REVIEW ARTICLE

Evidence-Based Cognitive Rehabilitation: Recommendations for Clinical Practice

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ABSTRACT. Cicerone KD, Dahlberg C, Kalmar K, Langenbahn DM, Malec JF, Bergquist TF, Felicetti T, Giacino JT, Harley JP, Harrington DE, Herzog J, Kneipp S, Laatsch L, Morse PA. Evidence-based cognitive rehabilitation: recommendations for clinical practice. Arch Phys Med Rehabil 2000; 81:1596-615.

Objective: To establish evidence-based recommendations for the clinical practice of cognitive rehabilitation, derived from a methodical review of the scientific literature concerning the effectiveness of cognitive rehabilitation for persons with traumatic brain injury (TBI) or stroke.

Data Sources: A MEDLINE literature search using combinations of these key words as search terms: *attention*, *awareness*, *cognition*, *communication*, *executive*, *language*, *memory*, *perception*, *problem solving*, *reasoning*, *rehabilitation*, *remediation*, and *training*. Reference lists from identified articles also were reviewed; a total bibliography of 655 published articles was compiled.

Study Selection: Studies were initially reviewed according to the following exclusion criteria: nonintervention studies; theoretical, descriptive, or review papers; papers without adequate specification of interventions; subjects other than persons with TBI or stroke; pediatric subjects; pharmacologic interventions; and non-English language papers. After screening, 232 articles were eligible for inclusion. After detailed review, 61 of these were excluded as single case reports without data, subjects other than TBI and stroke, and nontreatment studies. This screening yielded 171 articles to be evaluated.

Data Extraction: Articles were assigned to 1 of 7 categories according to their primary area of intervention: attention, visual perception and constructional abilities, language and communication, memory, problem solving and executive functioning, multi-modal interventions, and comprehensive-holistic cognitive rehabilitation. All articles were independently reviewed by at least 2 committee members and abstracted according to specified criteria. The 171 studies that passed initial review were classified according to the strength of their methods. Class I studies were defined as prospective, randomized controlled trials. Class II studies were defined as prospective cohort studies, retrospective case-control studies, or clinical series with well-designed controls. Class III studies were defined as clinical series without concurrent controls, or studies with appropriate single-subject methodology.

Data Synthesis: Of the 171 studies evaluated, 29 were rated as Class I, 35 as Class II, and 107 as Class III. The overall evidence within each predefined area of intervention was then synthesized and recommendations were derived based on consideration of the relative strengths of the evidence. The resulting practice parameters were organized into 3 types of recommendations: *Practice Standards*, *Practice Guidelines*, and *Practice Options*.

Conclusions: Overall, support exists for the effectiveness of several forms of cognitive rehabilitation for persons with stroke and TBI. Specific recommendations can be made for remediation of language and perception after left and right hemisphere stroke, respectively, and for the remediation of attention, memory, functional communication, and executive functioning after TBI. These recommendations may help to establish parameters of effective treatment, which should be of assistance to practicing clinicians.

Key Words: Practice guidelines; Cognitive disorders; cerebrovascular accident; Brain injuries; Rehabilitation.

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IMPAIRMENTS OF COGNITIVE FUNCTION are a significant cause of disability after traumatic brain injury (TBI) and stroke. These cognitive impairments are often the most persistent and prominent sequelae of brain injury in patients with moderate or good neurologic recovery. Interventions designed to promote the recovery of cognitive function and to reduce cognitive disability are a standard component of brain injury rehabilitation: 95% of rehabilitation facilities serving the needs of persons with brain injury provide some form of cognitive rehabilitation, including combinations of individual, group, and community-based therapies.[1]

Cognition is defined as the process of knowing. It includes the discrimination between and selection of relevant information, acquisition of information, understanding and retention, and the expression and application of knowledge in the appropriate situation. Cognitive disability may be seen in reduced efficiency, pace and persistence of functioning, decreased effectiveness in the performance of routine activities of daily living (ADLs); or failure to adapt to novel or problematic situations.

Cognitive rehabilitation is defined as a systematic, functionally oriented service of therapeutic activities that is based on assessment and understanding of the patient's brain-behavioral

deficits. Specific interventions may have various approaches, including (1) reinforcing, strengthening, or reestablishing previously learned patterns of behavior; (2) establishing new patterns of cognitive activity through compensatory cognitive mechanisms for impaired neurologic systems; (3) establishing new patterns of activity through external compensatory mechanisms such as personal orthoses or environmental structuring and support; and (4) enabling persons to adapt to their cognitive disability, even though it may not be possible to directly modify or compensate for cognitive impairments, in order to improve their overall level of functioning and quality of life. Cognitive rehabilitation may be directed toward many areas of cognition, including (but not necessarily limited to) attention, concentration, perception, memory, comprehension, communication, reasoning, problem solving, judgment, initiation, planning, self-monitoring, and awareness. It can be distinguished from traditional rehabilitation and psychotherapy by its primary focus: alleviation of acquired neurocognitive impairment and disability. Although cognitive rehabilitation may incorporate interventions directed at the person's emotional and psychosocial functioning when these issues relate directly to the acquired neurocognitive dysfunction, they are not the service's sole focus. Regardless of the specific approach or area of intervention, cognitive rehabilitation services should be directed at achieving changes that improve each person's function in areas that are relevant to their everyday lives.

Given the prevalence, and relevance, of cognitive rehabilitation services for persons with acquired brain injury, a need exists to establish empirically based recommendations for the practice of cognitive rehabilitation. Since 1982, this concern has been formally recognized by a subcommittee of the Brain Injury–Interdisciplinary Special Interest Group (BI-ISIG) of the American Congress of Rehabilitation Medicine. The initial recommendations of the committee were published in 1992 as the Guidelines for Cognitive Rehabilitation,[2] a document that defined cognitive rehabilitation, set forth the qualifications of independent practitioners, and established minimal practice requirements. The recommendations made at that time were based on "expert opinion" and did not take into account empirical evidence on the effectiveness of cognitive rehabilitation.

Recently, an independent, nonfederal panel presented their findings before a US National Institutes of Health (NIH) consensus panel regarding the scientific basis of common therapeutic interventions for the cognitive and behavioral sequelae of TBI.[3] This panel reviewed the literature for cognitive rehabilitation published from January 1988 through August 1998, including 11 randomized, controlled studies.[4] Their review noted that data on the effectiveness of cognitive rehabilitation programs were limited by the heterogeneity of subjects, interventions, and outcomes studied. Nevertheless, the panel identified several studies, including randomized controlled studies and case reports, that documented the ability of interventions to improve specific neuropsychologic processes—predominantly attention, memory, and executive skills. The panel noted specifically that compensatory devices, such as memory books, improved particular cognitive functions and compensated for specific deficits. It was also noted that comprehensive, interdisciplinary programs that included individually tailored interventions for cognitive deficits were commonly used for persons with TBI. Although this personalized approach made it difficult to evaluate program effectiveness because of the heterogeneity of programs and persons served, several uncontrolled studies and a nonrandomized clinical trial supported the effectiveness of these approaches.

Since 1996, the BI-ISIG has been in the process of developing clinical recommendations for the practice of cognitive rehabilitation, based on an evidence-based review of the existing literature. The recommendations of the Cognitive Rehabilitation Committee, contained in the present report, were based on an exhaustive review and analysis of existing research. We reviewed papers addressing interventions for persons with both TBI and stroke, because they represent the most prevalent forms of acquired brain injury requiring intervention for cognitive impairments. The selected reports consisted of both treatment efficacy studies and studies of clinical effectiveness. *Treatment efficacy studies* were defined as highly constrained studies that typically evaluated time-limited interventions of selected, homogenous samples, primarily for research purposes. Studies of *clinical effectiveness* were defined as empirical evaluations of treatments within clinical settings, which may incorporate clinical judgment and strategic modification of interventions, thus reflecting the actual use of an intervention. The most widely accepted means of evaluating treatment efficacy are randomized controlled trials that compare the intervention in question with a no-treatment control condition. In clinical practice, these conditions may be difficult or impossible to establish. Controlled studies of treatment effectiveness may therefore attempt to determine whether the intervention offers specific benefits, compared with an alternative treatment, although this approach may be less useful for initially establishing the effectiveness of an intervention. Ultimately, the effectiveness of any given treatment should be established by comparing its benefits with the "best available" treatment with known effectiveness. Within a typical clinical setting, the best available treatment may be the combined application of standardized treatment protocols and individualized treatments dictated by clinical experience.[4] At present, the closest approximation to such a model is sound, single-subject research designs or controlled multiple-baseline designs across subjects or interventions. For this reason, these types of studies were considered in making the current recommendations.

METHOD

To develop its evidence-based recommendations, the committee identified and refined the questions to be addressed, identified the relevant literature, reviewed, analyzed, and classified the existing research, and wrote recommendations based on the strength of available evidence. A MEDLINE literature search was conducted using the following combinations of search words: *attention*, *awareness*, *cognition*, *communication*, *executive*, *language*, *memory*, *perception*, *problem solving*, *reasoning*, *rehabilitation*, *remediation*, and *training*. In addition, relevant articles were identified by members of the committee, all of whom are experienced in brain injury rehabilitation and have contributed to the published literature. Reference lists from identified articles were searched to complete the initial list of references. This process yielded 655 published articles. The abstracts or complete reports were reviewed to eliminate reports according to these exclusion criteria: (1) reports not addressing intervention; (2) theoretical articles or descriptions of treatment approaches; (3) review papers; (4) reports without adequate specification of interventions; (5) subjects other than persons with TBI or stroke (8 reports were retained that included diagnoses of "other brain injury" when these clearly represented a minority of subjects or when it was possible to distinguish the results for the subjects with TBI and stroke); (6) pediatric subjects; (7) single case reports without empirical data; (8) non–peer-reviewed articles and book chapters; (9) pharmacologic interventions; and (10) non-English language papers. Through this screening process the committee selected 232 articles for inclusion in the study. Basing their assignment on the initial review, the committee placed each

Table 1: Definitions of the 3 Levels of Recommendations

Practice Standards	Practice Guidelines	Practice Options
Based on at least 1, well-designed Class I study with an adequate sample, or overwhelming Class II evidence, that directly addresses the effectiveness of the treatment in question, providing good evidence to support a recommendation as to whether the treatment be specifically considered for persons with acquired neurocognitive impairments and disability.	Based on well-designed Class II studies with adequate samples, that directly address the effectiveness of the treatment in question, providing fair evidence to support a recommendation as to whether the treatment be specifically considered for persons with acquired neurocognitive impairments and disability.	Based on Class II or Class III studies, with additional grounds to support a recommendation as to whether the treatment be specifically considered for persons with acquired neurocognitive impairments and disability, but with unclear clinical certainty.

article into 1 of 7 categories, reflecting its primary area of intervention: attention, visual perception and constructional abilities, language and communication, memory, problem solving and executive functioning, multi-modal interventions, and comprehensive-holistic cognitive rehabilitation. All articles were reviewed by at least 2 committee members and abstracted according to specific criteria: subject characteristics (age, education, gender, nature and injury of severity, time postinjury, inclusion/exclusion criteria); treatment characteristics (treatment setting, target behavior or function, nature of treatment, sole treatment or concomitant treatments); methods of monitoring and analyzing change (eg, change on dependent variable over course of treatment; pretreatment and posttreatment tests on measures related to target behavior; patient, other, or clinician ratings related to target behaviors; change on functional measures; global outcome status); maintenance of treatment effects; statistical analyses performed; and evidence of treatment effectiveness (eg, improvement on cognitive function being assessed, evidence for generalized improvement on functional outcomes).

