DOCUMENT RESUME

ED 401 390 CE 072 872

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TITLE Human Cognition and Information Processing: Potential Problems for a Field Dependent Human Sequential Information Processor.
PUB DATE 96
NOTE 5p.
PUB TYPE Information Analyses (070) -- Reports - Research/Technical (143)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS Adult Education; *Adult Learning; Career Choice; Case Studies; *Cognitive Processes; Comparative Analysis; Field Dependence Independence; *Job Training; *Nuclear Power Plant Technicians; *Vocational Aptitude
IDENTIFIERS Luria (A R)

ABSTRACT

Numerous cognitive psychologists have validated the hypothesis, originally advanced by the Russian physician, A. Luria, that different individuals process information in two distinctly different manners: simultaneously and sequentially. The importance of recognizing the existence of these two distinct styles of processing information and selecting a career suitable to one's method of processing information is illustrated by the cases of two sequential information processors who participated in training programs for nuclear power plant operators. Although both men handled serially ordered tasks very well, neither was capable of comprehending the overall structure of related tasks. Because both training programs in which the men were involved were designed for simultaneous information processors, each man failed his respective training course. One of the men chose a new career that was suitable for sequential information processors and went on to become a respected contributor in reactor engineering for a nuclear steam supplier. The other man eventually managed to obtain certification as a nuclear power plant operator by enrolling in a different training program; however, his inability to process information simultaneously eventually led to failure as a nuclear power plant operator and loss of his nuclear license. (Contains 11 references.) (MN)

HUMAN COGNITION AND INFORMATION PROCESSING: POTENTIAL PROBLEMS FOR A FIELD DEPENDENT HUMAN SEQUENTIAL INFORMATION PROCESSOR

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SUMMARY

The driving forces behind the present day understanding of information processing strategies in humans have been the various studies and resultant findings of Luria and Das. What is remarkable is that in all the literature viewed, there has been consistent agreement amongst the theorists, experimentalists, and evaluators concerning the existence of certain common strategies (i.e., simultaneous, sequential, etc.) for information coding and processing. The Luria model, with few exceptions, has stood the test of time and today still stands unchallenged as the most important concept in understanding how humans code and process information.

I. INTRODUCTION

Dr. A. Luria, practicing in a clinic outside Moscow, observed that patients undergoing treatment for brain lesions (most were war veterans with head injuries) processed information in two distinctly different manners. Thus, Dr. Luria developed a model for human cognitive information processing. The model was used on normal adults without known brain lesions and the results indicated that two factors existed which he identified as sequential and simultaneous information processing. Over the intervening years other investigators into human cognitive processes (Das, Kirby, & Jarman, 1975), (Kirby & Das, 1977), (Kamphaus & Kaufman, 1986) and others have verified, validated, and refined Luria's model, forming a consensus and acceptance in the community of cognitive psychologists for the existence of the two independent human information processing strategies of sequential and simultaneous.

II. CASE STUDIES

We would like to tell you about two students. One was a student (we will call him Willie) in the Naval Nuclear Power program at a prototype in the East. The other (we will call him Max) was a student in the Civilian Nuclear Power Program at a training center operated for a nuclear steam supplier (NSS). What Willie and Max had in common, though the training environments were greatly dissimilar as was the nuclear power plants they were studying and hoped to qualify on, was that they were both sequential information processors and were strongly field dependent. They both "locked on" to a given stimulus (alarm, horn, alarm light, evolution, etc.). Any other stimuli that arrived at their respective sensory register was ignored until they resolved the needs associated with the stimulus they were locked onto. As teachers

