INTEGRATION OF NEUROPSYCHOLOGICAL AND COGNITIVE THEORY IN REHABILITATION

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Clinical neuropsychology has focused on the diagnosis and localization of brain damage. Much of the early progress in the field relied upon an atheoretical-actuarial approach. Recently a link between neuropsychology and cognitive psychology has emerged. From the early focus upon brain-behavior relationships, neurocognitive theories have emerged to explain observed brain functions. Although many researchers have enjoyed the collaboration between neuropsychology and cognitive psychology, others continue to investigate functions without considering the merging of finds. This article reviews integrative elements of cognitive and neuropsychological research and the emergence of cognitive neuropsychology.

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During the past 30 years clinical neuropsychology has emerged as a specialized area of research and clinical practice. The development of the area represents the convergence of experimental physiology, neurology, cognitive psychology, and clinical psychology. Much of the clinical research exploring brain function has been done in an atheoretical fashion, considering brain-behavior relationships. That is, research based in clinical neuropsychology has been concerned more with distinguishing between brain-damaged and psychiatric nonbrain-damaged patients than with outlining the brain-related cognitive functions. On the other hand, cognitive psychology has a rich history of theory regarding the processes that underlie brain functions. In fact, much of the theory underlying clinical neuropsychology has roots in cognitive psychology. With this in mind, this article explores salient research in neuropsychology and cognitive psychology that underscores the convergence of the two. Specifically, we examined the theoretical similarities between cognitive and neuropsychological positions in the processing and learning of information. Data are offered to illustrate the integration of cognitive and neuropsychology in terms of process and the implications of such an approach in assessment, intervention, and therapy. The final portion of this article addresses the current status of cognitive neuropsychological theories.

Cognitive psychologists and neuroscientists have independently considered the storage and retrieval of information for some time. A number of systematic studies have attempted to integrate cognitive and neuropsychology points of view. Examples are the Bimodal theory (e.g., Pavia, 1977) of processing and the dual encoding hypotheses of information processing.

COGNITIVE NEUROPSYCHOLOGY

Although a number of notable attempts have been made to integrate neuropsychological and cognitive views, it is important to acknowledge that much research in cognitive psychology and neuropsychology has been independent of the other. For example, Jarman, Vavrik, and Walton (1995) point out that research in cognitive psychology focuses on metacognition or metacognitive processes, while neu-
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Neuropsychological research is concerned with localized functioning. These authors argue that both metacognitive processes and frontal lobe processing refer to similar concepts, with some variation, but with little acknowledgment of each other. Moreover, both have similar theoretical premises and results indicative of similar processes/functions. These theoretical premises center around the notions of cognitive control and metacognitive monitoring. Cognitive control refers to monitoring of thought to obtain certain intellectual goals. The degree of self-awareness of one’s cognition refers to the concept of metacognitive monitoring. Although Luria (1978) would have argued that self-awareness is implicit in control, neuropsychology emphasizes the singular aspect of cognitive control while cognitive psychology stresses metacognitive monitoring in addition to control. Given the similarities theoretically and empirically, it is important that investigations of metacognitive and frontal lobe processing be integrated to advance our understanding of the cognitive and anatomical underpinnings of this function (Jarman et al., 1995).

A number of cognitive neuropsychological theories have developed. Such theories are characterized by an interactive relationship between models of normal cognitive processes and investigations of impaired functioning in patients (McLean-Thorns, 1994). One goal of these theories is to explain patterns of impaired and normal cognitive performance. A secondary goal of many cognitive neuropsychological theories is to offer information regarding diagnosis, related dysfunctions, prognosis, remediation, and assessment of treatment. Finally, based on theory, one should be able to draw conclusions about cognitive processes based on patterns of neurologic functioning.

Morton’s logogen model represents one of the clearest attempts to meet these goals while integrating basic concepts from neuropsychology and cognitive psychology. In an explanation of language processing, Morton’s model combines the dual processing of cognitive psychology and the bimodal theory of neuropsychology. From this point of view, information received by separate modalities is processed independently before connection is made at the semantic level. According to this model, visual and auditory inputs are processed independently while associated with their respective shapes or sounds, and eventually their respective logogens (word source/
birth). These logogens are then combined at the next level of processing as they enter the cognitive system and meaning is attached. Following the attachment of meaning, the information is translated in the phonological output logogen and language can then be produced.