Sixty-one additional studies were excluded after detailed review. They included single case reports without data, subjects with diagnoses primarily other than TBI and stroke, and nontreatment studies consisting of brief, usually single trial, experimental manipulations.

For each of the remaining 171 studies, the committee determined the level of evidence, basing their decisions on an adaptation of previously established criteria[5,6] for the development of evidence-based clinical practice parameters. Three levels of evidence were established. Studies that had well designed, prospective, randomized controlled trials were considered Class I evidence. Within this category, several studies featured a prospective design with "quasi-randomized" assignment to treatment conditions, such as prospective assignment of subjects to alternating conditions. These were designated as Class Ia studies. Studies were considered Class II evidence if they consisted of prospective, nonrandomized cohort studies; retrospective, nonrandomized case-control studies; or clinical series with well-designed controls that permitted between-subject comparisons of treatment conditions, such as multiple baseline across subjects. Clinical series without concurrent controls, or studies with results from 1 or more single cases that used appropriate single-subject methods, such as multiple baseline across interventions with adequate quantification and analysis of results, were considered Class III evidence. All classifications were based on the agreement of at least 2 reviewers. Disagreement between reviewers was resolved through joint discussion or by obtaining third review. The initial classification of all studies was reviewed by the committee to ensure consistent application of the criteria and to establish consensus

before the final classification. Of the 171 studies evaluated, 29 were rated as Class I, 35 as Class II, and 107 as Class III.

After the studies were classified, the overall evidence within each predefined area of intervention was synthesized and recommendations were derived from consideration of the relative strengths of the evidence. The resulting practice parameters reflect 3 potential types of recommendations (table 1) from the best supported, *Practice Standards* and *Practice Guidelines*, to the less evidenced *Practice Options*.

RESULTS AND DISCUSSION

Remediation of Attention Deficits

Attempts to remediate impairments of attention have generally relied on drill and practice, with exercises designed to address specific aspects of attention (eg, processing speed, focused attention, divided attention). Most of the reported interventions in this area have used stimulus-response paradigms, which required subjects to identify and select among relevant auditory or visual stimuli, and often used speeded stimulus presentations. The implicit, if not explicit, rationale for most of these interventions is to restore basic attentional abilities through repeated practice. Several studies[7-9] have explicitly incorporated and/or evaluated therapeutic interventions such as feedback, reinforcement, and strategy teaching into the attention remediation programs. Most studies have relied on psychometric measures to assess improvements in attention attributable to treatment, although a few studies have included behavioral ratings or naturalistic observations.

Thirteen studies were reviewed in this area, including 3 Class I prospective randomized studies,[7,8,10] 4 Class II controlled studies[9,11-13] (of which 2 used a multiple-baseline method), and 6 Class III studies.[14-19] Most controlled studies compared attention training with an alternative treatment, but did not include a no-treatment condition.

One Class I and 2 Class II studies evaluated the effectiveness of attention treatment during the acute period of rehabilitation. The Class I study[7] compared the effectiveness of "focused" treatment consisting of sequential, hierarchical interventions directed at specific attention mechanisms versus "unstructured" intervention consisting of nonsequential, nonhierarchical activities requiring memory or reasoning skills. Forty-four subjects matched for age, education, and time since injury were randomly assigned to treatment conditions during the acute period of rehabilitation (average, 6wk postinjury). Subjects received 30-minute treatment sessions 5 times per week throughout their inpatient rehabilitation, which varied from 1 to 15 weeks. Both groups received an average of 10 hours of total treatment for attention. Both groups improved, but no differences existed between groups on initial or posttreatment neuropsychologic

functioning, ADL status, or staff ratings of cognitive functioning. Because the subjects were in the acute period of rehabilitation, the observed improvements are likely to reflect spontaneous recovery.

One Class II study[9] employed a multiple-baseline-across-subjects design and evaluated a program for the remediation of speed of processing deficits in 10 subjects with severe TBI who were between 6 and 34 weeks postinjury. Treatment was conducted over 6 weeks for a total of 15 hours. The initial 3-week treatment consisted of the training process alone, whereas in the second 3 weeks, the training process was combined with therapist feedback and encouragement. Subjects were also divided into 2 groups according to length of baseline. All subjects showed a gradual improvement across phases, with no differences in the rate of improvement between groups; thus a treatment effect was not shown when the effects of spontaneous recovery were controlled. In the second Class II study,[11] 35 subjects with lateralized stroke (27 left, 8 right) received 7 hours of computer-assisted reaction training over a period of 3 weeks during the acute phase of recovery (4–36wk postonset). Beneficial effects of attention training beyond the effects of practice and spontaneous recovery were reported on 5 of 14 outcome measures. These benefits were apparent on measures of perceptual speed and selective attention, 4 of which resembled the training tasks, with no effect shown on measures of vigilance or general cognitive functioning. The treatment effect was primarily apparent for subjects with left hemisphere lesions (most of whom were also aphasic) rather than for subjects with right hemisphere lesions.

Two Class I and 2 Class II studies evaluated the effectiveness of attention treatment during the postacute period of rehabilitation. Gray et al[10] treated 31 subjects with attention dysfunction as identified by subjective report and impaired performance on a screening measure of attention. Subjects were randomly assigned to receive either computerized attention retraining or an equivalent amount of recreational computer use to control for any nonspecific effects of using microcomputers. The subjects were stratified into TBI versus other diagnoses (including stroke) and mild/moderate versus severe attentional dysfunction. Neither variable influenced treatment results. Time postinjury varied widely from 7 weeks for 1 mild stroke subject to 10 years. Subjects received approximately 16 hours of treatment over 3 to 9 weeks. The selection of microcomputer-based attention training tasks was based on the demands placed on control processes in the brain involved in alerting (defined as increasing reaction times), manipulating information in working memory, or dividing attention. Specific training included practice on simple and discrimination reaction time with feedback and reinforcement, as well as simultaneous dual tasks with training in verbal regulation and allocation of attention in complex situations. Externally paced tasks, masked stimuli, or short stimulus displays were excluded from the recreational computing games used in the control condition. Immediately after training, the experimental group showed marked improvement relative to the control group on 2 measures of attention, although, when premorbid intelligence score and time since injury were added as covariates, the treatment effect was no longer significant. At 6-month follow-up, the treatment group showed continued improvement and superior performance compared with the control group on tests involving auditory-verbal working memory. In some cases, the performance of the control group deteriorated from posttreatment to follow-up. The researchers suggest that the initial improvement in the control group was compatible with a nonspecific effect of increased attention and activity levels during the treatment period. In contrast, the treatment group's pattern

of initial improvement during training, which continued over the follow-up period, was consistent with a strategy training model, with "some benefit as the strategy is implemented, but increasing benefit as it becomes increasingly automated and integrated into a wider range of behaviors."[10]

In the second postacute Class I study,[8] community-dwelling subjects with moderate to severe brain injury and time postinjury between 12 and 72 months were screened for orientation, vision, aphasia, and psychiatric illness. Twenty-six subjects were randomly assigned to receive either attention training or a comparison treatment condition consisting of memory training over a 9-week period. A total of 36 hours of individual treatment was received. The attention treatment consisted primarily of computerized tasks directed at improving focused and alternating attention to visual and auditory stimuli and divided-attention tasks intended to improve the allocation of attentional resources. Comprehensive feedback and strategy teaching was provided within each session. The effects of training were evaluated through repeated measures administered throughout training, as well as pretreament and posttreatment neuropsychologic assessment of attention and memory. The attention measures were chosen to have "predictive validity for daily activities," although no direct measures of functional outcome were employed. Several additional measures were administered only before and after treatment to assess near generalization of treatment effects. After treatment, the experimental attention training group improved significantly more than the alternative treatment group on 4 attention measures administered throughout the treatment period, although the effects did not generalize to the second set of neuropsychologic measures. Both treatment groups exhibited some improvement on all measures, but the effects on specific measures were weak.

Sohlberg and Mateer[12] employed a (Class II) multiple-baseline design with 4 subjects, 12 to 72 months postinjury, to evaluate the effectiveness of a specific, hierarchical attention training program. Treatment was provided for 7 to 9 sessions weekly and lasted from 4 to 8 weeks. All 4 subjects showed gains on a single attentional-outcome measure administered after the start of attention training but not after training on visuospatial processing. Several components of the attention training tasks closely reflected aspects of the outcome measure, suggesting the possibility of a relatively task-specific treatment effect. Strache[13] conducted a prospective (Class II) study of 45 subjects with mixed trauma and vascular etiologies, most of whom were more than 6 months postinjury, and compared 2 closely related interventions for concentration with subjects in an "untreated" control group who were receiving general rehabilitation. After 20 treatment sessions, both attention treatments resulted in significant improvement on attention measures relative to control subjects, with some generalization to memory and intelligence measures. No attempt was made to control for the large number of variables measured. The interpretation of these 3 studies is tempered by the limited range of relevant outcome measures and, in some cases, the relatively small effects of treatment.

