, or compose a narrative. This component involves goal setting, as well as anticipating and monitoring feedback. Second, attention, or arousal, is the process that allows a person to selectively attend to some stimuli while ignoring others, resist distractions, and maintain vigilance. Third, simultaneous processing integrates stimuli into groups. As a result, stimuli are seen as whole, each piece being related to the others. Fourth, successive processing includes integrating stimuli in a specific serial order. For example, to understand

Published by Blackwell Publishing Inc.

English syntax, an individual has to process words in order to determine their grammatical function. The PASS theory was developed with the intention of predicting and explaining normal as well as atypical cognitive functions. The theory links the four processes with particular areas of the brain, following the work of Luria (1966).

NEUROPSYCHOLOGICAL LINKAGE

Luria (1966) described human cognitive processes within a framework of three functional units: one that regulates arousal and attention, a second that codes information using simultaneous and successive processes, and a third that provides for planning, self-monitoring, and structuring of cognitive activities. According to Luria, the first unit is located in the brain stem and its connections with the frontal lobes; the second is in the back of the cortex in occipital, parietal, and frontotemporal regions; and the third is located in the frontal lobes (see the next section).

Although Luria's work was a blueprint for the PASS model, my colleagues and I have also considered recent neuroimaging research that has revealed a wealth of new information about the roles various brain structures play in human cognition (e.g., Posner, 1993). For instance, research has shown that attention is divided into four subprocesses: the engagement, maintenance, disengagement, and shifting of attention (Posner, 1993, p. 644). These functions are spread over several regions of the brain, including the posterior parietal cortex, frontal eye-field, and brain-stem reticular formation. The addition of the parietal cortex, which regulates spatial processing, to the functional location of attention is necessary in order to account for aspects of spatial attention. These findings support two of Luria's notions: (a) a complex function cannot be strictly localized in one region of the brain, and (b) spatial information is processed in the occipital-parietal region.

PASS THEORY IN BRIEF

The PASS theory provides a model to conceptualize human intellectual competence. My colleagues and I first presented it comprehensively more than 25 years ago (Das, Kirby, & Jarman, 1975). At that time, the model included three processes: planning, simultaneous processing, and successive processing. Since that time, we have added the component of attention-arousal and elaborated the planning component (Das, Kar, & Parrila, 1996; Das, Naglieri, & Kirby, 1994).

Over the years, we have written about the implications of the model for understanding various cognitive processes, such as reasoning, memory, imagery, and language. We have also developed practical applications of the model, including the Cognitive Assessment System (CAS; Naglieri & Das, 1997) and the PASS Reading Enhancement Program (PREP), a remediation program for reading difficulties (Das, 1999). Another successful application of the model is a program for remediating arithmetic difficulties, which are related to deficiencies in planning. Throughout the theory's 25-year developmental period, Luria has been an influence on how we have framed research questions, designed assessment devices, and constructed intervention procedures.

Figure 1 is a diagram of the PASS model, showing the basic division of input, processing, and output (Das et al., 1994). First, input information is received from external sources through the senses and from internal sources; internal cognitive information such as images, memories, and thoughts become part of the input. External input information can be presented serially or concurrently. When the sensory information is sent for analyses, the four central processes (planning, attention-arousal, simultaneous processing, and successive processing), as well as the knowledge base, become active. Similarly, output can occur in two forms, serial and concurrent.

Consistent with Luria's (1966) framework, the PASS components are broadly associated with four different parts of the brain (Das et al., 1994). Planning is located in the frontal lobe. Specifically, cognitive functions such as reasoning are attributed to the prefrontal dorsolateral cortex, whereas socially relevant decision making may be the function of the fronto-orbital cortex. Planning is required when an individual makes decisions ranging from specific actions to general plans such as revising life's goals. Planning also guides how people focus their attention and use simultaneous and successive processes when required.

