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INCOG 2.0 Guidelines for Cognitive Rehabilitation Following Traumatic Brain Injury, Part V: Memory

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Introduction: Memory impairments affecting encoding, acquisition, and retrieval of information after moderate-to-severe traumatic brain injury (TBI) have debilitating and enduring functional consequences. The interventional research reviewed primarily focused on mild to severe memory impairments in episodic and prospective memory. As memory is a common focus of cognitive rehabilitation, clinicians should understand and use the latest evidence. Therefore, the INCOG ("International Cognitive") 2014 clinical practice guidelines were updated. **Methods:** An expert panel of clinicians/researchers reviewed evidence published since 2014 and developed updated recommendations for intervention for memory impairments post-TBI, a decision-making algorithm, and an audit tool for review of clinical practice. **Results:** The interventional research approaches for episodic and prospective memory from 2014 are synthesized into 8 recommendations (6 updated and 2 new). Six recommendations are based on level A evidence and 2 on level B. In summary, they include the efficacy of choosing individual or multiple internal compensatory strategies, which can be delivered in a structured or individualized program. Of the external compensatory strategies, which should be the primary strategy for severe memory impairment, electronic reminder systems such as smartphone technology are preferred, with technological advances increasing their viability over traditional systems. Furthermore, microprompting personal digital assistant technology is recommended to cue completion of complex tasks. Memory strategies should be taught using instruction that considers the individual's functional and contextual needs while constraining errors. Memory rehabilitation programs can be delivered in an individualized or mixed format using group instruction. Computer cognitive training should be conducted with therapist guidance. Limited evidence exists to suggest that acetylcholinesterase inhibitors improve memory,

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On behalf of the INCOG Expert Panel.

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so trials should include measures to assess impact. The use of transcranial direct current stimulation (tDCS) is not recommended for memory rehabilitation. **Conclusion:** These recommendations for memory rehabilitation post-TBI reflect the current evidence and highlight the limitations of group instruction with heterogeneous populations of TBI. Further research is needed on the role of medications and tDCS to enhance memory. **Key words:** *acetylcholinesterase inhibitors (AChE)*, *amantadine*, *cognitive rehabilitation*, *errorless learning*, *external memory compensatory strategies*, *group rehabilitation*, *instructional strategies*, *internal memory compensatory strategies*, *memory compensatory strategies*, *memory enhancing medications*, *memory rehabilitation*, *methylphenidate*, *neurostimulation (tDCS)*, *restorative memory strategies*

MEMORY IMPAIRMENTS are the most frequently reported cognitive deficit following moderate-to-severe traumatic brain injury (MS-TBI).[1] The resulting disruption in learning and task completion can range from mild to severe memory impairment, and is associated with significant functional consequences[2] persisting up to a decade post-injury.[1,3–5] Consequently, management of memory impairments is one of the most common areas of intervention in cognitive rehabilitation.[6] The most frequently described memory impairments are in prospective and episodic (retrospective) memory.[7,8] Prospective memory describes the ability to remember to carry out a planned intention or action at a future time, while episodic memory describes the recollection of prior information or events.[9] Both involve the encoding, storing, and retrieval of information, with prospective memory also including planning, initiation, and monitoring of outcomes related to the specified future intention or action, necessitating more executive skills.[10,11] After MS-TBI most individuals will experience injury to cortical systems affecting prospective and episodic memory due to the disruptions to multiple brain regions, particularly frontal and temporal lobe regions.[8,12,13] Approaches to the management of prospective and episodic memory impairments can be classified into compensatory strategies and restorative techniques.[14] Compensatory approaches reduce the impact of memory impairments on functional tasks, whereas restorative approaches use repeated practice in an attempt to restore function.[15]

The original INCOG guideline translated the rehabilitation literature related to the management of memory impairments following MS-TBI up to 2014 into clinical practice guidelines.[16] The objective of the current review was to update the clinical practice guideline based on the memory rehabilitation literature from 2014. This is an important update, as memory strategies are the most frequently addressed area of cognitive rehabilitation by clinicians working in TBI.[17]

METHODS

The reader is referred to the methods paper of this series (INCOG 2.0: Methods, Overview, and Principles)[18] for a complete review of the strategies used in the updated literature review and development of the recommendations and other tools. In brief, the updated INCOG (with INCOG being an acronym for "International Cognitive") guideline follows a thorough search, review, and critical evaluation of currently published studies. An international expert panel comprising TBI cognitive rehabilitation researchers and clinicians formed the authors. In preparation, a detailed Internet and Medline search was conducted to identify new published TBI and cognitive rehabilitation evidence-based guidelines (from 2014). A systematic search (2014 to July 2021) of multiple databases (Medline, Embase, Cochrane, CINAHL, and PsycINFO) was also conducted to identify TBI articles and reviews. Research articles meeting inclusion but published after July 2021 were added based on the discretion of the expert panel. Two authors independently aligned the research articles within the existing INCOG guidelines and flagged areas where new guidelines may be warranted based on the research evidence. This synopsis of evidence for memory was distributed to the INCOG 2022 memory working group. During the series of videoconference meetings, the working group examined the recommendations matrix and updated some recommendations based on new evidence, articulated novel recommendations based on the new evidence available, and considered the clinical utility of recommendations to enhance meaningful outcomes for individuals with MS-TBI. For each recommendation, the cumulative evidence (studies used in the original guidelines and new articles) was evaluated by the panel in terms of study design and study quality, to determine the level of evidence grading (see Table 1). All relevant references from 2014 were consolidated into a