McLean-Thorns (1994) applied this model to a case study in an attempt to consider strategies for educational intervention. This analysis provided some explanation of impaired and intact cognitive processes as well as information regarding related problems, diagnosis, and prognosis. Although interesting, questions remain as to whether current theory in cognitive neuropsychology is capable of offering treatment approaches (Baddeley, 1993; Basso, 1989; Caramazza & Hillis, 1993). Other researchers are less pessimistic stating that theory does, or at least can, translate to therapeutic approaches (Howard & Patterson, 1989; Mitchum & Berndt, 1989). Wilson and Patterson (1990) investigated three cases of successful rehabilitation to determine if treatment went beyond mere deficit analysis. These authors assumed that theory should be effective in planning rehabilitation. While the success of each case could be explained in a post-hoc fashion, Wilson and Patterson (1990) could find no evidence that such a priori theory contributed to treatment. In one case a successful treatment approach was developed by a professional in another discipline. A second successful treatment was discovered via trial and error. In this case, two patients with indistinguishable dysfunctions were successfully treated using distinctly different treatment approaches. Wilson and Patterson (1990) concluded that successful treatment may be possible without reference to cognitive or cognitive neuropsychological theory, for such theory offers little guidance in rehabilitation of cognitive dysfunctions. Moreover, they argued that theory relates almost exclusively to deficit analysis.

CURRENT STATUS OF COGNITIVE NEUROPSYCHOLOGICAL THEORY

Although cognitive neuropsychology is theoretically based, it is insufficient for guiding therapeutic intervention. In the absence of a theory that is capable of accounting for intact and impaired cognitive systems as well as delineating the factors of conditions that
could lead to modification of the damaged cognitive systems, little theoretical progress in this area is likely. Wilson (1989) argues that there are at least five common neuropsychological approaches to rehabilitation of cognitive functioning. The first approach involves attempts to restore lost functioning through exercise, practice, or stimulation of the affected cognitive system. The second approach attempts to reorganize or bypass the problem area. For example, patients who have difficulty reading would be taught to avoid circumstances in which reading is necessary. For amnesic patients one would avoid relying on memory by labeling objects and providing procedural lists at strategic locations in the environment. A third approach to remediation of cognitive functioning is the reorganization of functioning within the cerebral cortex. This entails encouraging the development of language functioning in the right hemisphere for individuals whose left hemispheric language function has been disrupted. The fourth approach involves the use of intact systems to compensate for the damaged system. This procedure is demonstrated in individuals with verbal memory deficits who are taught to use nonverbal memory methods while individuals with global aphasia are taught alternative means of communication. Finally, the fifth common remedial method involves teaching patients to use more efficiently what skills remain in the impaired area. An example of this method is the employment of study techniques (SQ3R) to improve recall and understanding of verbal material. Even cursory examination of these methods indicates little connection between observed deficits and the approach to treatment of the impaired cognitive skill (Wilson & Patterson, 1990).

Neuropsychological assessment provides probable locus of a deficit, but few successful attempts have been made to tie impaired functions to theory-based cognitive systems. Indeed, to provide guidance for treatment, a theory must combine both structure and therapeutic intervention (Caramazza, 1989; Wilson & Patterson, 1990). The critical component of such theories includes specification of the manner in which the damaged system(s) may be modified using a particular intervention.

Caramazza and Hillis (1993) have argued for a theory of remediation of cognitive deficits. These authors provide a framework for the development of theory-driven remediation of cognitive deficits. They
see such a theory as having three essential components. First, it must articulate the relationships between pre- and post-therapy damaged states. Next, hypotheses must be generated regarding the nature of the damage to specific cognitive systems and the manner in which change between pre- and post-therapy occurs. Finally, the means by which specific interventions modify functioning must be hypothesized. This entails identification of patient characteristics and dimensions of treatment procedures relevant to intervention outcomes.

This argument maintains that it is necessary to understand the cognitive systems being treated as well as how these systems can be changed by experience. However, the Caramazza and Hillis (1993) approach is not without critics. For example, Baddeley (1993) criticized this approach to developing rehabilitation theory, arguing that it entails waiting for successful rehabilitation to occur then trying to explain it. Furthermore, Baddeley (1993) suggested that therapy is not as atheoretical as one might be led to believe. That is, behavior change is generally the primary goal of treatment, and psychological theory has enjoyed much success in changing behaviors based on theories such as classical/operant conditioning and social learning theory. More importantly, Baddeley (1993) contended there are numerous aspects of cognitive theory that may contribute to successful remediation. Specifically, approaches to remediation of cognitive deficits should capitalize on knowledge of learning theory in producing practical and applicable rehabilitation strategies. This approach may be less ambitious than that developed to meet the criteria set forth by Caramazza and Hillis (1993). However, Baddeley (1993) contended that a theory of remediation must be based on principles of learning and changes in cognitive systems secondary to treatment.