The attention-arousal component is more difficult to locate. Arousal keeps people awake and alert and is associated with arousal activities in the brain stem as well as with inhibitory activities in the thalamus. The mobilization of attentional resources, however, is the function of the frontal lobes and closely connected to planning.

Simultaneous and successive processing are located in the posterior region of the cortex. Simultaneous processing is broadly associated with the occipital and parietal lobes, whereas successive processing is associated with the frontal-temporal lobe. All four processes must be active in the context of an individual's knowledge base. Knowledge is built upon the base of past experiences and includes

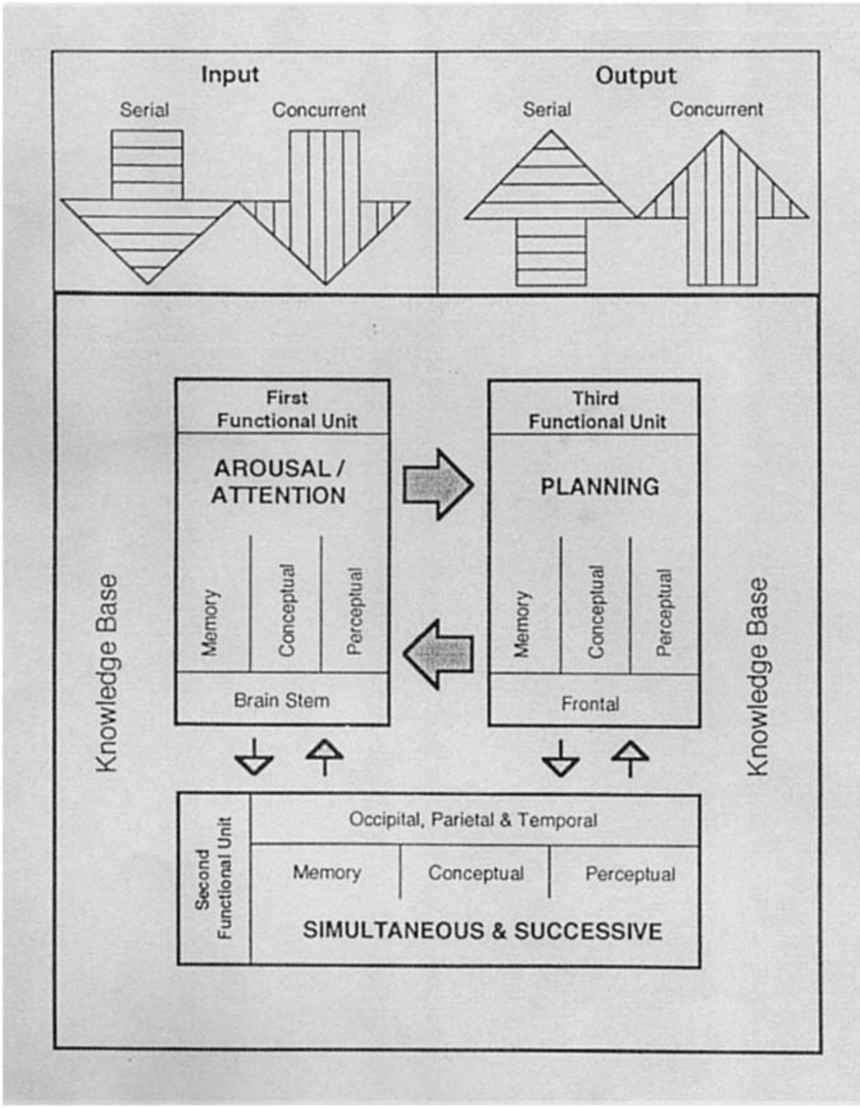

Fig. 1. Diagram of the Planning, Attention, Simultaneous, and Successive (PASS) model.

both formal and spontaneously acquired knowledge. It is essential for providing the background for information to be processed. It is as if the PASS processes are floating on a sea of knowledge; without the water, they cannot operate and will sink. Knowledge can be of two kinds: tacit (spontaneous, experiential) and explicit (formal, instructed).