Within the attention domain, several attempts were made to establish the differential effectiveness of training for specific components of attention. Improvements in speed of processing appear to be less robust than improvements on nonspeeded tasks.[9,14,15] Consistent with this finding, several studies also suggest greater benefits of attention training on more complex tasks that require selective or divided attention than on basic tasks of reaction time or vigilance.[10,11,14]

Limited direct evidence exists for the generalization of benefits attributable to attention remediation, with a tendency to

observe gains on tasks most closely related to the training tasks. However, evidence from a well-designed (Class III) single-subject study suggests that attention training may be related to improvements in daily functioning and generalized outcomes. Wilson and Robertson,[16] implementing a series of individualized interventions intended to facilitate voluntary control over attention during functional activities, effectively decreased the attentional lapses that the subject experienced when reading novels and texts.

The studies conducted to date have concentrated on providing subjects with practice on training tasks related to specific aspects of attention. Evidence suggests that the quality of therapeutic intervention beyond the specific training tasks employed may be an important variable in the effectiveness of treatment. For example, in the Ponsford and Kinsella[9] study, 3 of the 10 subjects appeared to gain significant clinical benefit from the addition of feedback and reinforcement to the computer-mediated training. The study by Wilson and Robertson[16] incorporated highly personalized treatment procedures, including therapist feedback and "confidence building" by monitoring the subject's emotional reactions to deficits. In the study by Niemann et al,[8] at least 30 to 40 minutes of each 2-hour session were devoted to specific training tasks, whereas the remaining time was allocated to providing the subjects with feedback on their performance and actively teaching strategies to improve their functioning.

Recommendations. Evidence from 2 Class I[8,10] studies with a total of 57 subjects and 2 Class II studies[12,13] with a total of 49 subjects supports the effectiveness of attention training beyond the effects of nonspecific cognitive stimulation for subjects with TBI or stroke during the postacute phase of recovery and rehabilitation. This form of intervention is recommended as a Practice Guideline for these persons. Interventions should include training with different stimulus modalities, levels of complexity, and response demands. The intervention should include therapist activities such as monitoring subjects' performance, providing feedback, and teaching strategies. Attention training appears to be more effective when directed at improving the subject's performance on more complex, functional tasks. However, the effects of treatment may be relatively small or task-specific, and an additional need exists to examine the impact of attention treatment on ADLs or functional outcomes.

Evidence is insufficient to distinguish the effects of specific attention training from spontaneous recovery or more general cognitive interventions for subjects with moderate-to-severe TBI and stroke during the acute period of recovery and inpatient rehabilitation. Thus, specific interventions for attention during the period of acute recovery are not recommended. Although improvements in attention and functional status appear to occur in these subjects, this finding may be attributable to the effects of spontaneous recovery or the more general effects of acute brain injury rehabilitation. In the studies reviewed, all subjects were receiving inpatient brain injury rehabilitation that included interventions directed at orientation, memory, or general cognitive skills. No studies were found that directly compared recovery of attention between treated and untreated subjects; therefore, improvements attributable to the natural course of recovery and those attributable to cognitive interventions within the context of comprehensive acute brain injury rehabilitation programs are confounded.

Remediation of Visuospatial Deficits

Within the area of remediation of visuoperceptual and constructional deficits, 1 group of studies focused on the remediation of basic abilities and behaviors such as visual scanning or

visual perception. Another group of studies addressed the remediation of complex, high-level skills involved in constructional or functional activities that require spatial relationships for assembly, arrangement, or mobile interaction with the environment. Of the 40 articles considered for final review in this area, there were 12 Class I studies,[20-31] 12 Class II studies,[32-43] and 11 Class III studies.[44-59]

Five Class I or Ia studies assessed the effectiveness of interventions for visual scanning or visual neglect. In an early study of cognitive remediation, Weinberg et al[20] compared standard rehabilitation with an intervention designed to train subjects to compensate for impaired scanning habits after right hemisphere stroke. Subjects in the standard rehabilitation sample ($n = 32$) and the experimental group ($n = 25$) were at least 4 weeks postinsult. The experimental treatment group received 20 hours of training in which graded visual material was used to promote left-sided scanning. The treatment group gained significant benefits on both specific measures of scanning and academic reading tests that were hypothesized to depend on intact visual scanning. Young et al[22] also compared standard occupational therapy with experimental training in visual scanning in 27 subjects with right hemisphere stroke and left-sided neglect. The experimental groups not only significantly improved on several measures closely related to the training procedures but also significantly improved on academic measures of reading and writing. In contrast with these 2 studies, a Class Ia study by Robertson et al[23] did not show any benefit of microcomputer-based visual scanning training. The visual scanning intervention was based, in part, on tasks used by Weinberg[20] and was compared with recreational computing (which excluded tasks requiring visual scanning or timed presentations). Thirty-five subjects were selected on the basis of impaired performance on a measure of behavioral inattention; 32 of them had sustained a stroke (of unspecified laterality) and several were diagnosed with head trauma or meningioma. Less than one third of the subjects showed improvement on behavioral measures of inattention, with no differences between the groups immediately after treatment or 6 months later.

Two of these studies of visual neglect used functional outcome measures.[24,25] Wiart et al[24] showed greater resolution of unilateral neglect and reduced functional impairments for 11 subjects who received a combination of visual scanning and voluntary trunk rotation compared with 11 subjects who received traditional rehabilitation for acute stroke. Kalra et al[25] compared conventional stroke rehabilitation directed at restoration of normal tone and motor activity with an experimental treatment that involved "spatiomotor cuing during limb activation" in the affected hemispace. The experimental intervention produced significant improvements on specific measures of body image and spatial exploration. In addition, the visual neglect subjects who received the active intervention had significantly shorter lengths of hospital stay. The latter finding may be particularly noteworthy, given that the presence of unilateral neglect in subjects with right hemisphere stroke is associated with greater functional disability and prolonged hospitalization.[60]

Seven Class I and Ia studies incorporated training of complex visuospatial skills for subjects with acquired brain damage. Two of these studies featured a hierarchical approach to treating subjects with right hemisphere stroke who exhibited visuospatial deficits, including unilateral visual neglect. Weinberg's group[21] built on their earlier study of scanning and academic skill performance to evaluate training effects on more complex sensory and spatial skills for 53 subjects with right hemisphere stroke. The 30 subjects in the experimental condition received 20 hours of training in sensory awareness and

spatial organization in addition to a condensed version of the original visual scanning training. The 20 subjects in the control condition received an equivalent amount of occupational or physical therapy. The subjects receiving the visuoperceptual remediation benefited significantly on visuospatial and academic tasks relative to the control subjects. As in the earlier study, the benefits were most apparent among subjects with more severe perceptual disturbance. Weinberg[21] suggested that the training that incorporated multiple treatment levels produced more robust benefits and greater generalization than the original single treatment program. In another study,[26] this group further evaluated the claim for the effectiveness of systematic treatment directed at multiple levels of visuospatial impairment. A comprehensive program of treatment for visuoperceptual disturbances associated with right hemisphere stroke was developed by integrating 3 types of previously evaluated perceptual remediation techniques in a sequentially administered intervention: basic visual scanning, somatosensory awareness and size estimation, and complex visuoperceptual organization. Among 77 subjects with right hemisphere stroke receiving inpatient rehabilitation at least 4 weeks postinsult, 48 received the experimental treatment and 29 received conventional rehabilitation. At rehabilitation discharge, the experimental group showed greater gains than the control group in all 3 areas of visuospatial functioning. Evidence for generalization of these gains to functional outcome was shown by the increased time that the experimental subjects spent reading. However, these gains were less apparent at 4-months' follow-up, both because of the continued improvement seen in the control subjects and the plateau or decline seen in the performance of the experimental subjects.

The remaining 5 Class I studies[27-31] compared the effectiveness of visuospatial remediation with conventional rehabilitation therapies for subjects without specific evidence of unilateral neglect and in some cases included subjects who had left hemisphere stroke or TBI. One of these studies[27] provided training in visual scanning, visuospatial orientation, and time judgment to subjects within the first week after right or left hemisphere stroke. The subjects who received the perceptual-cognitive training had significantly greater improvement after 3 to 4 weeks of treatment than did subjects who received "conventional" stroke rehabilitation. The results do not allow one to determine the possible differential benefits for subjects with left and right hemisphere stroke. Another study[28] provided training designed to establish a systematic strategy for organizing visual material. The study was for patients with perceptual organization deficits without visual neglect after right hemisphere stroke, most of whom were more than 3 months postonset. Compared with conventional rehabilitation, the experimental treatment produced benefits on measures of visual analysis and organization, with no differential improvement in general cognitive functioning. The researchers noted that the treatment effect was less dramatic than previous studies that treated patients with neglect, perhaps because of the attempt to treat a general cognitive domain rather than a specific behavioral anomaly. In 2 studies,[29,30] no differential improvements in perceptual functioning or ADLs occurred as a result of the experimental treatment, compared with conventional occupational or physical therapies that did not directly address visuoperceptual functioning.

Only 1 study specifically addressed the treatment of visuoconstructional deficits in subjects with TBI.[31] Treatment was provided for 45 male TBI subjects who were at least 6 months postinjury and none of whom exhibited signs of unilateral neglect. Researchers compared visuospatial training on a parquetry task with functional activity training in meal preparation, while controlling for the level and type of cuing. Each treatment produced highly task-specific improvement on a measure of constructional ability and kitchen evaluation, respectively.

Of the 12 Class II studies, 8 addressed the remediation of unilateral visual neglect.[32-39] All these studies showed significant benefits of cognitive remediation, as did an additional 8 Class III studies,[44-51] including evidence of generalization to functional tasks.[34,36,37] As was seen among the Class I studies, the Class II[32,40,41] and Class III[52-56] studies that addressed visuospatial deficits other than neglect generally produced less dramatic or equivocal effects of treatment. However, it is worth noting that several of these interventions did result in improvements that generalized to complex, functional ADLs.[40,53]

Two Class II[34,35] and 2 Class III studies[54,57] reported decrements in visual field defects in nonrandomized studies of specific remediation procedures. However, these results are discrepant with the conclusion based on a randomized study[20] that functional improvements are associated with increased compensation through improved scanning and not with any appreciable change in the underlying neurologic deficit. Kekhoff et al[35] also commented that the observed reduction in visual field defects that his group recorded was insufficient to explain the associated reduction in functional impairments in visual scanning and reading. Most of the studies reporting positive results indicate that training in compensation through visual scanning is required to reduce functional impairments in activities such as reading and perception of the visual environment.