In hypothesizing on future directions of cognitive theory, Logie and Bruce (1990) identified applications of cognitive theory to neuropsychology as a promising topic of research. They contended that although no real theory of intervention exists, models of parallel distributed processing (PDP) (McClelland & Rumelhart, 1986) provide a potential tool for further development. These models integrate learning and cognitive processing theory into networks that are capable of learning. The networks of PDP models are con-
structured of simple processing elements, at various levels, which send excitatory or inhibitory signals to each other via weighted connections. The network conducts a series of computations that will determine the models' output. These computations are performed and evaluated by comparing the models' output to the performance of real subjects on the similar tasks. PDP models use this feedback as a learning device as they gradually identify important distinctions among various inputs. From this point of view, relevant distinctions for the patient are discovered within the network.

As complicated as cognitive networks appear, they are, at best, primitive representations of individual brain functions. However, the use of such constructs to learn and evaluate performance is a promising tool in our understanding of the processes that underlie brain functions. Of particular interest is the developing ability of these networks to demonstrate some resemblance to particular brain functions. For example, much like the brain, a meaningful entity does not correspond to a specific place or node; rather meaning is associated with patterns of activity across areas (Kolb & Whishaw, 1996; Das & Varnhagen, 1986). Even more compelling is the performance of networks when specific areas are damaged. The subsequent performance does not dramatically diminish or disappear; instead performance slowly decreases in accuracy and efficiency (McClelland & Rymelhart, 1986; Patterson, Seidenberg, & McClelland, 1989). The promise of such findings lies in the comparisons that can be made to the demented patient who displays gradually diminishing skills, presumably due to numerous mini-lesions (e.g., the formation of plaques in the brain).

NEUROPSYCHOLOGY AND COGNITIVE INTERACTIONS

An example of the interaction between neuropsychology and cognition psychology comes from early research suggesting that the two hemispheres of the brain serve specialized functions (Dearborn, 1933; Henschelwood, 1917; Orton, 1937). This line of inquiry has its historical roots in a study of diseased brains during the nineteenth century and has produced a bimodal theory of processing (Jackson,
1874; Broca, 1865). Specifically, based on clinical observations of brain-injured patients Jackson (1874) proposed two different yet coexisting modes of cognitive processing that follow hemispheric lines of the brain. These conclusions were congruent with Broca’s (1865) earlier observations that control of many aspects of speech and language was localized in the left hemisphere of the brain for most people. Although strict theories localizing functions to microstructures of the brain have been rejected by most neuroscientists, broad organizational principles and notions of hemispheric differences in functions have gained respectability during the last 30 years (Dean, 1978; Bryden & Saxby, 1986; Kolb & Wishaw, 1996).

On the basis of investigations of patients who had undergone surgery that severed the major nerve connections between hemispheres, Sperry, Gazzaniga, and Bogen (1969) concluded that complex, linguistic functions are served by the left hemisphere of the brain, while the right cerebral hemisphere represents visual-spatial reality. These data were consistent with Reitan’s (1955) work with brain damaged patients and the idea that the left hemisphere is better inclined for processing speech, language, and calculation. Given these findings and the confirmation of other studies, researchers agree that verbal information, such as speech, language, and calculation, are more efficiently processed by the left hemisphere (Dean, 1979; Gray, Dean, & Seretny, 1986; Batchelor, Williams, Hill, & Dean, 1997). In contrast, the right hemisphere of the brain seems better able to process visual-spatial transformations and analyze complex visual patterns. Unfortunately, some problems have arisen with these early conclusions (Reitan, 1955) when applied to the functioning of normal individuals. This is true because patients with known cortical lesions may function quite differently from normal subjects.

Attempts to refine the bimodal theory of cerebral processing have involved investigations that employ non-invasive methods on subjects without neurological difficulties. Researchers generally agree that while a good deal of communication occurs between hemispheres of the brain, each cerebral hemisphere selectively serves independent cognitive functions (Kolb & Wishaw, 1996). Consequently, empirically based refinements of the bimodal theory originally articulated by Jackson (1874) and Broca (1865) allow one to conclude that the observed hemispheric differences may be better
understood as differences in cognitive processing rather than specialization for specific types of stimuli (i.e., verbal/nonverbal).

In sum, the left cerebral hemisphere may be portrayed as processing information in a linear (analytical), serial (temporal), or sequential (logical) manner, and as such, language lends itself well to these processes. In contrast, research suggests a holistic, concrete (visual), or simultaneous mode of functioning in the right hemisphere. As such, the right side of the brain would be more suitable for the processing of spatial relations presented visually.

