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PASS Model Of Intelligence: A Multidimensional View Of Cognitive Processes

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Abstract
The Planning, Attention, Simultaneous, and Successive (PASS) model of intelligence offers a multidimensional perspective on human cognitive processes, drawing foundationally from A.R. Luria's theory of brain function. This paper reviews the theoretical underpinnings of the PASS model, emphasizing its basis in Luria's three functional units of the brain and the subsequent evolution of the theory by Das, Naglieri, and colleagues. The model delineates intelligence into four core processes—planning, attention-arousal, simultaneous processing, and successive processing—each associated with distinct neuropsychological structures and functions. The review highlights how the PASS model reconceptualizes intelligence as an interplay of cognitive processes informed by an individual's knowledge base, departing from traditional unidimensional IQ constructs. It also discusses the practical implications and empirical validation of the PASS theory through assessments such as the Cognitive Assessment System (CAS) and Brain-Based Test of Intelligence (BBIT). The findings suggest that the PASS framework provides a comprehensive and contemporary approach to understanding cognitive diversity, supporting targeted interventions in educational and clinical settings.

Keywords: *PASS Model, Intelligence, Luria's functional unit, Information processing approach*

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I. Introduction

The PASS model, as developed by Das et al (1994), represents a multidimensional view of cognitive processes, drawing significantly from Luria's theoretical framework. It serves as a contemporary reflection on Luria's functional units, explaining the neuropsychological correlates that underlie complex cognitive processes. The Planning, Attention, Simultaneous, and Successive (PASS; Naglieri & Das, 1997) theory is rooted in the work of A. R. Luria *(1966,* 1973a, 1973b, 1980) on the functional aspects of brain structures. Das, Naglieri, & Kirby(1994) used Luria's work as a blueprint for defining the important components of human intelligence Their efforts represent the first time that a specific researched neuropsychological theory was used to reconceptualize the concept of human intelligence. According to Luria, cognitive functions can be understood through three different functional units, each fulfilling specific roles in overall mental activity.

Luria's Three Functional Units: A Neuropsychological Approach to Intelligence

The influence of neuropsychology on cognition is attributed mostly to the clinical research of the Russian neuropsychologist A.R. Luria. He developed a framework for understanding human cognition based on brain functions which later laid the stone for cognitive neuropsychology. His pioneering work introduced the concept of three functional units of brain, which he suggested as essential for human cognition. These units are correlated to the different groups of cognitive functions and their neural substrates. Luria's work systematically explored the underpinnings of brain structure in complex cognitive behaviour. Luria's framework divides brain functions into three distinct zones, each associated with different levels of processing. These brain zones are effectively integrated with the concept of functional units, providing a deeper understanding of how different brain areas work together. The three zones i.e., primary, secondary and tertiary corresponds to the three functional units of the brain and their underlying neurological structures. Each of these functions carry out identifiable group of processes and are interdependent through the spread of neural networks.

The primary zone of the brain includes the basic functional units that handle simple sensory and motor tasks, such as the primary visual and auditory cortices and the primary motor cortex. The secondary zone includes more complex functional units which are responsible for integrating and interpreting sensory information. This includes visual and auditory association areas that help in recognizing objects and sounds. It highlights the importance of sensory integration for formation of complete perceptions. The tertiary zone consists of higher-level functional units. This third zone involves complex cognitive processes such as reasoning, planning and problem solving. Anatomically these functions are primarily controlled in the frontal lobes (Luria, 1973a).

The integration of Luria's anatomical zones with its functional units explains a hierarchical organization within the brain. According to this functional framework, the basic sensory and motor functions lay the foundation for more complicated cognitive operations. Moreover, each functional unit is responsible for distinct group of functions which are carried out by interacting and interdependent structures.