The last component of the PASS model is output, which is expressed in behavior. Donald (1991) has suggested that there are three output modes: movements, mimetics, and language. Movements include both gross and fine movement; mimetics comprises dance, music, theatrical poses, and body language; and language includes oral and written language, as well as graphs and signs.

ASSESSMENT OF PASS PROCESSES: AN ALTERNATIVE TO IQ TESTS

The CAS (Naglieri & Das, 1997) is a measurement instrument that can be used to determine an individual's competence and level of cognitive functioning. It can be used, for example, to diagnose learning strengths and weaknesses, learning disabilities, attention deficits, mental retardation, and giftedness. Scores on this instrument can be used to determine whether an individual meets the eligibility criteria for state or federal intervention programs, and more generally to guide decisions on the appropriateness of treatments and instructional programs.

The CAS is an individually administered test designed for children and adolescents ages 5 through 17 years. The test consists of 12 subtests, three for each of the four PASS scales. There is also a total score called the Full Scale. The tests vary in content: Some are verbal, some are not; some involve memory, others do not. For example, a Planning test is Matching Numbers, in which the task is to find and underline two identical three-number sequences in a row of six three-number sequences (249, 371, 539, 467, 539, 749). An Attention test is Receptive Attention, in which the task is to underline pairs of letters that are physically the same (e.g., AA, but not BA) or that have the same name (e.g., aA, but not eA). In the Simultaneous Verbal-Spatial Relations task, children are presented with six drawings and a printed question that may be read aloud by the examiner (e.g., "Show me the picture that has a triangle to the left of a circle."). A Successive processing task is Sentence Repetition and Questions, in which the child listens to a sentence spoken by the examiner and answers a question (e.g., "The brown greened the red yellow. Who greened the red?").

Some evidence of the usefulness of this instrument is presented in the following sections, which show how PASS can help in clarifying the mental processes not only

Published by Blackwell Publishing Inc.

Table 1. *Case studies of attention deficit disorder*

Case	Age	Country	Gender	Reason for referral	Scores			
					Planning	Attention	Simultaneous	Successive
1	12	United States	Male	Attention deficit disorder	115	87	110	117
2	8	South Africa	Male	Attention deficit disorder	98	84	110	98

of normal children, but also of children and adults with reading difficulties and mental retardation.

CLINICAL USES OF THE PASS MODEL AND CAS

One possible use of CAS is to diagnose children with attention deficit disorder (ADD). Such children should score lower in attention than in planning or simultaneous and successive processing. Table 1 shows the CAS scores of 2 boys who had been diagnosed with ADD. The scores show the predicted pattern, confirming the original diagnosis.

A second example of clinical usefulness of CAS is provided by a 12-year-old American boy who sustained a closed head injury when he hit the dashboard of a moving car (Naglieri & Das, 1997). He was referred for treatment because of behavior control problems and poor grades in school. His IQ scores fell within the normal range, between 112 and 98. In contrast, his CAS scores were as follows: Planning, 73; Attention, 79; Simultaneous, 100; and Successive, 110. These scores clearly show the profile for a deficit in planning and attention-arousal.

The CAS has been used in several countries, including the United States, and has aided in the diagnosis of cognitive deficits (see Table 2). None of the individuals whose scores are reported in Table 2 had a below-average full-scale IQ score, but their CAS scores show clear deficits in particular cognitive components. These results support the position that a general view of intelligence is of little value in obtaining the cognitive profiles in these cases. Obviously, a single IQ score by definition does not provide a profile; as a consequence, individuals with cognitive deficits will often not be identified by IQ measures and will not benefit from the diagnosis that would be afforded by multidimensional systems of cognitive assessment.

