Cognitive Perceptual Motor Retraining: Remediation of Deficits Following Brain Injury

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The rehabilitation of persons with brain injury is complex, often requiring comprehensive services from several rehabilitation professionals to ensure that multiple problematic areas are addressed. This article introduces and describes Cognitive Perceptual Motor (CPM) retraining, an approach to the treatment of brain injury utilized by occupational therapists at Origami Brain Injury Rehabilitation Center and at the Michigan State University Rehabilitation Medicine Clinic. Developed by Madhav Kulkarni, Ph.D., O.T.R., CPM has been utilized for the remediation of deficits in sensory-motor, perceptual-motor, and cognitive functioning immediately following the acquisition of mild to severe brain injury. This approach has also been extremely successful for individuals several years post injury or those who have been discharged from traditional forms of rehabilitation.

The underlying premise of the CPM approach is that persons with brain injury should be guided through a process of reacquiring the spectrum of cognitive, perceptual, and motor skills, from very basic foundational skills through complex cognitive processes, in the same sequence they were first acquired during normal development. Treatment is aimed at restoring the disrupted brain processes that underlie complex cognitive operations, in order to promote accurate and efficient functioning (Kulkarni, 1987). The foundation of CPM retraining builds upon the sensory integration and information processing theories of Luria (Neurobehavioral Functions), Ayres (Sensory integration), and Piaget (Cognitive Development), as well as other theorists.

Guiding Principles

CPM retraining has several key principles (Kulkarni, 1993): (1) The brain can recover function through environmental stimulation (plasticity of the brain). (2) The reacquisition of skills is hierarchical and must follow the path of their original development, i.e. requisite skills need to be remediated prior to higher-level skills. (3) The therapeutic regimen must be graded in speed, complexity, and duration in order to ensure success, promote adaptation, and improve competencies. (4) Feedback promotes self-awareness and refinement of skills. (5) Active participation in meaningful and purposeful activity with additional consideration for feelings, attitudes, and behaviors, promotes motivation. (6) Practice, with and without variation, facilitates the reacquisition of skills, and aids in the reorganization of functional systems of behavior. (7) Metacognitive processes should be promoted to increase self-awareness.

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Role of the Therapist

A therapist utilizing the CPM approach must keep the aforementioned principles in mind from the time of the initial evaluation until the termination of services. When working with individuals with a brain injury, the therapist will most likely need to address the behavioral manifestations that may be present. A successful therapist incorporates therapeutic use of self by modeling appropriate behavior, overcoming one's instincts to overreact, remaining calm, using slow speech, and being as tactful as possible (Frank, 1958). The therapist should attempt to promote consonance among the three selves of the individual, the acting self, perceived self, and the ideal self. A person with a brain injury may have difficulty integrating who they are (acting self) who they think they are (perceived self), and who they want to be (ideal self). The use of metacognitive processes, such as the use of "W" questions, who, what, when, where, and why, and open – ended questions regarding the client's view of their own performance, brings additional self-awareness, a key factor in promoting the integration of the three selves. The therapist must facilitate the client's positive outlook on therapy by empowering him or her to make decisions and identify realistic goals pertinent for the quality of life they desire.

It should be noted that although the CPM retraining approach was originally developed to be used by occupational therapists, it may be, and has been, used by other clinicians intensively trained in the CPM approach such as psychologists and speech language pathologists. In this article, "therapists" refer to any CPM-trained clinician.

The CPM Evaluation Process

The CPM evaluation is a multifaceted process requiring a therapist to be thoroughly trained in CPM. This is because the therapist is the most influential variable in the assessment process (Kulkarni, 1993). Building therapeutic rapport, explaining the testing procedures in detail, and providing immediate feedback, will assist in easing test anxiety, fostering confidence in the therapist's ability, and increasing deficit awareness.

The initial CPM evaluation consists of an initial interview, formal assessments of cognitive, perceptual, and motor competencies, and informal assessments/clinical observations. A typical evaluation lasts three to four hours, with additional

time needed to generate scores and interpret data. The evaluation determines current functional status, including both strengths and weaknesses.