of nuclear power plant design, engineering, construction, and operations, like associates at the time, we were at a loss at how to "unlock" these two students so that they could see the larger picture. We might have tried forever and not succeeded. You are all probably aware of people just like Willie and Max. People who seem to do a very good job at serial, well defined and confined tasks, yet who fail to comprehend or see how their personal contribution fits into the larger, open and unconfined big picture. You yourself may be like Willie and Max. What was unknown at the time that both failed to qualify was the work of Luria (Luria, 1966), wherein he, working with World War II Russian veterans with mild to severe head wounds, identified the independent cognitive processes we know as sequential and simultaneous information processing. Willie and Max were sequential information processors. They could do very well on serial ordered tasks but were unable to comprehend the overall structure of related tasks. Recent work has identified allied concepts of field-dependent (sequential processor) and field-independent (simultaneous processor). What Luria also identified (Luria, 1966) and what has been corroborated by a large number of cognitive psychological investigators (Das, Kirby,& Jarman, 1975 and Kirby & Das, 1977 and Kamphaus & Kaufman, 1986) among others, is that Willie and Max were born as primarily sequential information processors. They did not nor could they have learned it. We are all born naturally as sequential or simultaneous information processors. Some of us, unlike Willie and Max, are able to utilize some of each cognitive information processing strategy. As with other cognitive abilities that overlap, these information processing strategies appear to overlap. However, factor analysis of results of tests designed to measure sequential and simultaneous information processing strategies in humans (Das, Kirby, & Jarman, 1975) has shown that these cognitive processes are independent i.e., Varimax rotation of factors clearly shows orthogonality (Das et al, 1975 and Das & Dash, 1983). A substantial amount of work in the area of overlapping cognitive strategies has been done. At this point one might ask "Are Willie and Max not intelligent?" Willie was a graduate engineer, with some 20 years of experience, who had risen to the senior engineer individual contributor position of a large NSS vendor. It is significant to note that he was not an engineering manager. Max, on the other hand, was a high school graduate who had risen to the Senior Shift Supervisor position, after some 20 or more years of experience, for an eastern fossil fueled power generating station. The work of Cowart and McCallum (1984) has shown that the information processing strategies of sequential and simultaneous are stable over a person's life span and no evidence have they found to indicate any change in these information processing strategies as a function of age. Merritt and McCallum (1982), and McCallum and Merritt (1983) found that no gender differences exist in our utilization of the sequential and simultaneous information processing strategies. Sahu and Devi (1984) showed that the cognitive information processing strategies of sequential and simultaneous are independent of individual intelligence. Another question could be "Why did they fail to qualify?" In a sense, we set them up for failure. During their nuclear power training, no attempts made to identify how they

cognitively processed the mass of information they were being fed. In Willie's case, he chose a career position which was suited to an individual contributor, a sequential information processor. Max chose a career position for which later events showed he was not suited. Were Willie and Max, the sequential information processors, unequipped with operational procedural guidance specifically designed for their unique cognitive abilities, set up for failure? The answer is an unequivocal YES. The naval program, at which Willie was failed, utilized operational procedures that were written in lengthy paragraph format. Even some simultaneous information processors had trouble seeing the stable plant end state. A sequential processor was hopelessly lost in the verbiage. The work of Sahu and Devi (1984) showed that good readers were simultaneous processors primarily, and possessed differentiated strategies (they overlap), while poor readers were not proficient at either sequential or simultaneous strategies and did not possess differentiated strategies. Kirby and Robinson (1987), in a study of reading disabled-children, found that children with reading disabilities employed simultaneous information processing, if they possessed it, in tasks where normal children used sequential information processing. This was Willie's and Max's problem: they utilized their sequential strategy for reading and went from word to word and never grasped the whole purpose of the procedure. Max's utility, as all did and may still do, utilized a lengthy paragraph format in its operational procedures. NASA, at least for the astronauts in the space shuttle, saw the need to attempt to pictorialize (flow chart format). Airlines, for the immediate action on emergencies, provide a pictorial format, again as a flow chart. If the most recent incident at Salem (Nuclear News, June 1994) and the questions raised by the Three Mile Island accident are any indication, we still seem to have our operators burdened with impossible procedures. This is especially true for those identified, or perhaps suspected, as being sequential processors. The procedures were not designed with recognition of, and allowances made for, their unique cognitive information processing strategies.

III. CONCLUSIONS

Willie went on from his failure to become a well respected individual contributor in reactor engineering for a large NSS vendor. Max went to another nuclear power training center at which he succeeded in qualifying. He was placed on shift at an eastern nuclear generating station and, after a series of incidents, was relieved of his shift duties, lost his nuclear license, and retired into obscurity. Could their stories have turned out differently? Yes, but we have to take into account more of an individual's unique cognitive ability. This is especially important where it directly impacts not only how he processes information cognitively, but how that information processing, utilized by him determines how much and of what quality the information is that reaches his long-term store.

IV. RECOMMENDATIONS

We would strongly recommend that we test all current and potential future nuclear plant operators to determine their predominant information processing cognitive

strategies, sequential or simultaneous. We then must design training programs and procedures that recognize these individual cognitive styles and equip the current and potential operators for the emergencies that are still to come. This will be especially important as fusion reactors become a reality in the 21st century. Of course you will take note of your children. They are not tested either for cognitive information processing strategies, unless a learning disability is suspected or is evident. Yet the sequential information processor in your child's 5th grade class, maybe your child, will struggle and struggle throughout the subsequent school years. None of the school curriculum is specifically designed for the sequential processor. It does not have to be for the simultaneous processor; however, who is probably bored to tears. As some of you may be aware, the calculus curriculum is being extensively revised at many universities to make it more pictorial. The emphasis will be on visual computer displays with the computer doing the traditional student's computational calculus work. Will this display of functionalism be a boon or another bust for the sequential information processor?

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CE072872

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