APPLICATION TO READING DISABILITY

Does the source of dyslexia lie in cognitive skills needed only in reading-related tasks (i.e., in proximal processes), or does it lie in a more fundamental process identifiable in nonreading tasks as well (i.e., in distal processes)? Proximal processes whose impairment could result in dyslexia include phonological processes, which deal with the sound structure of language (e.g., Wagner & Torgesen, 1987), and orthographic processes that are essential for recognizing an array of letters as a word. Orthographic processes are involved in pronunciation and spelling of words in which the same spelling has different pronunciations (e.g., *bead* and *dead*). The four PASS processes are distal processes that could be related to dyslexia. These processes enable individuals to learn the sound system and orthography of their language, as well as strategies for the appropriate application of phonology and orthography. On the basis of research based on our theory, we can distinguish between individuals who have specific reading disability (dyslexics) and those who are simply generally poor readers. Individuals with true dyslexia have a specific deficit in successive processing. Their reading problems are specific: They make phonological errors while reading real or made-up words or are slow in reading them (i.e., are slow decod-

Table 2. *Case studies of cognitive deficits*

Case	Age	Country	Gender	Reason for referral	Scores			
					Planning	Attention	Simultaneous	Successive
1	14	Spain	Male	School failure	69	94	76	81
2	10	United States	Male	Reading disability	117	118	94	81
3	16	India	Female	School failure	71	71	103	100

ers), or are both slow and inaccurate. In contrast, individuals who are generally poor readers may have low Successive scores, like dyslexics, but unlike dyslexics can have lower than average scores on the three other PASS measures. They make phonological errors and are slow decoders. But unlike dyslexics, they show difficulties in comprehension of syntax and meaning.

New research using brain-neuroimaging techniques continuously advances researchers' knowledge of cognitive processes, such as reading. For example, a recent study (Pugh et al., 2000) demonstrated that on reading tasks that required phonological processing, such as determining if two made-up words rhyme, normal readers showed robust connectivity between the angular gyrus and other areas in the back of the left hemisphere, whereas dyslexics did not. However, normal readers and dyslexics showed similar connectivity between these areas on reading tasks that did not demand phonological processing. Such research implies that supporting neural connections that are intact can be utilized by dyslexics if active phonological exercises are not demanded of them. Appropriate remediation or intervention programs, such as PREP, that do not teach phonics and do not require oral reading, but still enhance successive processing, can be effective in helping dyslexics become better readers. If such programs are instituted during the developmental period, true dyslexics can also make use of compensatory mechanisms available through the posterior parts of the right hemisphere.

APPLICATION TO MENTAL RETARDATION: DOWN SYNDROME

CAS has also been used to investigate the deficits of individuals with mental handicaps of various etiologies. A comparison of individuals with Down syndrome (DS) and individuals who have mental retardation but not DS showed that DS is associated with a broad deficit in successive processing. Individuals with DS have weak serial recall of spoken words, and it is therefore suspected that DS is linked to a deficit in phonological memory. Further, CAS tasks show that age-related decline in attention and successive processing is faster in individuals with DS than in those without DS. The majority of individuals with DS develop dementia after age 50 and perform very poorly on all CAS tasks compared with mentally handicapped individuals who do not have DS (Das, Divis, Alexander, Parrila, & Naglieri, 1995).

DIRECTIONS FOR FUTURE RESEARCH

What might be some useful leads for further research? Each of the four processes represented in the PASS model requires further investigation. For example, successive processing contributes to understanding printed words and comprehending syntax. But at a more specific level, can the model illuminate the difference between reading disabilities associated with a slow rate of word reading and those characterized by a high rate of phonological errors? Poor readers who are slow but not inaccurate should do poorly on the CAS successive-processing test that demands articulation, Speech Rate. This test requires rapid repetition of two or three simple words 10 times. Slow-but-accurate readers should not perform poorly on other successive-processing tests (e.g., serial recall of words and sentences) that do not demand fast articulation. In contrast, people who are both slow and inaccurate readers should do poorly on all successive-processing tests. This prediction is yet to be investigated, but if it is in fact correct, is a deficit in successive processing still a useful explanation for the slow-but-accurate type of reading disability? Perhaps while reading they not only take longer to decode words, a task that engages successive processing, but also take a longer time to disengage attention from one word to the next, which slows down reading. This possibility can be tested with a naming-time task in which the test taker is required to read a series of familiar words rapidly. Is the slow-but-inaccurate reader poor in both speech-rate and naming-time tasks?