The Clinical Interview

The clinical interview gathers a brief medical and treatment history from the client. A report of the problem areas, specifically in basic and instrumental activities of daily living, is formulated through the use of open-ended questions. The individual's premorbid and current life roles, support systems, educational background, cultural influences, employment status, and hobbies/interest areas are gathered. This information assists the therapist in ascertaining the client's level of deficit awareness and reality orientation. The final stage of the initial interview involves the client stating his or her rehabilitation goals. This stage is critical because it guides the treatment process. Goals of returning to work versus independence at home may have a differing treatment emphasis. It is important to note that family members are encouraged to participate in the clinical interview, especially if the client has deficits in communication and/or awareness. Before the objective testing portion of the evaluation begins, time is allotted for the client to ask any questions he or she may have for the therapist. The client is informed that the assessment process identifies the specific areas of functioning that have been affected by the injury.

The CPM Test Battery

Several standardized assessments of cognitive, perceptual, and motor functions have been carefully chosen for inclusion in the CPM battery (refer to Table 1 for specific tests per domain). Supplemental and non-standardized tests are frequently used, which serve as valuable additions to the traditional CPM evaluation. Even though the CPM battery has been established to include certain assessments, some of these assessments may be omitted or modified to meet the specific needs of the client and the allotted time for the evaluation. The therapist's clinical observations and judgment are essential in making sound decisions regarding which assessments are used. Longer assessments are often interchanged with short assessments, taking into account the need for rest periods. Although tests are

Table 1
Summary of Standardized Assessment Battery

CPM Domains	Standardized Tests
Visual-Spatial Perception	Figure Ground Perception Test (SCSIT*) Cancellation of "H" (Kulkarni, 1993) Alternating Dot-to-Dot (Kulkarni, 1993) Minnesota Spatial Relations Test (Dawis, 1979)
Tactile-Kinesthetic Perception	Graphesthesia Test (SCSIT*) Manual Form Perception (SCSIT*)
Motor Skills	Slosson Visual Motor Performance Test (Slosson, 1996) Purdue Pegboard (Tiffin, 1948) Grip and Pinch Strength (Mathiowetz, 1985) Standing Balance Eyes Open/Eyes Closed (SCSIT*) Imitation of Posture (SCSIT*)
Cognitive-Perceptual	Symbol Digit Modalities Test (Smith, 1991) Detroit Tests of Learning Aptitude-2 (Hammil, 1985) Subtest: Object Sequences Subtest: Letter Sequences Useful Field of View (Ball & Roenker, 1988)

NOTE: SCSIT – Southern California Sensory Integration Test (Ayers, 1966), adult norms from Hsu & Nelson (1981), Peterson, Goar, & Duesen (1985), and Peterson & Wikoff (1983)

classified into subsections based on the primary skills to be assessed, these skills are interdependent. Several tests overlap into other areas of function. For example, basic cognitive skills, such as attention and concentration, are required to complete both perceptual and motor assessments.

Testing of Perceptual Functions. The perceptual portion of the CPM battery is divided into visual-spatial perception and tactile-kinesthetic perception. Visual-spatial perception is the ability to perceive visual information, process it, and organize it into meaningful patterns. First assessed are visual acuity, visual fields, and ocular motility, since these are prerequisites for the remaining visual-spatial skills (see figure 1). Adult norms were developed for assessments originally used with children (Peterson and Wikoff, 1983 & Peterson, Goar and Duesen, 1985, as cited in Kulkarni, 1987). The client's performance on each of these assessments helps to determine which specific visual-spatial perceptual skills have been affected. Visual attention (focused, shifting, and selective), visual scanning, visual sequencing, figure ground perception, size and shape discrimination, visual matching, depth perception, visual organization, and visual-spatial processing speed are each interpreted as being within average, low average, or indicative of mild, moderate, or severe impairment.

