Review article

Evidence-based instructional techniques for training procedures and knowledge in persons with severe memory impairment

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SUMMARY

The instructional literature clearly demonstrates that *structuring the manner in which target information or behavior is introduced and reviewed can facilitate learning*. By implication, careful planning of how to train and instruct people with damaged learning systems allows clinicians to optimize experience-dependent learning.

Key words: Evidence neurobiological, severe memory impairment.

RESUMEN

La literatura educacional demuestra claramente que, *estructurar la manera en la cual se proporciona y revisa la información o comportamiento puede facilitar el aprendizaje*. Implícitamente, la planeación cuidadosa de cómo entrenar e instruir a personas con daño en los sistemas de aprendizaje, permite a los clínicos optimizar la experiencia-aprendizaje dependiente.

Palabras clave: Evidencia neurobiológica, debilitación severa de la memoria.

Evidence of neurobiological changes that support recovery following brain damage is accumulating. However, the recovery landscape is complex. The range of mechanisms believed to underlie neuroplasticity including unmasking of existing circuits, modification of synaptic connectivity and inter-hemispheric competition do not account for the whole recovery story. Task requirements and context greatly influence neurological activity. For example, Stuss[1] reviews lesion studies suggesting that when task demands are manipulated, there is fluid recruitment of different processes throughout the brain as required by the current task. Similarly, plasticity appears to operate differently depending upon the specific neural network; human research has shown that experience induced functional changes occur the most rapidly in motor, language and visual systems after stroke.[2,3] The differential responsiveness of various brain networks to targeted input is only beginning to be systematically studied.

The goal of this talk is to examine the impact of a specific domain of structured experience on learning and recovery post injury: the domain of instructional and training practices. Although the neurobiological mechanisms activated by particular methods of input have not been studied, I would argue that increasing our understanding and implementation of effective methods for structuring input via instruction and training practices will facilitate experience-dependent learning in cognitive-linguistic rehabilitation.

The field of cognitive-linguistic rehabilitation has traditionally used a binary classification to group treatment approaches into interventions that target change at the level of restitution (i.e., “restorative approaches”) and those that target change at the level of behavior (i.e., “behavioral approaches”).[4] The separation of interventions targeting restitution versus behavior is encouraged by the health and disease classification system promoted by the World Health Organization. This influential body conceptualizes the effects of disease or trauma based on *level of impairment* –a change in body function or process (e.g., a memory impairment) versus *reduced activity or participation* –a diminished ability to perform life’s activities or a roles.[5] An example of cognitive interventions that target impairment (i.e., restitution) would be direct attention training,[6] while training the use of external memory aids[7] would be an example of an intervention that targets activity (i.e, behavior).

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The basic distinction between behavior- or activity-oriented versus impairment-based therapies has theoretical and practical merits. For example, measurement of treatment outcomes for impairment-based therapies would include changes in corresponding neuropsychological or standardized tests as well as functional gains in the activities that are dependent upon the impaired cognitive-linguistic processes. An indicator of improvement resulting from activity-based training would be changes in the behaviors or activities trained. Impairment-based interventions are generally believed to be associated with restitutive reconnection, while behavioral-based therapies are thought to be associated with reorganization/redistribution and use of adjacent and remote neuronal circuits.[8] There is, however, an important bridge between these approaches. Both require some type of structured environmental experience. Whether repetitively stimulating an impaired cognitive process or training the steps to a functional activity, neuronal plasticity occurs in response to structured input.

The common clinical challenge is how best to structure the input to restore the impaired process and/or achieve the desired behavioral change. That is the task required of rehabilitation professionals and the focus of this talk. Much of our literature is devoted to reviewing current evidence that might explain the *underlying mechanisms* (e.g., neuronal plasticity) responsible for positive outcomes following rehabilitation. Today I want to examine evidence supporting the role of *external input,* specifically instruction and training techniques, in cognitive-linguistic rehabilitation.