Recommendations.　　Evidence from 6 Class I[20-22,24-26] studies with a total of 286 subjects and 8 Class II[32-39] studies totaling 248 subjects shows that visuospatial rehabilitation that includes practice in visual scanning improves compensation for visual neglect after right hemisphere stroke and is superior to "conventional" occupational or physical therapies. Only 1 Class I study[23] of 36 subjects in which the treatment was limited to microcomputer-based remediation failed to confirm this finding. Visuospatial rehabilitation with training in visuospatial scanning is recommended by the committee as a Practice Standard for persons with visuoperceptual deficits associated with visual neglect after right hemisphere stroke. For these subjects, additional training on more complex visuospatial tasks appears to enhance the benefits of treatment and facilitate generalization to other visuospatial, academic, and everyday activities that require visual scanning (eg, reading, working written arithmetic problems).[20,21,26] Treatment effects also generalize to more effective performance in rehabilitation and everyday living activities,[24,32,39,40] as evidenced by improved driving ability,[43] and greater gains and shorter lengths of stay in acute rehabilitation.[25] Treatment effects appear to be maintained in the long term (ie, up to 1yr).[24]

Additional evidence from nonrandomized, controlled (Class II) studies suggested several specific factors that should be considered in developing clinical visuospatial rehabilitation programs. Training appears to be most effective in subjects who have more severe visuoperceptual impairment that includes visual neglect.[20,21] With this subject group, scanning training appears to be an important, even critical, element of the intervention. Thus, the committee recommends as a Practice Guideline scanning training for persons with visual neglect. Comparisons across the few studies finding negative results and those studies producing positive effects suggest that effective training generally needs to be relatively intense (ie, daily). Effective treatment typically involved 20 1-hour sessions delivered over the course of 4 weeks. Scanning training may be most effective when the intervention features a large

apparatus that challenges peripheral vision. A nonrandomized study[35] suggests that scanning training may be more effective if done without head rotation. However, another study[24] suggests that training to improve trunk rotation may enhance the effects of scanning training. Because most studies had relatively acute stroke subjects (ie, onset < 6mo before start of treatment), the effectiveness of similar interventions with a more chronic or diagnostically diverse group is uncertain.

The benefits of cognitive rehabilitation for persons with visuoperceptual deficits but without visual neglect have not been clearly shown. Evidence from 2 Class I studies[27,28] suggests that visuospatial rehabilitation is superior to conventional therapies, whereas the results of 3 additional Class I studies are equivocal.[29-31] Basing its observation on these studies, the committee recommended as a Practice Option that persons with visuoperceptual deficits without neglect after right hemisphere stroke may benefit from systematic training of visuospatial and organizational skills as part of their acute rehabilitation. No consistent evidence exists to support the specific effectiveness of visuospatial remediation for persons with left hemisphere stroke or TBI who do not exhibit unilateral spatial inattention, and this intervention cannot be recommended in these cases.

Although several studies have reported decrements in visual field defects as a result of specific perceptual remediation procedures, the effects appear related to compensation through improved visual scanning and not to any appreciable change in the underlying neurologic deficit. Basing its decision on the available research and conflicting evidence, the committee does not recommend clinical interventions to directly increase visual fields.

Based on the results of a single Class I study,[23] the treatment of unilateral left behavioral inattention through the isolated use of microcomputer-based exercises is not effective and is not recommended.

Remediation of Language and Communication Deficits

A dynamic interaction exists between language and cognition in that linguistic processes are critical to the acquisition of knowledge and mediation of cognitive processes, and cognitive impairments often produce related communication impairments.[61] Language deficits after TBI and stroke include specific language disorders (ie, aphasia), functional disorders such as impaired reading comprehension, and impairments in communication pragmatics. Recognizing the interrelatedness of cognitive and linguistic processes, the committee reviewed treatment studies that addressed a broad scope of language-related impairments. As a result, the review of research in the area of language and communication revealed a wide range of treatment approaches. The majority (84%) of the studies that the committee reviewed researched subjects with stroke, with 16% of studies addressing communication disorders from TBI. This distribution seems to reflect the recent focus on TBI treatment and the availability of larger homogeneous samples of subjects with left hemisphere stroke. Of the 41 studies identified to review in this area, 8 were Class I studies,[62-69] 7 were Class II studies,[70-76] and 26 were Class III studies.[77-102] Of the Class I studies, 6 were conducted using subjects with left hemisphere stroke and 2 involved subjects with TBI.

Two Class I studies of language remediation included an untreated control group. Wertz et al[62] evaluated the effectiveness of language treatment for aphasia among 94 subjects that had left hemisphere stroke. These subjects were randomly assigned to 3 groups: treatment in a clinic, treatment at home, and deferred treatment. Treatment was designed to reduce deficits in comprehension, expressive language, reading, and writing. General treatment protocols were specified and con-

sisted of traditional facilitation techniques and specific language programs, although specific techniques were individualized and designed to meet each subject's needs. Treatment was administered for 8 hours weekly throughout each 12-week study period. The home treatment condition was designed and monitored by speech-language pathologists, but was administered by trained volunteers. After the initial 12 weeks, the clinic treatment group showed a significant treatment effect over the deferred (no treatment) group. After an additional 12 weeks, during which clinic treatment was provided to the deferred treatment subjects, the differences between the groups were eliminated, a result that indicated treatment effectiveness past the period of expected spontaneous recovery. This study also addressed the specific effectiveness of clinic-based treatment in comparison with a home-based program of structured language stimulation. The home treatment group improved more than the untreated group but less than the clinic treatment group; however, neither of these differences was significant.

In a prospective (Class Ia) study, Hagen[69] evaluated a homogeneous sample of 20 subjects with posterior left hemisphere stroke who were sequentially assigned to treatment or no treatment conditions at 6 months postinjury. Both groups were in the same chronic care environment, with the only reported difference being the intensive communication therapy provided for the experimental group. The treatment consisted of individual, group, and programmed independent therapies focused on each subject's specific level of language abilities and deficits, which were identified and remediated by speech/language pathologists. The study showed a significant treatment effect at 1 year in 5 areas: reading comprehension, spelling, arithmetic, language formulation, and speech production. No difference was found in auditory and visual comprehension skills. This finding was attributed to spontaneous recovery before the start of the treatment. Because treatments were individualized according to specific deficits, and personally meaningful and useful material was developed for each subject, the strict comparability of interventions among the subjects in the treatment group is limited. However, this situation also approximates the typical clinical situation and may support the generalizability of treatment effectiveness. These 2 studies provide evidence that language remediation after a single left hemisphere stroke is effective.

Three Class I studies compared the effectiveness of language remediation and alternative forms of treatment for communication impairments after left hemisphere stroke.[63-65] Wertz et al[63] conducted a (Class I) multi-center study that compared the effectiveness of individual treatment of specific language deficits versus group treatment designed to improve communication without direct treatment of specific language deficits. All subjects received 8 hours of weekly therapy, beginning at 4 weeks postonset and continuing up to 48 weeks postonset. Individual treatment of specific language deficits resulted in significantly greater improvement on the Porch Index of Communication Ability, although there was evidence of significant improvement for both groups, with no other differences between groups on specific language measures. David et al[64] reported the results of another (Class I) multi-center, randomized controlled trial, with 96 subjects with aphasia due to stroke assigned to either 30 hours of individualized, "conventional speech therapy" over 15 to 20 weeks or an equal amount of stimulation and support from volunteers. Volunteers were given a detailed description of each subject's communication problems and were asked to encourage the subject to communicate as well as possible, but they were given no instruction in speech therapy techniques. Improvement of functional communication was apparent for both groups, with no significant

difference between the groups. It was also noted that subjects referred for treatment more than 20 weeks postonset showed a similar pattern of improvement, suggesting that the effects were not due to spontaneous recovery, although again no differences were found between treatment conditions. In this study, the volunteers were informed of each subject's deficit areas and were asked to focus on these areas and encourage communication. A related study by Hartman and Landau[65] compared 6 months of formal language therapy for acute stroke-induced aphasia with an equal amount of emotionally supportive counseling therapy. Both interventions were provided by speech-language therapists. The alternative treatment (counseling) was unstructured and conversationally based; however, therapists were trained specifically not to provide instruction or specific suggestions for language practice. Both groups showed small improvements, and conventional speech was no more effective than emotional support without formal language instruction. These studies suggest that nonspecific treatment factors such as therapist interest, support and encouragement, and stimulation may contribute to the effectiveness of treatment for communication deficits after stroke.

Four Class II studies provide evidence directly related to the effectiveness of language remediation compared with no treatment; 3 provide support for language remediation[70-72] and 1[73] provides negative evidence. Basso et al[70] evaluated the effect of language remediation on specific skills of comprehension, expression, reading, and writing among 281 subjects who were aphasic because of stroke (85%) or TBI (1%). Treatment had a significant effect on all language skills. Time postonset and aphasia severity were inversely related to amount of improvement, although subjects who entered treatment several months or even years postonset showed improvement. Shewan and Kertesz[71] compared 2 forms of language remediation ("language therapy" or group facilitation by speech-language therapists) versus alternative treatment (group stimulation by nurses) or no treatment among 100 subjects with aphasia due to stroke. Significant improvement occurred only in the 2 language remediation conditions. Poeck et al[72] compared the treatment of 68 aphasic stroke subjects with 92 untreated, historical controls. Significant benefits of treatment were observed beyond the effects of spontaneous recovery, even in subjects in late (4–12mo) or chronic (>12mo) stages of recovery. Prins et al[73] compared 2 forms of language remediation consisting of either conventional therapy or a systematic program of remediation for auditory comprehension, with a no treatment control condition. The sample consisted of 32 aphasic stroke subjects averaging 3 years postonset and as long as 17 years postonset. Groups were not matched for age, severity, or chronicity. No clear effect was found on the recovery process for either form of language remediation.

In addition to the relatively broad-based interventions already discussed, another Class I study refined treatment focus and examined the efficacy of a computer-based program to improve reading comprehension after left hemisphere stroke.[66] Fifty-five aphasic subjects were randomly assigned to receive either treatment for reading comprehension, generalized computer stimulation for the same time period, or no treatment. Significant treatment effect existed for the computer reading treatment, with improved functioning in reading comprehension and generalization to other language functions. The strength of this study lies in the focused nature of the intervention on a specific language function, with each subject exposed to a systematic hierarchy of language-based treatment stimuli. This study more closely analyzed the efficacy of what is currently considered a cognitive-linguistic remediation technique, with strong evidence for efficacy given the time elapsed

postinjury and the lack of change with computer stimulation alone or no treatment. Three small Class II studies have provided evidence for the effectiveness of specific language interventions directed at sentence production[74,75] or sentence comprehension,[76] with no negative findings in Class II studies of specific interventions. Several Class III studies have evaluated interventions for specific language deficits, including naming and word retrieval,[77-82] sentence production,[83-86] alexia,[87] and verbal perseveration.[88] These studies support the effectiveness of individualized treatment for cognitive-linguistic deficits after left hemisphere stroke.