Tactile-kinesthetic perception is the ability to integrate information from joint movement and from the sense of touch, then to process it, and finally to organize it into meaningful patterns. The first areas assessed as prerequisites for tactile-kinesthetic perception are sharp, dull, hot, cold, light touch, and deep touch sensations. In addition, proprioception and kinesthesia are important sensations to test prior to assessing higher-level integrated functions. Higher-level skills such as tactile-kinesthetic memory, tactile-kinesthetic discrimination, stereognosis, and tactile-kinesthetic processing speed, are also assessed. Adult norms were developed for assessments that

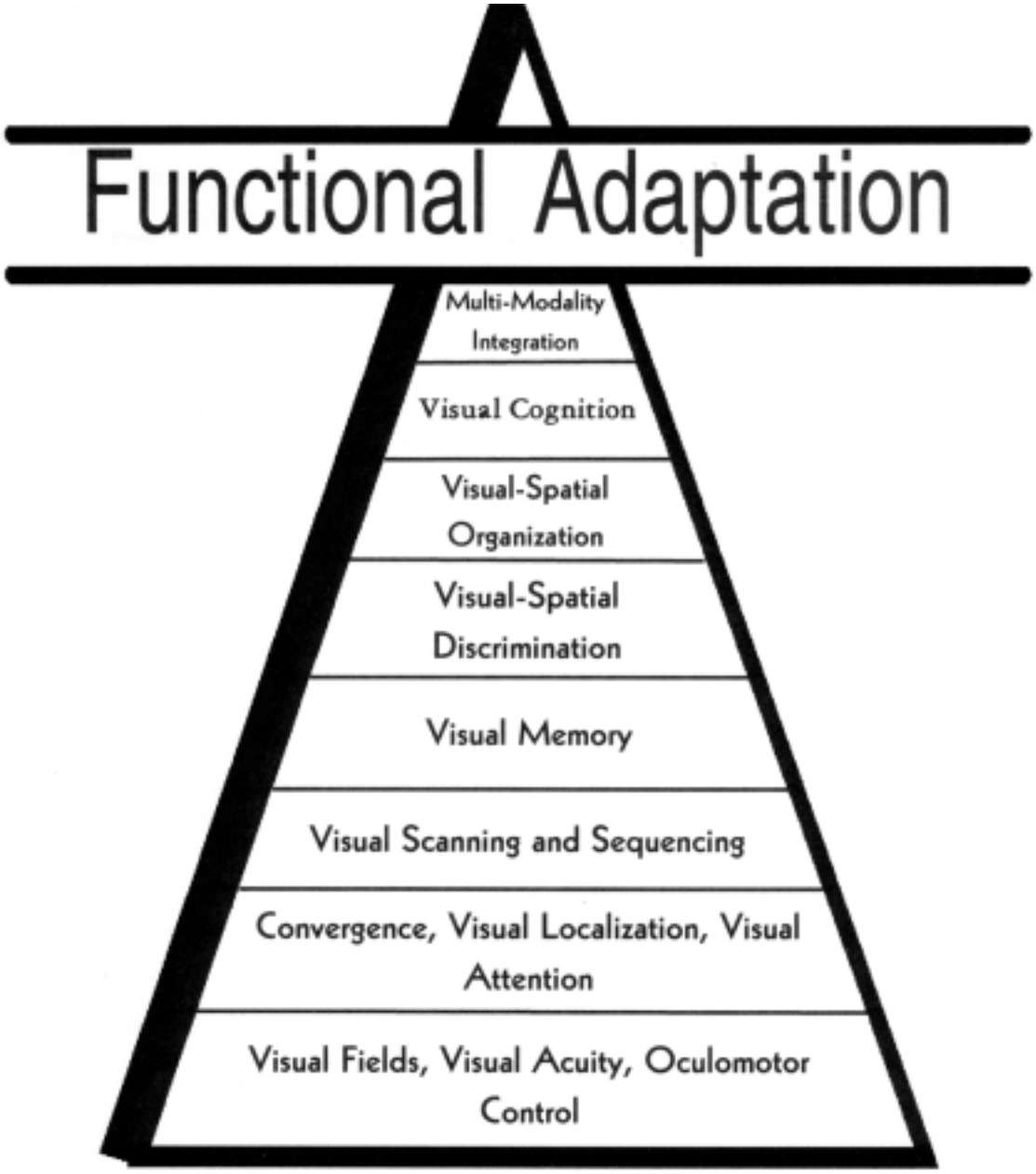

Figure 1. A Hierarchy of the Acquisition of Visual-Spatial Skiils. *Adapted from: Kulkarni, (1993), Unpublished Manuscript