Arousal – Attention

This unit provides the brain with appropriate level of arousal or cortical tone. This unit plays a vital role in the regulation of arousal and attention processes which forms a fundamental basis for cognitive operations (Posner & Petersen, 1990). Anatomically it includes the midbrain and the reticular formation. The midbrain serves as an essential relay station for sensory information. The reticular formation serves as an advanced filtering system which assesses incoming stimuli to determine which information should be processed by the higher cognitive areas of the brain (Sarter, Givens, & Bruno, 2001), acting as an filtering unit. One of the primary functions of this unit is to reduce sensory overload. This filtering unit selectively allows relevant stimuli to enter conscious awareness and discard the irrelevant ones thereby enabling focused attention (Aston-Jones & Cohen, 2005). The crucial function of this unit are, regulating the arousal levels and adjusting the individual's state of alertness where situation demands. It enhances the ability to engage in tasks that require sustained focus and supports prompt reactions to potential threats. These abilities are critical for effective decision-making and adaptive behaviour in dynamic contexts (Berridge & Waterhouse, 2003).

However, damage to the this unit can lead to significant consequences for cognitive behaviour associated with attention and arousal. Lesions or dysfunction within the reticular formation may result in a variety of attentional deficits, including a reduced capacity to focus and maintain attention—phenomena commonly observed in several neuropsychological disorders (Posner & Petersen, 1990). Difficulty in filtering out irrelevant stimuli, may lead to distractibility and diminished task performance. Impairment in this unit can influence arousal levels, giving rise to excessive fatigue or, in contrast, heightened anxiety and hyperarousal. Such irregularities in arousal level may severely impact daily functioning in an individual, resulting in diminished ability to effectively engage in learning and memory processes, thereby affecting educational and occupational success (Aston-Jones & Cohen, 2005). The capacity to adapt to changing environments may also be compromised. Those with damage to this unit might face difficulties in responding appropriately to new stimuli, which can result in unsuitable behavioural responses or impaired decision-making in everyday contexts (Berridge & Waterhouse, 2003).

Sensory Input and Integration

This unit is located in the posterior inferior region of the parietal lobe. It acts as a coding unit. The major function of this unit include reception, analysis, and storage of sensory information, which is essential for cognitive processes. Neurologically, it serves as a hub where inputs from different senses—such as visual, auditory, and tactile—are integrated and interpreted (Luria, 1973). This processing is essential for creating a cohesive understanding of experiences, allowing for the categorization and retention of information for future use.

This unit involves the processing of information in the brain, specifically through two different coding processes namely, simultaneous and successive coding.

Simultaneous Coding is the ability to process multiple pieces of information at the same time. It involves a holistic approach where individuals understand and integrate various elements of an information simultaneously. For example, in visual processing, a person might take in a whole image, grasping various features like colors, shapes, and spatial relationships all at once. This method is often linked to tasks that require a synthesis of information, such as problem-solving or understanding complex patterns (Luria, 1973). In contrast, successive coding is more linear and sequential. It is the ability to process information in a step-by-step manner. One piece of information follows another, which is similar to how we might follow a narrative or a list. This method is typically associated with tasks requiring detailed logical reasoning, such as mathematical calculations or following directions (Luria, 1973). Luria's framework emphasizes that both coding styles are essential for cognitive functioning. Different tasks may rely more heavily on one coding method than the other, and individuals may exhibit strengths in one area over the other. Understanding how these coding processes work can aid in identifying learning styles and potential cognitive weaknesses in individuals (Luria, 1966a).

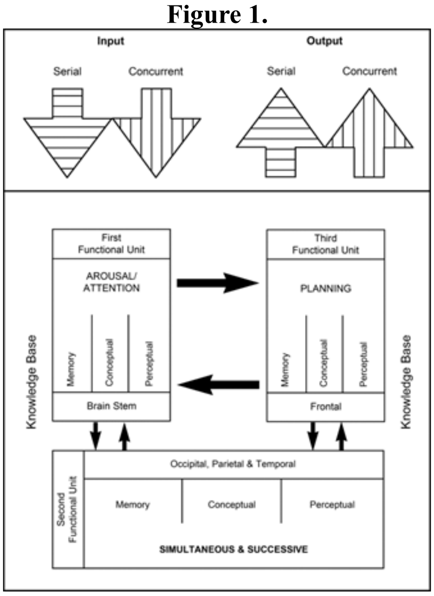
Planning and Execution

The third functional unit is identified with higher integrative functioning. These include complex cognitive processes such as planning, reasoning, and problem-solving. Anatomically this unit is primarily associated with the frontal lobe, particularly the prefrontal cortex, which is crucial for executive functions (Luria, 1973; Miller & Cohen, 2001). Higher integrative functions enable individuals to manage their behaviour in a goal-directed manner. These behaviour include a series of complex processes such as the ability to set objectives, organising actions, inhibiting impulsive behaviours and adjust plans based on feedbacks received from the environment. It involves integrating information. Responding to novel situations require integrating sensorimotor and verbal units and then combining these sensory input with language and conceptual frameworks to produce logical as well as flexible responses. Damage to this unit can result in significant impairments in executive functioning, leading to difficulties in decision-making, attention, and emotional regulation. Conditions such as frontotemporal dementia and traumatic brain injury often reveal the critical role of this unit in maintaining cognitive and emotional balance (Stuss, 1992).