Two Class I studies evaluated the effectiveness of cognitive remediation for functional communication deficits after TBI. Helffenstein and Wechsler[67] evaluated the effectiveness of a group intervention designed to improve interpersonal communication skills compared with nontherapeutic attention. Treatment involved systematic feedback on videotaped communication interactions for 20 hours total for the therapy group. The control group received an equivalent amount of treatment in individual sessions with no feedback on interpersonal communication skills. Although group size was small ($n = 16$), a significant treatment effect was found, with the experimental subjects showing improvements on measures of self-concept, others' ratings of interpersonal and communications skills, and the observed frequency of specific behaviors related to effective interpersonal communication in nontherapeutic, social settings.

Thomas-Stonell et al[68] evaluated the effectiveness of a computer-based program for the remediation of "higher level cognitive-communication deficits (i.e., those that require the interplay of cognitive, memory, and language processes)" in 12 young adults with TBI. The computer-based intervention (TEACHware[a]) addressed 5 skill areas: attention, memory and word retrieval, comprehension of abstract language, organization, and problem solving. The subjects were selected on the basis of demonstrated cognitive-linguistic impairments on standardized neuropsychologic tests and randomly assigned to receive the 16-hour program of the computer-based cognitive remediation or control treatment. The cognitive remediation was conducted by a speech therapist, occupational therapist, or teacher who also provided insight into cognitive strengths and weaknesses, provided training in the use of compensatory strategies, and facilitated transfer of skills from the treatment tasks to real-life situations. The 6 subjects in the control group were already receiving either intensive rehabilitation or were in community school programs. Although some remediation of cognitive deficits was apparently included in the control subjects' program, the nature of these interventions was not specified and skill transfer to real-world situations was reported as a focus of the control groups' treatment. The computer-based remediation group showed significant improvements on several standardized language measures, whereas the control group did not. It was also noted that unsolicited reports of improved concentration, memory, and classroom performance were received from classroom teachers of students in the experimental group but not for the control group.

Five small Class III studies have also reported benefits related to remediation for social and pragmatic communication abilities after TBI.[98-102] Ehrlich and Sipes[98] showed improved social and conversational skills in 6 TBI subjects after 12 weeks of group treatment. Gajar et al[99] provided feedback and self-monitoring training to improve conversational interactions for 2 TBI subjects who were at 18 months postinjury. Conversational skills improved to a normal range with generalization observed to less structured situations. Similarly, Giles et al[100] found improved pragmatic communication skills in 1 TBI

subject, with maintenance of gains at least 2 months posttreatment. Although limited by small sample size, these studies show the effectiveness of focused cognitive interventions to improve interpersonal and functional communication skills after TBI.

Recommendations. Because good evidence exists to support the effectiveness of cognitive-linguistic therapies beyond the period of spontaneous recovery for the treatment of subjects with language deficits from left hemisphere stroke, the committee recommends this approach as a Practice Standard. Among the 3 Class I studies[62,66,69] and 4 Class II studies[70-73] comparing language remediation with no treatment, 6 studies with 676 subjects report significant benefits of language remediation and 1 Class II study[73] with 38 subjects reported no clear effect.

Because the results of a controlled prospective study,[67] supported by several Class III studies, indicate that significant benefits may be derived from interventions directed at improving pragmatic communication and conversational skills after TBI, the committee also recommends these interventions as a Practice Standard.

With evidence from 2 well-controlled, prospective (Class I) studies to support the use of cognitive interventions for specific areas of language impairment (eg, reading comprehension, language formulation) after left hemisphere stroke[66] or TBI,[68] the committee recommends this approach as a Practice Guideline.

Remediation of Memory Deficits

Studies of the remediation of memory deficits have addressed a range of memory-related issues including general concerns ("everyday memory problems," impaired learning, capacity to learn during posttraumatic amnesia), specific memory problems (remembering names, dates, routes, lists, faces, appointments, routines), the capacity to use effectively compensatory aids (computers, memory books), and individual subjective memory complaints. Interventions to address these problems have included use of external compensatory aids such as computers, pagers, or notebooks; individualized remediation programs with heavy involvement of client input, family/social/therapist support, and environmental adaptations; didactic lessons and homework assignments; training in compensatory strategies such as rehearsal, organizational strategies, visual imagery, verbal labeling, and use of mnemonics; and implicit memory tasks.

Among the 42 studies reviewed in this area, 4 were prospective, randomized controlled studies of subjects with TBIs.[103-106] Four studies were considered Class II designs[107-110] and 34 were Class III studies.[111-144]

The 4 Class I studies addressed the effectiveness of training compensatory strategies in memory rehabilitation. Berg et al[103] compared memory strategy training with a "pseudotreatment" (drill and repetitive practice on memory tasks) and a no-treatment condition. Most of the 39 subjects were at least 1 year postinjury, although the range extended up to 24 years. All of the subjects were living independently, and about one half were working either full- or part-time in their previous vocation, although at a reduced level, which suggested that most subjects exhibited a relatively mild degree of memory impairment. The memory strategy training consisted of teaching the subjects to apply "well known principles of memory functioning" to daily functioning. Subjects in the strategy training group identified 3 personal functional memory problems they were experiencing as target behaviors for treatment, and the interventions were highly individualized. The "pseudotreatment" consisted of practice with various memory tasks and

games. Objective pretreatment and posttreatment assessments of memory function were conducted, and subjective ratings of improvement were obtained. Results of objective memory testing showed improved memory function in the strategy training group only, although subjects in both treatment groups reported that they found the training beneficial in terms of their everyday memory function. The largest effect of strategy training was found at follow-up 4 months after therapy, suggesting that subjects continued to practice the strategies learned.

Ryan and Ruff[104] combined "empirically proven" mnemonic techniques into a comprehensive treatment program with the goal of improving verbal and nonverbal memory capacities. Twenty TBI subjects with mild to moderate memory impairments from 1.5 to 7.5 years postinjury were matched for age, education, gender, and time postinjury before being randomly assigned to the treatment group. The experimental group received memory retraining employing rehearsal and visual imagery strategies on associational and chaining tasks. The control group received alternative treatment, including computer games and psychosocial support. Both groups followed the same schedule in terms of intensity and duration of treatment, which lasted for 6 weeks. After treatment, both groups improved on neuropsychologic measures of memory functioning, no matter which treatment they received. Post hoc, the groups were divided based on severity of initial neuropsychologic functioning, and the data were reanalyzed. Differential benefit of the memory retraining was observed only in those subjects who had mild memory impairment before treatment. Kerner and Acker[105] evaluated the effectiveness of using memory retraining software and a computer for remediation of "mild to moderate" memory impairment at least 3 months postinjury. Significant improvement was observed on psychometric memory performance after 12 training sessions, suggesting that memory skills were enhanced by using computer-based memory retraining software. However, these gains were not maintained when the subjects were tested again 15 days later, so there was little evidence of lasting benefits of treatment beyond what would be expected from spontaneous memory improvement.

Schmitter-Edgecombe et al[106] evaluated the efficacy of a 9-week, notebook training treatment relative to supportive therapy for rehabilitation of memory disturbance in 8 TBI subjects more than 2 years postinjury. The degree of memory impairment in all subjects appeared to be relatively mild. The treatment consisted of teaching a specific protocol for use of a memory notebook and individualized modifications to address the subjects' personal needs and application to novel settings. The control subjects received supportive therapy that allowed them to express frustrations about their cognitive and psychosocial functioning. After treatment, subjects who received the notebook training reported fewer observed, everyday memory failures than the supportive therapy subjects. Of the subjects who received the memory remediation, 3 were still actively using the memory notebook to assist with their daily activities at 6-month follow-up. The memory remediation group reported fewer retrospective memory failures and continued to report a reduction of observed everyday memory failures 6 months after treatment, although the difference from control subjects was no longer significant.

One Class II study[107] supported the findings related to the effectiveness of training compensatory strategies, although, again, evidence from several Class III studies indicates that this form of memory remediation is effective for subjects with mild impairments but not subjects with severe memory impairment.[111-113] The remaining Class III studies addressing compensatory memory retraining included training in the use of

rehearsal, semantic elaboration, visual imagery, prospective memory, and specific mnemonics. Several of these studies addressed highly specific behaviors such as learning name-face associations.[114] In 1 (Class III) study,[115] visual imagery and verbal elaboration were effective in teaching name-face associations in subjects with severe memory impairment. However, the learning strategy was externally imposed on the subjects to reduce the cognitive demands of strategy use, with no attempt to teach them to use any of the strategies independently or to apply the strategies to new situations. The authors noted that the effectiveness of such training may therefore be specific to the nature of the memory task and the material to be learned.

One Class III study[116] compared the effectiveness of 3 memory retraining strategies (verbal rehearsal, written rehearsal, acronym formation) with memory notebook logging to improve recall of specific, functional material over a 24-hour period. The memory notebook (which was available to subjects at the time of recall) was superior to all of the retraining techniques. The differential benefits of using the memory notebook was most apparent for the subjects with more severe memory difficulties, for whom the retraining techniques were largely ineffective. Three single-case (Class III) reports supported the effectiveness of training subjects who had severe memory impairment from TBI[117,118] or stroke[119] to use a memory notebook to facilitate performance of daily activities.

These studies suggest that the use of a memory notebook as an external, compensatory aid should be distinguished from interventions that attempt to promote the use of internalized, compensatory memory strategies. Of note, the effective use of memory notebooks may require extensive, structured training[118] and attention to subjects' emotional and social acceptance of such use.[117]

One Class II study[109] showed the effectiveness of a portable paging system to circumvent specific, everyday memory failures such as remembering to take medication on time or remembering to shut off appliances. All 15 subjects in this study benefited from the introduction of the external memory aid to varying degrees, and two thirds of the subjects were able to establish a stable routine after 3 months of treatment. Several additional Class III studies have addressed the effectiveness of specific learning interventions[120,121] or external memory aids[122,123] for subjects with moderate to severe memory disorders. These studies have generally shown the effectiveness of techniques for teaching subjects highly specific information, including the application of specific learning techniques and external memory aids to assist with the acquisition and performance of functional work skills.[123]

Recommendations. Four prospective, controlled (Class I) studies[103-106] with a total of 91 subjects have evaluated the effectiveness of training compensatory memory strategies for subjects with TBI. All of these studies compared memory remediation with an alternative treatment condition, and 2 studies included untreated controls. Three of these studies[103,105,106] showed beneficial effects of memory remediation on neuropsychologic indices of memory functioning or reductions in subjective reports of everyday memory failures. In the fourth study,[104] differential benefits of memory remediation in comparison with the alternative treatment were apparent when the subjects were stratified according to the severity of their initial memory impairment. Basing their decision on these results, the committee found the evidence for the effectiveness of compensatory memory training for subjects with mild memory impairments compelling enough to recommend it as a Practice Standard. The evidence also suggests that memory remediation is most effective when subjects are fairly independent in daily function, are actively involved in identifying the

memory problem to be treated, and are capable and motivated to continue active, independent strategy use. Efforts should be taken to ensure that subjects continue to use compensations through appropriate preparation and follow-up.