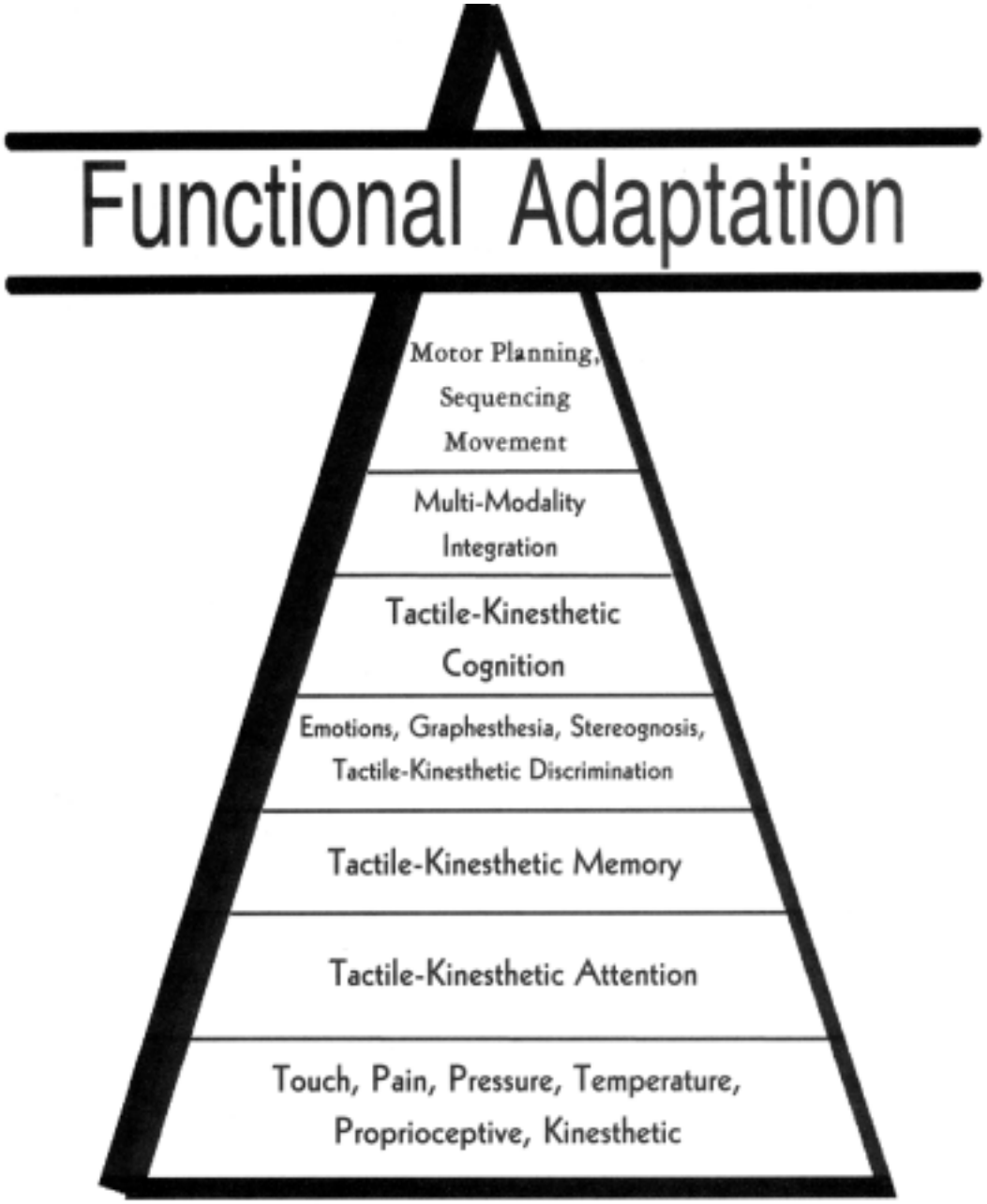

Figure 2: A Hierarchy of Tactile-Kinesthetic Skills. * Adapted from: Kulkarni, (1993), Unpublished Manuscript.

were originally used with children (Hsu and Nelson, 1981).