Before I move on to discuss instructional strategies, a caveat is in order. In recent years there has been an increased recognition of the need to take into account the complexity of factors that influence recovery. For example, the importance of contextual variables and collaborating with natural supports in order to achieve generalization of rehabilitation goals is becoming increasingly accepted.[9] Certain deficits are best addressed by altering the environment- rather than conducting person-oriented interventions. Similarly, the primacy of emotion and personality variables in recovering from cognitive impairments is acknowledged and factored into the development of many current treatment regimens.[10] Although I won't be discussing some of the critical contextual and collaborative intervention practices, I want to underscore their importance.

OPTIMIZING EXPERIENCE-DEPENDENT LEARNING FOR BEHAVIORAL-BASED INTERVENTIONS: A REVIEW OF INSTRUCTIONAL PRACTICES

Lessons from Special Education

The instructional model that has been subjected to the most experimental scrutiny is Direct Instruction (DI) pioneered by Engelmann and Carnine.[11] Direct Instruction is a comprehensive, 'explicit' instructional method shown to be effective in teaching a wide range of material (e.g., academic and social skills) across different populations with learning challenges, particularly individuals with learning disabilities.[11,12] DI requires systematic design and delivery of instruction in order to facilitate efficient skill acquisition and generalization. The key techniques associated with the DI design-delivery process include: 1) analyzing and sequencing instructional content (i.e., task analysis); 2) training a broad range of examples; 3) using simple, consistent instructional wording; 4) establishing a high mastery criteria; 5) providing models and carefully faded prompts; 6) providing high amounts of correct massed practice following by distributed practice; and 7) sufficient, cumulative review.[11-13] DI has been increasingly applied to the brain injury population given its success in facilitating learning in people who are amnesic.

Strategy-based instruction refers to another instructional model that has been experimentally evaluated within special education.[14-16] This model emphasizes teaching learners to monitor their own thinking, and it may be integrated with the previously described DI approach. Different terms are sometimes used to describe strategy-based instruction, including: "procedural facilitators", "scaffolded" instruction, or "cognitive" strategies.[12,14,17,18] Core instructional techniques may include the use of advanced organizers, instructor questions and/or prompts to encourage student self-assessment, summarizing and elaborating content, and simple outlines of important themes/structures.[17,19] Again, these notions have been incorporated into instructional and training practices within neuropsychology mostly under the domain of metacognitive training.

Several meta-analyses have attempted to parse out the most effective instructional practices and components within the special education literature.[19,20] The results indicated that a *Combined Model* using both Direct Instruction and Strategy Instruction techniques in concert produced the largest effect size compared to either method alone or nonstructured instruction.

Lessons from Neuropsychology

A number of instructional practices from the special education literature have been adapted and evaluated within the field of neuropsychology. For example, teacher modeling, an effective instructional technique intended to reduce the risk of errors during the acquisition phase of learning[13] has been extensively studied under the label "errorless" learning in the neuropsychology field.[21,22] Similarly, a form of distributed practice, called "spaced retrieval" has been shown to be effective with individuals with memory impairment due to dementia, stroke and TBI.[23-27]

I participated in the Evidence-Based Practice subcommittee of the Academy of Neurologic Communication Disorders and Sciences charged with reviewing the literature to develop evidence-based clinical practice guidelines for a range of neurogenic communication disorders, including instructional techniques.[28] Part of this work included an extensive search and review of the instructional literature from 1986-2006 resulting in over 40 relevant studies, ranging from single-case to randomized-control group research designs. Studies of errorless learning and related techniques comprised the majority of the instructional research studies found in the neuropsychological rehabilitation literature.