Specific interventions directed at facilitating the acquisition of specific skills and domain-specific knowledge rather than improving memory functioning per se, can be effective for subjects with moderate to severe memory impairments,[109,116-123] with evidence of their potential direct application to functional activities, and are thus recommended by the committee as a Practice Option. No evidence exists to support the effectiveness of cognitive remediation to restore memory function in subjects with severe memory impairment.

Remediation of Executive Functioning and Problem Solving

The term *executive functioning* refers to those integrative cognitive processes that determine goal-directed and purposeful behavior and are superordinate in the orderly execution of daily life functions. This term encompasses a broad array of cognitive function and dysfunction and is commonly used to characterize difficulties resulting from injury to the frontal lobes, although it is important that the anatomic and behavioral referents of this term remain distinct. These integrative functions include the ability to formulate goals; to initiate behavior; to anticipate the consequences of actions; to plan and organize behavior according to spatial, temporal, topical, or logical sequences; and to monitor and adapt behavior to fit a particular task or context. Disturbances of these executive functions also appear related to impaired emotional and behavioral self-regulation, reduced capacity for insight, and neurologically based disorders of awareness. These processes are often conceptualized to reflect the associated difficulties with everyday problem solving, reasoning, and decision making. Deficits in these areas are often difficult to operationalize because they deal not only with discrete skills but also with the cognitive structures and processes that control the use of these skills. Thus, although the scope of problems or target behaviors encompassed in this section ranges widely, even those studies that sought to train relatively discrete actions generally designed their interventions with the goal of establishing external structure and/or internalization of control over these actions.

Based on the final review of the literature, the committee evaluated 14 studies in this area. They included 1 Class Ia study,[145] 2 Class II studies,[146,147] and 11 Class III[148-158] studies that employed single-subject designs. The choice of interventions reflected a range of approaches that were primarily cognitive, behavioral, or combined cognitive-behavioral techniques. Often, behavioral techniques were used for specific skill training, whereas more cognitively based methods were employed to achieve greater internalization of strategies for initiation and self-monitoring of these skills.

The single Class Ia study in this area was conducted by von Cramen et al,[145] with alternating assignment to 1 of 2 groups, either problem-solving training or an alternative memory training control, and without a no-treatment control group. Training was provided to 37 subjects (from 61 consecutive inpatient rehabilitation admissions) who were classified as "poor" problem-solvers by virtue of obtaining 2 of 3 scores below the median on formal tests of problem solving. The study primarily included subjects with TBI or stroke, although 6 subjects had "other" brain injury diagnoses, with the average time postonset for the entire group being 7 months. The training in problem solving provided subjects with techniques to analyze complex problems into manageable steps based on a social problem solving model that emphasized training in problem orientation,

problem definition and formulation, generation of alternatives, decision making, and solution verification. Subjects in the memory training group were taught to use internal memory strategies, with the rationale that memory-strategy training might have implicit effects on problem-solving abilities. Problem solving and memory training were carried out with equivalent intensity and duration by 2 therapists. The problem-solving training was done on a group basis, although subjects with arousal difficulties were also treated individually, to allow prompting to maintain mental effort. Treatment outcomes were assessed with pre- and posttraining comparisons on neuropsychologic measures of intelligence and planning, with predefined improvement criteria and with behavioral ratings by clinicians on 9 aspects of impaired functional problem solving. Results of pre- and posttraining comparisons showed significant improvement for the problem-solving treatment on 3 of 5 intelligence subtests and on both measures of planning ability. Behavioral ratings revealed significantly greater improvement in the problem-solving treatment group than for subjects in the memory treatment group in awareness of deficits, goal-directed ideas, problem-solving ability, and premature actions. The behavioral ratings were interpreted as evidence for generalization of treatment effects to everyday ward activities.

The evidence for effectiveness of problem-solving interventions for subjects with TBI is supported by a Class II study[146] that developed and evaluated a program for teaching problem-solving strategies by using verbal analogs of problem situations in 4 general areas of everyday life relevant to community placement and adjustment: (1) community awareness and transportation; (2) medication, alcohol, and drugs; (3) stating one's rights; and (4) emergencies, injuries, and safety. The training of problem-solving strategies was based on the generation of alternatives and choice of a single solution. The training methods included the use of cue cards, response-specific feedback, modeling, self-monitoring, positive reinforcement, response practice, self-correction, and individualized performance criterion levels. Specific criterion questions were used for scoring, providing feedback, and providing cues during training. Training was provided to 3 subjects with TBI within a residential rehabilitation facility. Three individuals within the same facility served as untreated control subjects. Throughout the course of training, the percentages of criterion questions answered correctly by the experimental subjects increased from 29% to 96% correct. Performance on probes in which analogous problem situations were used increased from 26% during baseline to 93% after training. Generalization of training was measured by interview and simulated interactions conducted in the natural environment by facility staff. The experimental subjects showed significant improvements in problem solving after treatment, whereas the performance of the untreated subjects was essentially unchanged. The improvements in problem solving by the experimental subjects were maintained at a 6-month follow-up. The use of ecologically relevant problems and situational simulations is relatively unique, although the outcome measures largely represented only the subjects' verbal responses rather than measuring their actual performance in problem-solving situations. Despite the small number of subjects, the comparison with untreated control subjects and the attempt to address problem solving in relevant, everyday situations increase the value of this study in support of the effectiveness of problem-solving interventions.

One (Class II) study with multiple-baseline controls directly addressed the remediation of executive functioning. Cicerone and Giacino[147] adapted a self-instructional procedure to train executive functioning deficits in 6 subjects (5 with TBI, 1 with a benign tumor) by using a multiple-baseline-across-subjects design. All subjects had planning and self-monitoring difficulties, which were revealed by scores on frontal lobe measures and by reports from family and rehabilitation staff. Subjects received baseline pretesting on the Tower of London, which was also used as the training task. Training consisted of 10 to 20 hours of individualized treatment over 5 to 9 weeks to complete 3 phases of self-instruction. The graphic representation of results suggested that 5 of the 6 subjects showed dramatic decreases in task-specific errors, although some downward trend in errors was present before the start of treatment. Pre- and posttreatment analyses of neuropsychologic measures indicated significant reductions in maze errors and perseverative responses, which were interpreted as evidence of enhanced performance on tasks that required novel problem solving and inhibition of irrelevant responses. Additionally, generalization of training to the reduction in off-task, disinhibited behaviors was found during treatment and follow-up assessment. This finding was consistent with an earlier single-subject study of treatment protocol that showed application to everyday behaviors with extended training promoted generalization.[148] The effectiveness of verbally mediated, self-instructional training for executive function deficits receives some support from additional single-subject studies.[148-152] In a related form of intervention, Sohlberg et al[153] used external cuing to train the self-monitoring of verbal initiation and response acknowledgment in a subject who showed restricted affect and motivation after severe TBI. These studies have typically emphasized a program of treatment aimed at internalization of control of the skill to be learned, whether by saturated cuing, self-instruction, self-questioning, or self-monitoring. They have frequently used a combination of cognitive and behavioral interventions and have relied on detailed neuropsychologic and clinical assessment of subjects to identify specific target behaviors and to develop individually tailored interventions.

One (Class III) study[154] evaluated the use of an external cuing-monitoring system (NeuroPage[b]) and paper-and-pencil checklist in the rehabilitation of executive problems following anterior stroke. The subject had difficulty with timely initiation of intended actions, despite relatively preserved memory functioning. External cuing and monitoring were useful in increasing the probability that she would successfully initiate and complete specific tasks as part of her daily routine, with no attempt to remediate her executive functioning per se.

Unawareness of deficits after brain injury is often observed following TBI or stroke and may be associated with deficits of executive functioning. Several studies of executive functioning incorporated techniques such as formal feedback and self-monitoring of deficits[148,153,155] in an attempt to address subjects' self-awareness. However, we found very few empirical studies, and no controlled studies, of treatment to improve directly subjects' awareness of deficits. Two Class III studies suggest that having subjects predict their performance on tasks and providing them with tangible feedback may reduce discrepancies between their predicted and actual performance.[157,158]

Recommendations. Practice recommendations regarding interventions for problem-solving and executive functioning deficits are constrained by the small number of studies comprising Class I and Class II research in this area. Only 3 Class I or Class II studies were identified,[145-147] reporting results for a total of 43 subjects. Basing its decision on the studies that support the effectiveness of programmatic interventions for problem-solving deficits, the committee recommends training of formal problem-solving strategies and their application to everyday situations and functional activities[145,146] as a Practice Guideline.

Cognitive interventions that promote internalization of self-regulation strategies through use of verbal self-instruction, self-questioning, and self-monitoring may be considered a Practice Option for the remediation of deficits in executive functioning, including the reduction of problem behaviors in everyday situations.[147-152] Such interventions should incorporate detailed neuropsychologic and clinical assessment data to identify relevant behaviors for intervention and to make modifications in treatment interventions on the basis of individual patterns of strengths and limitations. Some persons, especially those with multiple cognitive impairments or severe impairments of executive functioning, may require consistent external structure and environmental management to achieve discrete improvements in skills or behaviors within limited contexts.[153,154] Interventions for cognitive deficits after acquired brain injury may also include efforts to assess subjects' awareness of their deficits and to improve the accuracy of subjects' self-appraisal of their performance. However, these interventions have not been adequately addressed through controlled studies.

Multi-Modal Interventions for Cognitive Deficits

In clinical practice, it is not uncommon for treatment to address multiple areas of cognitive functioning by providing specific interventions for each deficit (eg, attention, memory, problem solving). The specific interventions are typically administered sequentially, although some deficits may be addressed concurrently. For example, the study by Thomas-Stonell[68] incorporated interventions for attention, memory and word retrieval, comprehension of abstract language, organization, and problem solving to address "higher level cognitive impairments."