Apparently, individuals have some control over the mode of processing (i.e., left or right hemisphere) that will be utilized. For example, Levy (1969) and Dean and Hua (1982) offered data portraying hemispheric specialization as an active-constructive process in which information storage is dependent on the constraints of attention and individual differences in the brain functions. That is, regardless of whether stimuli are presented in a manner that can be processed more easily by one hemisphere or the other, learners can initiate strategies that are consistent with either hemisphere or both. For example, Conrad (1964) provided evidence that visual memory traces (Paivio, 1971) occur in the brain. Similarly, Das (1973) suggested that differences in hemispheric processes are complementary and representative of coexisting modes. Individuals have some cognitive control over the manner in which information is processed and encoded, regardless of the form the stimuli is presented. The learner may use strategies that facilitate processing of the same piece of information in either the right or left hemisphere. Thus, while cerebral hemispheres selectively serve independent cognitive processes, interhemispheric communication allows for considerable variation or adaptability in processing and encoding of information.

In addition, it should be emphasized that the majority of research in this area has focused on normal right-handed individuals. In this regard, numerous attempts have been made to explain a number of language disorders for otherwise normal individuals in terms of failure to establish complete specialization of the hemispheres of the brain. Related to this notion, Luria (1966) argued that specialization of hemispheres may not only vary from individual to individual, but more importantly to the present discussion, specialization may vary as a function of the specific cognitive system under investigation.
The neuropsychological approach examines individuals with verified damage to the central nervous system (CNS), and the localization of functions is then inferred from observed deficits. Conversely, the cognitive approach has been established on the study of normal individuals, without known CNS impairment. Paivio (1969, 1971) presented a cognitive perspective that has distinct neuropsychological implications. Paivo offered data in favor of a “dual coding theory” of memory in which two distinct yet interconnected systems process and store information. Paivio termed one mode the “imaginal mode,” which is purportedly specialized for the processing and representation of nonverbal material in a direct analog fashion. Essentially a more primitive system, the most idiosyncratic expression of its function has been conceptualized as imagery. Paivo hypothesized a second system, or verbal mode, as representing processing, and storing information abstractly in a sequentially arranged array with the aid of language.

Evidence for the dual coding concept and interrelations between modes comes from studies that indicate that visually presented material may be stored acoustically (Conrad, 1964), and verbally presented material may be represented as visual images (Paivio, 1971). Interestingly, learners store verbal information in memory on the basis of its verbal-abstract meaning as well as visual features regardless of the form (auditory or visual) of the original stimulus. Indeed, it seems that the learner’s frame of reference is important in that both expectancy (e.g., Frost, 1972) and learning instructions (e.g., Paivio, 1971) influence the strategy (left vs. right hemisphere) used in learning.

In accord with this dual coding hypothesis, abstract material should be processed and stored in conjunction with verbal or semantic strategies. This mode of processing may not be as effective in terms of recall because abstract materials do not have a readily available visual component. Thus, abstract or nontangible information has a low potential for the subject to generate an image (e.g., the word “justice”). On the other hand, concrete or tangible information (e.g., the word “dog”) has greater potential for imagery, which could be easily coded and remembered using either a visual or verbal mechanism or, more likely, both. Indeed, one would expect, and several investigators have found, a greater recall
of concrete material which would be interpreted and stored via both interconnected modes (Dean, YeKovich, & Gray 1988; Paivio, 1971; Rolwer & Ammons, 1971). In summary, these data are consistent with Paivio’s hypothesis that concrete information is more easily remembered because it can be encoded or stored as a visual image in an imaginal system, in a verbal system, or in both systems simultaneously.

INTEGRATION OF THE COGNITIVE AND NEUROPSYCHOLOGICAL VIEWS

Many have attempted to examine the neuropsychological underpinnings of this dual coding system. Some time ago, in a series of two experiments, Sherman, Kulhavy, and Burns (1976) auditorially presented learners with abstract and concrete word lists under various conditions meant to cause interference in the processing of either the right or left hemisphere. The results suggested that both hemispheres were efficient at learning concrete verbal material while the left hemisphere was better at processing abstract-verbal information. Support for this position was also presented by McFarland, McFarland, Bain, and Ashton (1978) who demonstrated a left hemispheric advantage for abstract words while concrete words were found to be stored in both left (verbally) and right (image) hemispheres. Seamon and Gazzaniga (1973) using visually presented stimuli have offered further support for the dual coding argument which followed hemispheric lines. They argued in favor of imagery as part of the visual processing system of the right hemisphere.