Testing of Motor Functions. The individual's upper extremities are examined for muscle tone, joint range of motion, and muscular strength and endurance. The therapist evaluates areas such as motor planning, motor control, gross motor coordination, fine motor coordination, hand/eye coordination, bilateral coordination, motor sequencing, and motor speed. Balance and equilibrium functions are assessed due to the requirement for balance during activities of daily living.

Testing of Cognitive Functions. Cognition involves mental processes of knowing, thinking, remembering, perceiving, awareness, learning, judging, and understanding of ideas. Skills specifically assessed in the CPM battery include levels of attention, short-term visual memory, short-term linguistic memory, encoding and decoding of information, incidental and intentional learning, logical and mathematical reasoning, problem solving, decision-making, organization, and planning. Clinical observation could also yield assessments of: orientation, problem solving, organization, planning, initiation/termination, judgment, sequencing, concrete/abstract reasoning, following directions, and procedural memory.

Interpretation and Recommendations. After an evaluation is complete, the person's performance is compared to normative data based upon his or her educational level, gender, age, and other demographics to help the therapist determine the severity of deficits; and then prognostic statements and recommendations are made. The formulation of a prognosis requires that the therapist make a clinical judgment by considering the following: premorbid and current levels of functioning, severity of the brain injury, neurological functions involved, length of time since the injury, previous rehabilitation services, the individual's deficit awareness, and psychosocial factors. During this process, the individual's goals and estimated potential are always kept in mind. Treatment recommendations should include the following when

Table 2
Components of Cognitive Perceptual Motor Retraining

CPM Dysfunctions	Selected Clinical Manifestations	Selected Therapeutic Approaches
Sensory Motor Dysfunction	Muscle Tone Postural Control Selectivity of Movement Coordination Range of Motion Sensory: Visual, Auditory, Tactile, Proprioceptive, and Vestibular	Therapeutic Exercise Positioning Strengthening Reflex Inhibition Sensory Stimulation Selective Orthotics Facilitation of Adaptive Response through Meaningful Activity: Graded, Progressive, Bilateral, and Reciprocal
Perceptual Motor Dysfunction	Visual Perceptual: Perception of Form & Space, Size, Shape & Depth Perception, Visual Scanning, Tracking & Sequencing, Figure Ground Perception, Perception of Verticality & Horizontality, Visual Motor Coordination Somato-sensory Perceptual: Body Scheme & Body Image, Motor Planning, Balance, Directionality, Manual Form Perception & Stereognosis Auditory-Verbal: Reading, Writing, Speaking & Number Concepts Memory: Visual, Auditory, Tactile Long Term, Short Term, and Working Memory Attention/Concentration	Self-Initiated Controlled Movement Balance Training Perceptual Motor Therapy Involving Therapeutic Activities Computer Based Visual Perceptual Training Self Regulated Home Activities & Leisure Memory Training: Memory Enhancement & Compensatory Memory Strategies
Cognitive Dysfunction	Problem Solving Decision Making Planning Organizing Divergent/Convergent/Abstract Reasoning Cognitive Behavioral: Self-Regulation, Self-Correction	Computer Based Cognitive Retraining: Problem Solving, Logical Thinking & Decision Making Exercises in Reading, Writing & Mathematical Concepts Job Related Cognitive Retraining Behavior Modification Individual & Group Counseling Education of Client and Significant Others

Adapted from: Kulkarni (1987)

applicable to the individual: frequency and duration of treatment, referrals to other professionals, level of supervision required, restriction from driving a motor vehicle if necessary, helpful adaptive equipment, and supplemental independent treatment programs. An approximate discharge date is also provided.

Cognitive Perceptual Motor Retraining

The CPM principle of hierarchical retraining leads to an initial focus on reacquisition of skills that were once automatic (habitual) but due to the effects of a brain injury now require controlled processing. "Controlled processing" means that the individual requires information be brought to their conscious control in order to better deal with that information, in contrast to previous automatic processing. An example of an automatic skill that sometimes becomes "controlled" after a brain injury is balance. Normally, individuals' ability to hold their body in an upright position is automatically managed by the brain. After an injury, they may have to consciously attend to their balance in order to maintain it. This conscious attention required for balance then uses up brain capacity that prior to the injury would have been used for higher level skills. Skills such as learning new information now require more effort. The functional signs that a person with a brain injury is not processing information automatically include: decreased information processing speed, increased effort to concentrate, and increased fatigue when performing everyday tasks; even those that were once very easy. The ultimate goal of CPM retraining is to assist the client in reacquiring the automatic skills they need in order to maximize their functional independence, or functional adaptation (Kulkarni, 1987). When automaticity is reacquired, it frees up the brain's capacity for higher level processing, thus maximizing brain functioning.