We evaluated 6 studies that provided multi-modal intervention for 1 or more deficits, including 2 Class II studies comparing the effectiveness of computer-assisted and noncomputerized cognitive remediation techniques[159,160] and 4 Class III studies.[161-164] The 2 controlled (Class II) studies[159,160] did not reveal any differential effectiveness of computer-assisted versus noncomputerized intervention techniques. In both studies, investigators compared computer-based cognitive remediation directed at attention, memory, visuospatial functioning, and problem-solving abilities with non-computer-based cognitive remediation. In the study by Batchelor et al,[159] both groups received similar training consisting of repeated practice and strategy training directed at memory, organization, planning and flexibility, reasoning, and problem-solving abilities. In the study by Chen et al,[160] the experimental group received a structured, hierarchical computer-based treatment, whereas the comparison group received other therapies, including speech and occupational therapies, in a postacute, brain injury rehabilitation program. It is likely that this group also received cognitive rehabilitation, although it was not specified by the authors. In these 2 studies, experimental and comparison groups both improved significantly on neuropsychologic measures, with no significant difference between treatment conditions.

Recommendations. The studies in this area, although few, suggest that cognitive rehabilitation therapies directed at multiple areas of cognitive impairment can significantly improve neuropsychologic performance in those skill areas. Multi-modal intervention may be considered for persons who have multiple areas of cognitive impairment, with specific interventions based on recommendations provided in the preceding sections. No evidence exists that computer-based cognitive remediation provides specific benefits or effectiveness, compared with other forms of cognitive rehabilitation. From the

evidence of 2 Class II studies,[159,160] the committee recommends as a Practice Option that computer-based interventions may be used within a multi-modal intervention for cognitive deficits, as long as a therapist is actively involved to foster insight into cognitive strengths and weaknesses, to develop compensatory strategies, and to facilitate the transfer of skills from the treatment tasks to real-life situations. Rehabilitation for cognitive deficits that relies solely on repeated exposure and practice on computer-based treatment tasks without extensive involvement and intervention by a therapist is not recommended.

Comprehensive-Holistic Cognitive Rehabilitation

Given the interaction of neurophysical, cognitive, and psychologic factors resulting from acquired brain injury, a persuasive argument can be made that persons with acquired brain injury are best served by a comprehensive, integrated, and holistic program of neuropsychologically oriented rehabilitation. These programs frequently provide intensive individual and group therapies that address both cognitive and interpersonal-emotional impairments within the context of an organized therapeutic environment, with explicit attention to establishing an effective therapeutic relationship, to increasing subjects' self-awareness, and to optimizing adjustment through realistic goals. The program may include psychosocial and vocationally oriented interventions as well as specific efforts to improve cognitive functioning. Improved function may be accomplished by patients' using their residual cognitive abilities more effectively, rather than by restoring the underlying cognitive deficits.[165,166]

The committee reviewed 15 studies that reflected a comprehensive-holistic approach to cognitive rehabilitation. These included a prospective Class Ia trial of cognitive rehabilitation,[167] 4 Class II studies using nonrandomized or historical controls,[168-171] and 10 Class III studies.[166,172-180]

The Class Ia controlled trial compared the efficacy of cognitive and psychosocial day treatment programs on neuropsychologic performance.[167] A subsequent publication[181] reported measures of psychosocial functioning for a subgroup of these subjects and these findings are included in our discussion of the present treatment efficacy study. To distinguish the contributions of structured neuropsychologic remediation and social support, the authors of these papers "quasi-randomly" assigned subjects with moderate to severe TBI to treatment conditions to match for demographic and neurobehavioral factors. Besides the group psychotherapy provided to all subjects, those in the neuropsychologic treatment condition received specific treatments directed at improving attention, memory, visuospatial ability, and problem solving. Subjects in the alternative (psychosocial) treatment condition received an equivalent treatment directed at coping skills, interpersonal functioning, independent living skills, computer and video games, and personal development. The entire treatment protocol was conducted in 8 weeks, totaling 160 hours of treatment for each subject. Both groups improved significantly on measures of neuropsychologic functioning and depression, which could not be accounted for by spontaneous recovery (based on a stable pretreatment baseline). The subjects who received structured neuropsychologic remediation showed marginally greater gains of attention, memory, and verbal reasoning. The authors concluded that structured treatment was beneficial, but the results did not indicate a specific advantage for the neuropsychologic treatment. They noted that the neuropsychologic and psychosocial interventions shared some essential components, such as participation in structured activities, establishment of a thera-

peutic alliance, increased self-awareness, and expectations for improvement.

The relative contributions of individualized cognitive remedial interventions and small-group based exercises in interpersonal communication within the context of a holistic neuropsychologic rehabilitation program were explicitly evaluated in a controlled (Class II) study by Rattok et al.[171] All subjects received a 20-week treatment program that included basic attention training, personal counseling, and community activities. Appropriate candidates received vocational counseling and work trials after the initial 20-week treatment. During the 20-week treatment program, 1 group of subjects received a mixture of additional cognitive remediation and interpersonal interventions. The cognitive remediation consisted of individualized cognitive training modules addressing motor, constructional, visuospatial, or logical reasoning skills. This group also received the group interpersonal training intended to improve their awareness of deficits and acceptance of limitations, self-acceptance, and social relatedness. The second group of subjects received the basic attentional training and individualized cognitive remedial interventions, but did not receive interpersonal communication training. The third group received the initial, basic attentional training followed by the interpersonal remediation, whereas the individualized cognitive interventions were withheld. Treatment effectiveness was evaluated on an extensive battery of neuropsychologic measures, including measures intended to assess both near transfer and far transfer of the training procedures. Subjects improved on all the near transfer measures and about half the far transfer measures. Only the 2 groups receiving the individualized cognitive remediation improved on near transfer measures of motor dexterity, constructional ability, and verbal reasoning, which may have reflected practice effects as these measures were similar to the tasks used in treatment. No group differences existed on far transfer measures attributable to the type of treatment received. This study also evaluated the incidence of "clinically significant change" (defined as an increase of at least 1 standard deviation from pre- to posttreatment scores) on neuropsychologic measures. Clinically significant improvements in visual processing, constructional skills, and verbal reasoning were more common in the subjects receiving individualized cognitive interventions. These findings agree generally with the Class I study, again suggesting slightly greater improvements on specific neuropsychologic outcome measures with cognitive interventions, with the greatest overall benefits resulting from combined neuropsychologic and psychosocial treatments.

Three Class II studies have been conducted that allow comparison between subjects receiving comprehensive-holistic cognitive rehabilitation and untreated control subjects; 2 studies used nonrandomized cohorts[168,169] and another used historical case controls.[170] Prigatano et al[169] evaluated the effects of neuropsychologic rehabilitation on productivity for 18 subjects with TBI compared with 17 subjects with TBI who underwent traditional rehabilitation but were unable to participate in the neuropsychologic treatment program. After adjusting for the contributions of demographic factors and initial level of performance, evidence existed that treated subjects performed significantly better than control subjects on measures of memory and nonverbal intellectual functioning, and had improved personality functioning relative to control subjects. Half the subjects receiving the neuropsychologic rehabilitation program were engaged in productive activity after treatment, compared with approximately one third of control subjects. In a subsequent study,[170] 87% of subjects receiving neuropsychologic rehabilitation, which included a therapeutic work trial, were participating in voluntary or gainful employment 2 or more

years postinjury, compared with 55% of the historical control subjects. Fryer and Haffey[168] reported significant reductions in disability status for a group of 18 treated subjects compared with 9 nontreated control subjects. Half the subjects receiving treatment were engaged in their preinjury role-related activities at 1 year postdischarge.

Although most studies of cognitive rehabilitation have relied on neuropsychologic measurement to evaluate the effectiveness of treatment, evidence exists that persons with acquired neurocognitive impairments can improve in their life functioning absent major changes in their specific cognitive faculties.[169,172-174] Return to productivity after participation in comprehensive cognitive rehabilitation programs has ranged from 40% to 78%.[166,170-172,175-177] It is difficult to compare these results across treatment studies or with nontreatment-related outcome studies, because of injury variables, subject characteristics, length of follow-up, and lack of a standard outcome measures. A previous review of postacute brain injury rehabilitation[182] included several studies of comprehensive-holistic rehabilitation. They reported that 71% of 856 subjects were employed after completing postacute brain injury rehabilitation, whereas 53% of 796 subjects who received no, unspecified, or only inpatient rehabilitation were employed.

Two controlled (Class II) studies have reported psychosocial outcomes. Prigatano[169] reported that emotional distress and psychopathology were significantly lower in treated subjects. Rattok[171] also evaluated differential effects of treatments on measures of functional competence (eg, adaptation to community, regulation of affect, involvement with others) and intra/interpersonal functioning (self esteem, self appraisal, empathy, social cooperation). All 3 types of treatment produced functional and interpersonal improvements with approximately the same number of subjects showing clinically significant improvement on measures of functional competence, although more subjects receiving the interpersonal training tended to improve on measures of affect regulation, self-appraisal, and self-esteem. The results of an uncontrolled study indicated significant reductions in self-perceived distress, a finding that remained stable for at least 1 year after they completed the rehabilitation program,[179] and these improvements were accompanied by improvements in psychosocial functioning in terms of personal relationships and leisure activities.[175,176]

Although external factors, such as lack of social support and financial disincentives, may influence treatment outcomes, subject selection variables should be considered in evaluating the effectiveness of comprehensive-holistic neuropsychologic rehabilitation programs. Neuropsychologic test scores, both before and after treatment, appear to bear a modest relationship to functional outcomes.[172,183] Subjects' awareness and acceptance of limitations, compliance with treatment objectives, and active participation in treatment are all related to treatment effectiveness.[170,177] The presence of multiple disabilities—physical, behavioral, and emotional—will affect patients' ability to benefit from cognitive rehabilitation.[166]

Recommendations. There were 3 controlled (Class II) studies[168-170] with a total of 138 subjects in which comprehensive holistic neuropsychologic rehabilitation was compared with untreated control subjects. These studies suggest significantly greater reductions in disability after treatment and provide evidence for the effectiveness of comprehensive-holistic neuropsychologic rehabilitation, which the committee recommends as a Practice Guideline. One Class Ia study[167] comparing cognitive rehabilitation with a structured, psychosocial intervention reported only marginal improvements on neuropsychologic measures related to cognitive rehabilitation. This study did not include measures of functional outcome, and the

length of treatment was shorter than a typical, postacute, comprehensive-holistic rehabilitation program. The results of another controlled (Class II) study[171] comparing cognitive and interpersonal interventions suggest that clinically significant improvements in neuropsychologic functioning are associated with individualized cognitive remediation, and improvements in psychosocial functioning (eg, affective regulation, self-appraisal) are associated with small group interpersonal training. Although this finding has not been confirmed by a controlled study comparing treated and untreated subjects, the evidence in this area suggests that the greatest overall improvements in functioning may be achieved by persons who receive an integrated treatment of individualized cognitive and interpersonal therapies, which the committee recommends as a Practice Option. Evaluating program outcomes, the committee finds evidence suggesting that subject selection factors, particularly the capacity to recognize and adapt to residual cognitive limitations, may moderate the effectiveness of comprehensive-holistic neuropsychologic rehabilitation.