Three Functional Units and PASS Theory

Luria's concept of the three functional units used as the basis of the PASS theory is diagrammatically shown in Figure 1.

Figure 1.



While a two-dimensional diagram has limitations when illustrating complex functional systems, it effectively emphasizes core elements of the PASS theory. The theory underscores the crucial role of an individual's knowledge base, which informs every cognitive process. Prior experiences, learning, emotions, and motivations shape this knowledge, providing essential context and sources for new information. Information from the environment enters through the senses and, once analysed by the brain, is joined by internal data such as memories, images, and thoughts. Therefore, the four cognitive processes always function within the knowledge base and never independently. As noted by Naglieri & Das (1997), cognitive processes both depend on and influence knowledge, which can be short-term or deeply ingrained. Furthermore, cognitive processing and learning mutually reinforce each other and are shaped by social and cultural backgrounds (Das & Abbott, 1995). Thus, knowledge is foundational in the PASS theory, a person may excel in reading English yet struggle with Chinese, not due to processing deficits, but simply because of limited knowledge of the latter.

Planning is conceptualized as an essential executive function that stimulates decision-making, problem-solving, and the creation of novel activities (Das et al., 1995). As explained in Luria's work, the frontal lobes are primarily implicated in these functions, governing the organization of thought, goal setting, and the ability to anticipate future consequences of actions (Luria, 1973). This aspect of cognition is vital for effective engagement with complex tasks requiring foresight and strategic intervention.

Attention–Arousal encompasses the mechanisms that enable individuals to selectively focus on relevant stimuli while systematically filtering out extraneous distractions. This process is intricately linked to the reticular activating system and the catecholaminergic projections from the brainstem throughout the cortex, as posited by Luria (Luria, 1973). The ability to maintain sustained attention is crucial for optimizing cognitive resources and ensuring an adaptive response to dynamic environmental demands.

Simultaneous processing refers to the cognitive ability to organize incoming information into a cohesive whole or gestalt, allowing for an immediate and comprehensive understanding of that information. This cognitive capability is associated with the occipital-temporoparietal junction, where visual and spatial data converge (Das et al., 1994). Luria’s theories on holistic perception emphasize the necessity for this integrative processing in promoting effective cognitive understanding and synthesis of multifaceted information.

Successive processing refers to the sequential handling of information where elements are processed one at a time, making it difficult to survey the entire sequence instantaneously (Aysto & Hanninen, 2003). In this framework, individual information components may not inherently be related; rather, they gain meaning through the overall understanding and subsequent chunking of the sequence. This process is correlated with the frontotemporal and perisylvian regions of the brain, where the systematic arrangement of information is facilitated (Luria, 1973). Such cognitive organization is indispensable for tasks that require the sequential understanding of verbal information, illustrating the neural support for language and communication.

Apart from the neurological underpinnings, the PASS model also emphasizes the integral role of a person's knowledge base in cognitive processing, which is a core element of the PASS theory. It highlights that an individual's background—comprising past experiences, learning, emotions, and motivations—shapes and supplies the information needed for cognitive processes. This information is initially received through sensory input from the environment, which the brain analyses. When sensory information is transmitted to the brain, several central cognitive processes are activated. However, the internal cognitive elements such as images, memories, and thoughts also contribute to the overall input that influences cognitive functioning. Thus, the processes of thinking operate within the framework of an individual's existing knowledge, which is pivotal for effective processing. Naglieri and Das (1997a) explained that cognitive processes are not only reliant on knowledge but simultaneously influence it: "Cognitive processes rely on (and influence) the base of knowledge, which may be temporary (as in immediate memory) or more long term (that is, knowledge that is well learned)". This reciprocal relationship suggests that as one engages in cognitive tasks, the processes they employ can enhance or modify their existing knowledge. Moreover, the model points out that cognitive processing is mutual with knowledge acquisition i.e., as individuals learn new information, it can reshape or enhance their cognitive abilities. This interaction is further complicated by social and cultural contexts, as noted by Das and Abbott (1995), who highlight that membership in specific social and cultural environments can influence both cognitive and knowledge processes. For example, a person who reads Odia proficiently but struggles with English may not have a processing deficit. Instead, their difficulty stems from a lack of knowledge of the English language. This clearly demonstrates that the effectiveness of cognitive processes is closely linked to the individual's knowledge base, reinforcing the idea that knowledge is a cornerstone of the PASS theory and overall cognitive functioning.