Errorless learning is a theoretically and empirically grounded training technique proposing that learning occurring in the absence of errors is stronger and more durable than learning that involves the correction of self-generated errors (e.g., 21). Elimination of errors is achieved by: 1) providing sufficient models before the client is asked to perform the target task or retrieve the target information; 2) encouraging the client to avoid guessing and immediately correcting errors, 3) carefully fading prompts, 4) breaking down the targeted task into small, component parts when training multi-step procedures/skills; and 5) providing practice such that treatment targets are over-learned through repetitive, successful practice and a rich schedule of positive reinforcement. [13,21,29,30] Errorless learning is contrasted with errorful learning (i.e., trial-and-error learning; discovery learning; standard anticipation) in which the client is encouraged to guess the targeted response before being provided with the information.[21,22,29] The benefits of errorless learning are typically reported in individuals with relatively spared procedural memory (memory without recalling the experience of learning) and severe, declarative memory loss (memory involving conscious recollection)

Results from numerous studies qualify that the benefits of errorless learning may depend on a number of variables. For example, the degree of memory impairment has been shown to be a factor; individuals with more severe memory impairments may show more robust improvements in learning with errorfree methods than those with lesser impairments. [22,31] The type of training task and recall conditions may also affect outcomes. [22,31,32] For example, Thoene & Glisky[32] showed that explicit, mnemonic techniques were more effective than implicit (i.e., procedural memory) techniques when instructing arbitrary face-name associations, whereas implicit techniques may prove more beneficial with perceptual-orthographic information (e.g., stem-completion tasks).

Consistent with the special education direct instruction literature, there are a number of techniques that have been shown to increase the effects of errorless learning and improve instructional outcomes in the adult neurogenic population. These include:

1. **High amounts of correct practice:** Frequent, correct practice has been shown to facilitate learning and retention, particularly when combined with distributed practice.[33,34]
2. **Distributed practice-spaced retrieval:** The benefits of distributed practice, specifically spaced retrieval (i.e., expanded rehearsal) have been well documented. Spaced retrieval provides individuals with severe memory loss practice at successfully recalling information over expanded time intervals, which is thought to enhance the "durability of learning".[23-26,35]
3. **Forward-backward chaining:** Chaining techniques are frequently used to teach multi-step tasks to individuals with severe learning disabilities.[36] Each new step is individually taught and mastered, then sequentially linked to the previous step The method of vanishing cues is a well-researched form of backward chaining developed for people with memory impairments that provides the client with progressively weaker prompts following successful recall of targeted information.[31,37-40]
4. **Varied training examples:** Carefully planned, multiple training examples are critical to preventing "stimulus-bound" learning and to facilitating generalization.[33,41]
5. **Effortful-processing and self-generation:** Increasing the amount of effort expended by the learner has been shown to enhance the effects of errorless learning techniques. Techniques for increasing effort while minimizing errors include carefully planned descriptions of the target item prior to a participant-generated answer,[42] or asking evaluative questions prior to providing the correct answer to the participant.[43]

The literature clearly supports the benefits of errorless over errorful (i.e., trial-and-error; anticipation) learning as well as the other instructional techniques summarized above for teaching wide range of activities (information and behavior) to individuals with memory impairment due to a variety of etiologies (e.g., traumatic brain injury, dementia, schizophrenia). These instructional techniques have been applied to a number of different learning domains which I will now review.

Instructional Practices Applied to Teaching Information

Face/Name Recall: Has been taught using errorless learning techniques. Treatment components in Clare et al. [26] study included verbal elaboration, method of vanishing cues and expanded rehearsal. Most of this work has focused on the Alzheimer's population.

Vocabulary: Is another target shown to be amenable to teaching using structured instructional techniques. Glisky, Schacter & Tulving[44] pioneered the use of the method of vanishing cues to teach computer-related vocabulary to individuals with severe memory impairments due to acquired brain injury. They demonstrated that MVC was superior to standard anticipation (i.e., trial-and-error) in training the recall of computer terms matched to definitions, using computers to deliver the training stimuli and prompts. Under the MVC conditions, the definition for a term would appear on the computer screen (e.g., "programs the computer carries out" followed by the first letter of the matching term ("S" for "software"). If the participant was unable to guess the term given the initial letter cue, then subsequent letters were provided until the term was correctly recalled. On subsequent trials, the word fragment appeared smaller by one letter than what the participant had required in the previous trial. The authors reported that although learning was slow and strongly cue-dependent on the initial letter, all participants learned a substantial amount of vocabulary, much of which was retained after 6 weeks with some transfer of knowledge observed.