Three treatment approaches used during CPM retraining are remediation, compensation, and adaptation. These may be used concurrently and/or sequentially in treatment. The remedial approach is typically initiated based on the CPM premise that the brain can reacquire function through environmental stimulation. Because CPM postulates that reacquisition of skills must follow the original path of acquisition (refer to Figures 1 and 2), a hierarchical approach to the remediation of perceptual deficits is used in treatment. In Piaget's model of cognitive development, the lower level performance components (i.e. sensory, perceptual, and motor) are acquired prior to more advanced cognitive skills (Kephart, 1968 and Wadsworth, 1978). Lower level cognitive skills can be compared to individual bricks in the foundation of a structure. If one of these skills (bricks) is weakened, the entire individual's functioning (structure) is at risk of dysfunction (collapsing). Treatment activities place initial emphasis on foundational skills, regardless of the individual's level of functioning, in order to ensure that the "foundation" is solid prior to advancing to higher cognitive levels. Functional adaptation results occur through the gradual presentation of environmental demands / challenges. The therapist embraces a variety of graduated remedial modalities within individual and group therapy sessions. These can include such modalities as computer-based exercises, paper and pencil tasks, and clinical/ community-based functional activities.

With remediation of skills typically being a lengthy process, the beginning stages of treatment include the introduction of compensatory techniques that help minimize the effects of the client's deficits on his or her everyday life. Such techniques may include repetition, decreasing speed to ensure attention to detail, verifying information, note keeping, chunking information, and pacing. Effort and time are painstakingly spent to ensure that compensatory memory techniques are consistently utilized to promote new learning, which is essential to the individual's rehabilitation. Generalization of these techniques from task to task is continually reinforced so that they become more automatic.

The adaptive approach places emphasis on changing the environment or activity to meet the needs of the individual. In CPM retraining, this approach is typically introduced once remedial and compensatory approaches are thought to have reached maximum potential. Such adaptations can include built-up handles for decreased grasp and finger coordination, elastic shoelaces, spinner knobs for steering wheels, and widening of doorways for wheelchairs. Table 2 lists select therapeutic approaches used for addressing identified deficits in sensory-motor, perceptual-motor, and cognitive functioning.

Ongoing assessment, in the form of activity analysis and re-administration of initial tests, is a continual process throughout CPM retraining. This guides treatment and improves the client's awareness. Within this paradigm, the client receives feedback and education as to current progress and persistent deficits. The building of awareness is emphasized with the therapeutic use of self, which decreases frustration levels and increases self-esteem. The CPM retraining method consists of concrete instruction in skill development, while also providing neurobehavioral counseling that promotes awareness through metacognitive processing. Coping and relaxation skills are taught to the client to counter the typical struggles that occur during rehabilitation.

A Team Approach

The client and their significant other(s) are core members of the rehabilitation team. They are provided with education and resources through every step of the rehabilitation process, and help guide the team's direction with their goals and individual needs. Regular meetings are held with the client and their significant other(s) to provide a forum for discussing any issues or concerns with the entire rehabilitation team at one time. The client's significant other(s) are invited and encouraged to attend the individual and group treatment sessions as is feasible, in order to assist with carry-over of learned strategies within the home environment.

The interdisciplinary team approach enhances the effectiveness of CPM retraining. It is essential for all team members to understand the principles that guide CPM and support the therapeutic interventions applied in treatment. All team members are well-versed in using the same concepts and terminology, in order to maximize the client's awareness and understanding of their needs. Co-treatments between disciplines are common, so that the other disciplines can witness the client using his or her compensations as they work on rebuilding their foundational skills. This allows each discipline to incorporate the goals and strategies of the other disciplines into their treatment sessions for repetition and reinforcement. As outlined in Figure 3, the rehabilitation process is systematic, and requires intervention from various disciplines in order to achieve its desired outcomes.