CONCLUSION

From a comprehensive review of the empirical literature on cognitive rehabilitation, 29 Class I studies were identified. Of these, 20 provide clear evidence supporting the effectiveness of cognitive rehabilitation for subjects with acquired TBI or stroke. Several studies showed an advantage of cognitive rehabilitation over conventional forms of rehabilitation. In most of the controlled studies with negative or equivocal results, the intervention in question was compared with an alternative form of treatment (in some instances, an alternative form of cognitive remediation), and in all but a single study the subjects improved significantly even though there was not evidence of a differential treatment effect. Of the 64 controlled Class I and Class II studies that were reviewed, only 2 studies failed to show improved functioning among subjects receiving cognitive rehabilitation. In no study was there evidence that cognitive rehabilitation was less effective than an alternative treatment. These latter findings provide indirect support for cognitive rehabilitation, while raising questions about the role of nonspecific factors in determining treatment effects.

Of the 20 Class I studies providing clear evidence in support of cognitive remediation, 8 offer evidence to support visuospatial remediation of impairments of visual scanning from right hemisphere stroke, and 4 offer evidence to support language remediation after left hemisphere stroke. Twelve Class I studies evaluated the effectiveness of cognitive remediation for samples consisting primarily of persons with TBI. (Of the 12 Class I studies addressing TBI, 8 were also reviewed by the NIH consensus panel. We included 2 studies not identified in that review and 2 studies that were classified as comparative studies. We excluded as experimental 1 study that was included in the NIH review.) Eight of these studies clearly support cognitive remediation's effectiveness for impairments of attention, functional communication, memory, and problem solving after TBI. In 2 studies, subjects receiving specific neuropsychologic interventions showed marginally greater improvements than subjects receiving treatments that were primarily functional or psychosocial in nature, and 1 study revealed no difference in improvement between a specific attention treatment protocol and more general cognitive rehabilitation during the acute postinjury period. In another study, the beneficial effects of compensatory memory training became apparent when treatment outcomes were analyzed independently for those subjects with milder degrees of impairment.

Specific recommendations based on the evidence of effectiveness of cognitive rehabilitation for persons with stroke and TBI are in table 2. All the recommendations for Practice Standards are based on evidence from randomized, controlled trials. The other recommendations required, at minimum, evidence from at least 1 controlled, Class II study that directly addressed the intervention in question.

Future Directions

Because persons with acquired brain injury are likely to exhibit multiple forms of cognitive impairment, we must continually evaluate the effectiveness of integrated therapies that address the complex interactions of cognitive, functional, and social impairments with the goal of alleviating disability and handicapping conditions. Similarly, the presence and interaction of physical, cognitive, and emotional factors appear related to treatment effectiveness. Although attempts to control for these factors by methods such as randomized allocation of subjects to treatment conditions do have merit, greater practical and clinical value may accrue from identifying subject variables and other prognostic factors that contribute to treatment efficacy and to adjust interventions accordingly. This issue has been addressed most directly through the provision of comprehensive-holistic programs of rehabilitation for persons with brain injury and evidence suggests that the greatest overall improvements in functioning may be achieved by subjects receiving an integrated treatment of individualized cognitive and interpersonal therapies.

Unlike medical interventions that attempt to reverse pathology, rehabilitation of persons with acquired brain injury is primarily concerned with reducing levels of disability and handicap. Most of the studies we reviewed assessed treatment effectiveness by means of psychometric measures presumed to reflect a change in the level of neurocognitive impairments. Even when the measured improvements can be attributed to treatment, the relationship between these changes and functional improvements may not be clear or may be limited by lack of generalization to everyday situations. Also, in some instances, the intervention goal was to train subjects to use adaptive, compensatory strategies for residual cognitive impairments. In these cases, the actual treatment benefits may not be apparent on measures that do not provide the opportunity to use such compensations. Cognitive rehabilitation should always be directed toward improving everyday functioning, and should include active attempts to promote generalization or directly apply compensatory strategies to functional contexts as a part of the intervention.

Relatively few studies have directly evaluated the generalization of treatment effects to everyday situations and behaviors, although several provide evidence to support the practical utility of cognitive rehabilitation. For example, subjects receiving visuospatial remediation improve in functional activities that require visual scanning; subjects treated for specific language and pragmatic communication deficits improved in academic classroom functioning and interpersonal interactions; subjects trained to use compensatory memory strategies had fewer everyday memory failures; and subjects treated for executive dysfunction improved their behavioral self-control and problem solving in everyday situations.

Few researchers have evaluated the long-term maintenance of improvements produced by cognitive rehabilitation. In several studies reporting follow-up information, it appeared that the lasting benefits of treatment depended on the subjects' continued use of compensatory strategies in functional situations. This finding suggests the need not only for long-term follow-up of subjects, but also for continued support and intervention after the initial period of rehabilitation. In general, it appears that the maintenance and generalization of benefits

Table 2: Evidence-Based Recommendations for Cognitive Rehabilitation

Practice Standards

Intervention	Recommendation
Visuospatial rehabilitation	Recommended for persons with visuoperceptual deficits associated with visual neglect after right hemisphere stroke.
Cognitive-linguistic therapies	Recommended during acute and postacute rehabilitation for persons with language deficits secondary to left hemisphere stroke.
Specific interventions for functional communication deficits, including pragmatic conversational skills	Recommended for persons with TBI.
Compensatory memory strategy training	Recommended for persons with mild memory impairments from TBI.

Practice Guidelines

Intervention	Recommendation
Attention training, including varied stimulus modalities, levels of complexity, and response demands	Recommended during postacute rehabilitation for persons with TBI or stroke. Insufficient evidence exists to distinguish the effects in persons with moderate and severe TBI of specific attention training provided during acute recovery and rehabilitation from spontaneous recovery or from more general cognitive interventions.
Scanning training	Recommended as an important, even critical, intervention element for persons with severe visuoperceptual impairment that includes visual neglect after right hemisphere stroke.
Visuospatial interventions intended to increase visual fields directly without the development of compensatory visual scanning	NOT recommended.
Cognitive interventions for specific language impairments such as reading comprehension and language formation	Recommended after left hemisphere stroke or TBI.
Training in formal problem-solving strategies and their application to everyday situations and functional activities	Recommended during postacute rehabilitation for persons with stroke or TBI.
Comprehensive-holistic neuropsychologic rehabilitation	Recommended to reduce cognitive and functional disability after TBI.
Isolated use of microcomputer-based exercises to treat unilateral left behavioral inattention	NOT recommended; does not appear effective.

Practice Options

Intervention	Recommendation
Use of memory notebooks or other external aids to facilitate acquisition of specific skills and knowledge	May be considered for persons with moderate to severe memory impairments after TBI; should directly apply to functional activities, rather than as an attempt to improve memory function per se.
Systematic training of visuospatial and organizational skills	May be considered for persons with visual perceptual deficits, but without visual neglect, after right hemisphere stroke as part of their acute rehabilitation. Not recommended for persons with left hemisphere stroke or TBI who do not exhibit unilateral spatial inattention, because no consistent evidence exists to support its specific effectiveness in these cases.
Verbal self-instruction, self-questioning, and self-monitoring to promote self-regulation	May be considered for persons with deficits in executive functioning after TBI, including the reduction of problem behaviors in everyday situations; should incorporate detailed neuropsychologic and clinical assessment data to identify those behaviors and to modify treatment on the basis of individual strengths and limitations.
Integrated treatment, ie, both individualized cognitive and interpersonal therapies	May improve functioning within the context of a comprehensive-holistic neuropsychologic rehabilitation program.
Computer-based interventions that include active therapist involvement to foster insight into cognitive strengths and weaknesses, to develop compensatory strategies, and to facilitate the transfer of skills into real-life situations	May be used as part of a multi-modal intervention for cognitive deficits.
Sole reliance on repeated exposure and practice on computer-based tasks without extensive involvement and intervention by a therapist	NOT recommended.

from cognitive rehabilitation are greatest when treatment is provided for appropriately long periods of time, when efforts are made by the clinician and patient to identify and apply interventions to personally relevant areas of functioning, and when patients are able to assume responsibility for using compensatory strategies in their everyday functioning.

Cognitive rehabilitation typically relies on individually tailored interventions to provide the best available treatment within a clinical setting. It is strongly recommended that outcome measures also be tailored to the specific, intended effects of cognitive interventions to evaluate realistically the rehabilitation program's effectiveness. Ideally, these measures should reflect meaningful improvements and functional outcomes such as the use of compensatory strategies to accomplish real-life demands, performance on everyday activities in the person's home or community, changes in level of productivity, and measures of subjective well-being. We also recommend that future efforts to validate the effectiveness and utility of cognitive rehabilitation include outcome measures that reflect the levels of disability and handicap, such as community integration[184] and the quality of life of the persons served. In addition, a need exists to develop novel, multivariate research designs and clinical trials that accurately evaluate the outcomes of cognitive rehabilitation.[185]

In sum, the evidence-based review of cognitive rehabilitation provides at least preliminary support for the effectiveness of several forms of this intervention for persons with brain injury resulting from stroke and TBI. Specific recommendations of this review may help to establish parameters of effective treatment, which should be of assistance to practicing clinicians.

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Suppliers

a. TEACHware; Centre for traumatic brain injury rehabilitation, 120 Eglinton Ave E, Ste 400, Toronto, Ontario, Canada M4P 1E2.

b. NeuroPage; Hersh & Treadgold, Inc, Interactive Proactive Mnemonic Systems, 6657 Camelia Dr, San Jose, CA 95120.