Information-processing Approach Tests Based on PASS Theory

The PASS theory not only aligns with Luria's theoretical contributions but also advances the discourse initiated by Das, Kirby, and Jarman, who conducted pivotal psychometric and cross-cultural investigations in terms of cognitive processes (Das et al., 1994). Their research provides empirical evidence for the bifurcation of cognitive functioning into simultaneous and successive processing units, further enriching the understanding of planning and attention as integral components of higher cognitive functions as delineated by Luria. This theoretical approach moves beyond traditional views of intelligence as a singular trait, instead presenting it as a complex interplay of multiple cognitive functions engaging specific brain regions. The development of the Cognitive Assessment System (CAS) in 1997 marked a significant milestone in applying the PASS theory in practical contexts. Designed by Das and Naglieri, the CAS assesses cognitive abilities using tasks that align with the four processing components of the PASS model. This instrument not only serves as a tool for evaluating individual cognitive profiles but also enhances our understanding of students' learning needs, particularly in educational settings. Through its structured approach, the CAS helps identify strengths and weaknesses in cognitive functioning, fostering targeted interventions and better educational strategies. Recent advancements, notably the Brain-Based Test of Intelligence (BBIT) introduced by Das et al. in 2020, reinforce the ongoing efforts to explore the neurocognitive foundations of intelligence. The BBIT extends the principles of the PASS theory by incorporating neuropsychological insights into its framework, offering a contemporary perspective on cognitive assessment. This test reflects a growing understanding that intelligence cannot be fully articulated through traditional IQ measures alone; rather, it requires a nuanced examination of the underlying cognitive processes that facilitate intelligent behavior. Research studies have consistently validated the PASS theory and its related assessments through empirical evidence, contributing to the broader field of cognitive psychology. For instance, Das, Naglieri, & Kirby (1994), Papadopoulos, Parrila, & Kirby (2015), and Gupta, Bhushan, & Behra (2018) have provided insights into how the components of attention and processing style are pivotal in shaping individuals' cognitive capabilities. Such studies illuminate the dynamic relationship between cognitive processing and intelligence, highlighting that variations in these functions can significantly impact learning outcomes and adaptive behavior. Similarly Mahapatra (2016), studied the relationship of planning behavior with reading achievement and had detailed the role of PASS processes in reading. Furthermore, the integration of neuropsychological, cognitive, and psychometric approaches within the PASS framework offers a comprehensive model for understanding individual differences in cognitive performance. This model not only explicates how brain structure and function are related to intelligence but also underscores the importance of educational contexts and interventions tailored to diverse cognitive profiles. The PASS theory and its evolving applications, such as the CAS and BBIT, represent a paradigm shift in understanding intelligence as an intricate interplay of cognitive processes, rather than a fixed trait.

II. Conclusion

In some ways, PASS theory is an attempt to revive the intentions of early intelligence test developers by taking a multidimensional approach to the definition of ability. The most important difference between traditional IQ and PASS theory, therefore, lies in the use of cognitive processes rather than general ability. The multidimensional, rather than unidimensional, view of intelligence that the PASS theory provides is one of its distinguishing aspects (Das & Naglieri, 1992). It is a theory for which research has increasingly demonstrated utility and practitioners have noted its consistency with the more modern demands placed on such tests. PASS is a modern alternative to *g* and IQ, grounded in neuropsychology and cognitive psychology, and that it is well-suited to meet the needs of psychologists practicing in the 21st century.

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