Discharge

Using a holistic, interdisciplinary approach, the team discusses discharge plans at the initial team conference; however, the discharge plans may change as treatment progresses and more information is gathered about the client's potential to reach his or her intended goals. A client's discharge goals using the CPM model are likely to be no different than a client who receives traditional occupational therapy services; however, because this approach is very systematic and comprehensive, it is unlikely that any deficit area will remain unaddressed. In order to assist in formulating the ideal discharge plan for the client, a balance between self-maintenance, work, and play/leisure, promotion of community integration, productivity, purposeful activity, and enhancement of quality of life are considered both independently and collectively. Necessary supports and resources are identified throughout the treatment process in order to ensure their consistent and appropriate use before the time of discharge. A well-planned discharge minimizes the individual's weaknesses and maximizes successful independent functioning.

Summary

The CPM model encompasses several guiding principles that help to shape treatment: primarily that the brain can recover function through the guided and sequential reacquisition of skills. Standardized and non-standardized assessments help the therapist gather information about the client's current level of functioning in perceptual, motor, and cognitive domains. Treatment is systematic and comprehensive, initially focusing

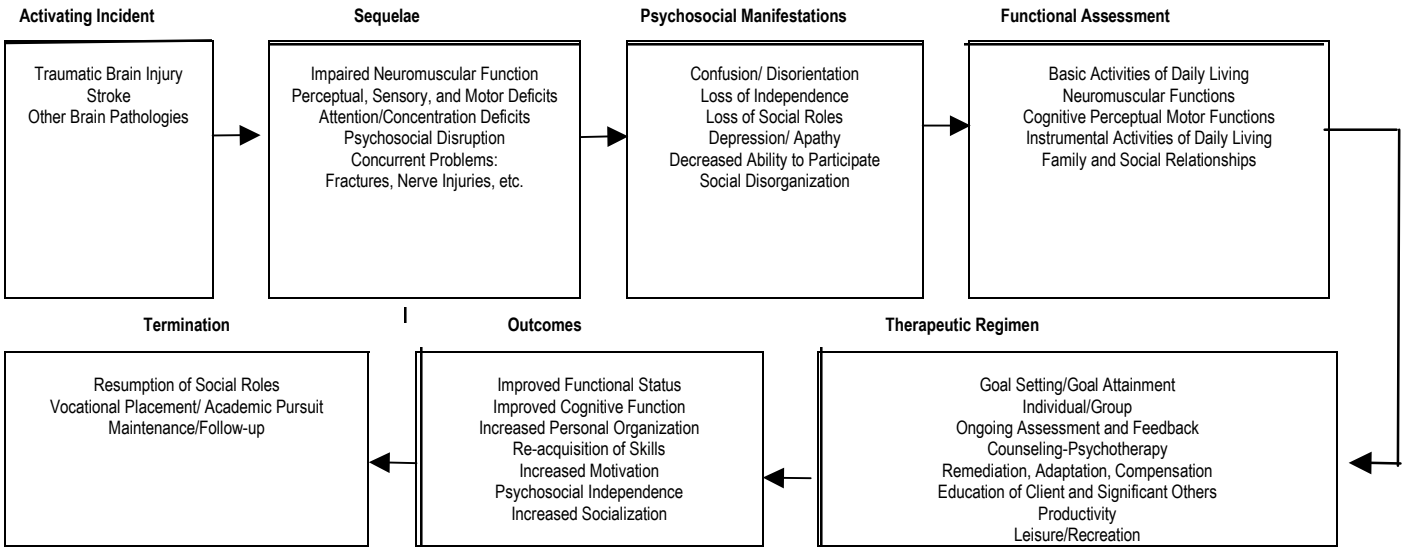

Figure 3: Rehabilitation Process for Persons with Cognitive Perceptual Dysfucntion. Adapted from: Kulkarni (1987)

on the remediation of foundational skills before advancing to higher cognitive levels. Compensatory techniques are used to minimize effects of the persisting deficits. Adapting the environment to meet current needs supplements the CPM approach. The effectiveness of CPM is enhanced with the addition of an interdisciplinary team approach, allowing for repetition and reinforcement of the remediated skills, ensuring that at discharge the client has reached his or her maximum potential to accomplish identified goals.

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