Instructional Practices Applied to Teaching Procedures and Skills

Use of Compensatory Aids: Training patients to use compensation strategies (e.g., notetaking) or external aids (e..g, memory books, personal digit assistants) is the most common rehabilitation technique for managing memory impairments.[7] Instructional techniques shown to be effective in teaching the procedural steps for strategies and devices include the following: 1) use of task analyses sequentially delineating the steps; 2) sufficient drill and practice with steps; 3) use of varied training examples and 4) cumulative review.[7]

Computer-related tasks: There are several studies that have shown the effectiveness of errorless learning coupled with frequent practice in training people with severe cognitive impairments to use computers. I want to detail one of our studies that I believe integrates much of the evidence in the instructional literature. We[33] developed an instructional package (TEACH-M) based on the experimental instructional literature and evaluated its effectiveness for teaching four individuals with severe memory and executive functions to use a multi-step email procedure. The TEACH-M procedures are summarized in the table below. Results of a multiple-baseline across participants study revealed that all four participants learned the 7-step email procedure, reaching the criterion for mastery (100% accuracy for three consecutive sessions) within 7-15 training sessions. Three participants retained the email procedure after a 30-day break and all participants generalized their skills to an altered (i.e., untrained) interface (Table 1).

Social-problem solving skills: Research on errorless learning techniques has predominantly focused on training relatively simple information (e.g., face-name recall) or tasks reliant on motor-procedures (e.g., mouse movement to perform computer tasks). Less understood is the application of these techniques to more complex cognitive strategies. Kern, Green, Mitchell, Kopelowicz, Mitz, & Liberman[30] evaluated the application of errorless learning principles to training social problem solving skills among individuals diagnosed with schizophrenia or schizoaffective disorders, conditions frequently associated with impairments in new learning/memory and executive functions. Sixty participants were randomly assigned to the experimental treatment or control (i.e, “symptom management”) groups. The experimental group participated in a social-problem solving training. The control group participants used similar content but with a strong problem solving component targeting identification of problems associated with their own illness and formulation of interpersonal solutions to their problems. Results showed a significant experimental training group effect favoring errorless learning with retention of some skills at three months follow up.

TAKE HOME MESSAGE

Unfortunately, careful adherence to task analyses, practice regimens, and delineation of relevant strategy instruction is

Table 1. TEACH-M components (33).

Component	Description
Task analysis	Know the instructional content. Break it up into small steps. Chain steps together.
Errorless learning	Keep errors to a minimum during the acquisition phase. Model target step(s) before the client attempts a new skill or step. Carefully fade support. If an error occurs, demonstrate the correct skill or step im mediately and ask the client to do it again. Use simple, consistent instructional wording.
Assessment	Initially: assess skills before initiating treatment for the first time. Ongoing: probe performance at the beginning of each teaching session or before introducing a new step.
Cumulative review	Regularly integrate and review new skills with previously learned skills.
High rates of correct practice	Practice the skill several times. Distributed practice encourages this.
Meta-cognitive strategy	The prediction-reflection technique can be used to encourage active processing of the material, or another appropriate trategy that encourages self-reflection and problem-solving.

not a mainstream practice. Clinicians typically do not view themselves as the designers and conveyors of curriculum, which is ultimately what must occur in order to implement the treatment principles discussed in this chapter. I conclude this talk with a call to practitioners working with people who have severe memory impairments to review the instructional design and delivery principles that have been experimentally validated and to identify how these practices can be followed when teaching or reteaching procedures and/or knowledge to clients. To those of you who are researchers and study brain changes in response to recovery or treatment, I hope I have made a case to prioritize studying the effects of structured experience or systematic training on brain systems.

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