In sum, the majority of the reported research supports a dual processing theory which operates along hemispheric lines of the brain. However, it should be noted that in each of these reported studies the information to be learned was individual words. Although one may hypothesize that similar hemispheric differences should occur concomitant with the concreteness of prose material, little published evidence relates to such a hypothesis.

In an effort to examine an integrated bimodal/dual processing theory, Dean (1984) investigated the degree to which the concreteness of prose materials would interact with learners’ hemispheric
processing. In this study, 96 normal adult learners were assigned to a control and imagery instructed, or hemispheric interference condition. Learners in each group were auditorially presented an abstract and a concrete expository passage. Subjects in the imagery condition were asked to form relational images of the passages presented. Learners in the interference conditions were asked to track a complex maze task while listening to the passage, a task which interferes with right hemispheric processing. Control subjects were asked simply to listen to the passage and to try to remember it. As predicted, subjects across conditions recalled a significantly greater number of ideas when the passage was concrete. This outcome was seen to indicate that concrete information is processed and stored via both modes/hemispheres. As predicted, the abstractness of the passage was found to interact with subjects' inferred processing mode. It was found that right-hemispheric interference decreased concrete recall but had little effect on more abstract material. These results favored a dual encoding strategy that operates consistent with hemispheric specialization lines. Apparently, visual processing offers a less efficient mode of encoding abstractly moderated discourse when compared to concretely moderated information in the passage.

Subsequent to this experiment (Dean & Rattan, 1986) attempted to examine this bimodal/dual processing integration with neurologically impaired learners and nonneurologically impaired (normal) learners. In general, as would be predicted with an integration of the bimodal and dual processing notions, the recall of concrete prose for patients with right-hemispheric damage (post-central lesions as evidenced via CT scan) was generally less facilitated by imagery instructions than normals or left hemispherically impaired patients, thus, showing the role of the right hemisphere in the processing of prose material in an imaginal fashion. These findings supported those reported by Bower (1970) in which right hemispheric damage (in the area of the temporal lobe) reduced the facilitative effects for imagery in prose learning for individual words. Although this seems to be the case, such right hemispheric lesions had little or no significant effect on abstract prose. This outcome would be expected if concrete prose involved dual hemispheric encoding and more abstract materials were processed by the left hemisphere. Learners
who exhibited no significant facilitation of recall with imagery instructions showed more difficulty in the integration of visual-verbal information than a right-hemispheric deficit in isolation.

IMPLICATIONS FOR LEARNING

Learners who exhibited no significant facilitation of recall with imagery instructions showed more of a difficulty in the integration of visual-verbal information when compared to those with a right-hemispheric deficit in isolation (Dean, 1984; Dean & Rattan, 1986). The results of investigations in our laboratory and those of others support a dual coding theory that follows the hemispheric division of the brain. Apparently, concrete prose material may be stored in verbal or semantic terms simultaneously with a visual representation. Moreover, neither visual interference nor right hemispheric lesions affect learner’s long-term recall of abstract text materials. This outcome would seem logical if the left hemisphere is specialized for sequential abstract material. Additionally, individual differences in cortical specialization seem to interact with the abstractness of text materials. Thus, for individuals with more mixed patterns of dominance, imagery and the visual encoding system seem to offer a less potent representative mode of learning. It may be hypothesized that difficulties in the recall of text information may relate in part to difficulties in the integration of visual and verbal coding strategies. Thus, it may be more effective to present classroom information in a manner that can be efficiently processed and encoded by either mode or processing system. That is, one should provide concrete examples of abstract ideas or concepts, when possible. Additionally, one should present information visually, auditorially, and in meaningful context whenever possible.

SUMMARY

The emergence of clinical neuropsychology as a specialty area appears to have been largely atheoretical. However, as the area has developed and begun to focus on understanding brain functions and
rehabilitation approaches, the influence of cognitive theory has taken on more importance. For some time, areas of neuropsychology and cognitive psychology independently investigated similar phenomena. The integration of the disciplines soon appeared inevitable. Unfortunately, the subspecialty of cognitive neuropsychology currently lacks an adequate theory for practical outcomes in rehabilitation. As a result cognitive neuropsychology may benefit from consideration of additional concepts, principles, and theories—specifically, theories of learning, principles of behavior change, and the practical needs of treatment. The theoretical progress in clinical neuropsychology depends not only on the integration of cognitive psychology and neuropsychology, but also the application of principles of learning and the development of immediately effective treatments.

REFERENCES