Another promising path for future research concerns the conceptualization of planning and its relation to efficiency in language representation. Planning is seen in regulation of behavior achieved through the use of language. Atypical individuals, such as those with DS (see the previous discussion) or people with congenital hearing loss (as opposed to acquired hearing loss), should be relatively weak in planning complex activities to the extent that language plays a role in such planning. Studies examining how they plan and how their ability to plan can be augmented hold promise for testing the connection between planning and language.

Recommended Reading

Das, J.P., Kar, B.C., & Parrila, R.K. (1996). (See References)
Das, J.P., Naglieri, J.A., & Kirby, J.R. (1994). (See References)
Luria, A.R. (1966). (See References)

Acknowledgments—This article reflects the ideas and writings of several collaborators, including R.F. Jarman, J.R. Kirby, J.A. Naglieri, T. Papadopoulos, and R.K. Parrila.

Note

1. Address correspondence to J.P. Das, Developmental Disabilities Centre, 6-123 D Education North, University of Alberta, Edmonton, Alberta, Canada T6G 2G5; e-mail: j.p.das@ualberta.ca.

References

Das, J.P. (1999). *PREP: PASS Reading Enhancement Program*. Deal, NJ: Sarka Educational Resources.

Das, J.P., Divis, B., Alexander, J., Parrila, R.K., & Naglieri, J.A. (1995). Cognitive decline due to aging among persons with Down Syndrome. *Research in Developmental Disabilities*, *16*, 461–478.

Das, J.P., Kar, B.C., & Parrila, R.K. (1996). *Cognitive planning*. Thousand Oaks, CA: Sage.

Das, J.P., Kirby, J.R., & Jarman, R.F. (1975). Simultaneous and successive syntheses: An alternative model for cognitive abilities. *Psychological Bulletin*, *82*, 87–103.

Das, J.P., Naglieri, J.A., & Kirby, J.R. (1994). *Assessment of cognitive processes: The PASS theory of intelligence*. Boston: Allyn and Bacon.

Donald, M. (1991). *Origins of the modern mind*. Cambridge, MA: Harvard University Press.

Frith, C.D. (1997). Linking brain and behavior. In R.S.J. Frackowiak, K.J. Friston, R.J. Dolan, & J.C. Mazziotta (Eds.), *Human brain function* (pp. 3–23). San Diego: Academic Press.

Gardner, H. (1983). *Frames of mind: The theory of multiple intelligences*. New York: Basic Books.

Luria, A.R. (1966). *Human brain and psychological processes*. New York: Harper and Row.

Naglieri, J.A., & Das, J.P. (1997). *Das-Naglieri Cognitive Assessment System*. Itasca, IL: Riverside Publishing.

Posner, I. (1993). *Foundations of cognitive science*. Cambridge, MA: MIT Press.

Pugh, K.R., Mencl, W.E., Shaywitz, B.A., Fulbright, R.K., Constable, R.T., Skudlarski, P., Marchione, K.E., Jenner, A.R., Fletcher, J.M., Liberman, A.M., Shankweiler, D.P., Katz, L., Lacadie, C., & Gore, J.C. (2000). The angular gyrus in developmental dyslexia: Task-specific differences in functional connectivity within posterior cortex. *Psychological Science*, *11*, 51–56.

Sternberg, R.J. (1985). *Beyond IQ: A triarchic theory of human intelligence*. Cambridge, England: Cambridge University Press.

Wagner, R.K., & Torgesen, J.K. (1987). The nature of phonological processing and its causal role in the acquisition of reading skills. *Psychological Bulletin*, *101*, 192–212.