TABLE 1 *INCOG level of evidence grading system*

A: Recommendation supported by at least one meta-analysis, systematic review, or randomized controlled trial of appropriate size with relevant control group.
B: Recommendation supported by cohort studies that at minimum have a comparison group (includes small randomized controlled trials) and well-designed single-case experimental designs.
C: Recommendation supported primarily by expert opinion based on their experience, though uncontrolled case studies or series may also be included here.

reference library that was made available to the author teams, as they drafted the manuscript and finalized the recommendations accordingly. Consensus of the working group was reached when members unanimously agreed to the wording and evidence grading assignment of all the recommendations. The team added new references related to assessment and management of memory for inclusion in the recommendations in this article. The clinical algorithm was updated accordingly in the management of memory.

LIMITATIONS OF USE AND DISCLAIMER

These recommendations are informed by evidence for TBI cognitive rehabilitation interventions that was current at the time of publication. Relevant evidence published after the INCOG guideline could influence the recommendations contained herein. Clinicians must also consider their own clinical judgment, patient preferences, and contextual factors such as resource availability in their decision-making processes about implementation of these recommendations.

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RESULTS

Recommendations and literature review

The current guidelines outline rehabilitation approaches to managing memory impairment based on studies published from 2014 for which at least half the study sample sustained an MS-TBI. There are 8 recommendations with the supporting evidence presented below. Table 2 sets out the recommendations and supporting evidence.

Memory #1: Teaching internal compensatory strategies may be used for individuals with TBI who have memory impairments. Their use tends to be most effective with individuals who have mild-to-moderate memory impairments and/or some preserved executive cognitive skills. They include instructional strategies (eg, visual imagery, repeated practice, retrieval practice, and Preview, Question, Read, State, Test [PQRST]) and metacognitive strategies (eg, self-awareness and self-regulation). Using multiple strategies is considered effective. They can be selected separately or combined in a structured program. Strategies can be taught individually or in a group format. With severe memory impairment, internal compensatory strategies that are effective may be used in conjunction with external memory compensatory strategies (updated from INCOG 2014,[16] *Memory 1, p. 374).*

Level A Evidence.

This recommendation in the INCOG 2014 guideline was supported by level A evidence. Supporting studies, which were conducted in an experimental setting, focused on improving episodic memory via teaching techniques, which elaborated on information in a meaningful manner. These techniques include mnemonics, visual imagery, retrieval practice, self-instructional techniques, or the PQRST method.[19–22] Improvement on more practical tasks using structured visual imagery was also demonstrated for episodic memory,[23] and for prospective memory[19,24] with the imagery content being relevant to the specific memory process.

New evidence did not change this recommendation but did strengthen existing evidence. For example, Sumowski et al[24] compared the efficacy of retrieval practice, massed restudy and spaced restudy on episodic memory using a within-subject design. Individuals with severe memory impairment following TBI completed a 15-week instructional program. Repeated retrieval practice, emphasizing increased meaningful exposure to information, was associated with better short- and long-term recall, particularly when the strategy was incorporated into daily routines.[24]

Metacognitive processes often described as "strategies" are typically used to strengthen the association between prospective memory cues and intended actions resulting in reduced forgetting in daily tasks.[25] Raskin et al[26] published a comprehensive review of prospective memory and noted that internal compensatory strategies such as awareness training should be defined separately, as they focus on improving the cognitive functions required to carry out an intended task. Therefore, the current recommendation was modified to separate metacognitive strategies from other internal compensatory strategies. Integrating structured visual images is often used to increase the awareness of cues for intended tasks and is strongly associated with reduced forgetting in many practical situations.[19,27–29] New evidence strengthened support for the use of visual imagery through techniques such as future event simulation, which in a controlled trial study, was associated with significant improvement in prospective memory tasks.[30] Raskin et al[31] used imagery strategies based on this simulation technique in a crossover controlled designed study, finding improvements in prospective memory tasks generalized to daily tasks and were maintained over 1 year. The use of visual imagery remains strongly supported, and new evidence supports the efficacy of enhancing visual imagery techniques.

Teaching multiple internal strategies is recommended, delivered individually or within a structured training program, as this has been shown to be effective in improving performance on standardized, behavioral, and prospective memory tasks delivered in a group or individual format.[32–36] The ability to impact

TABLE 2 *INCOG 2.0 guideline recommendations for memory and new supporting evidence*[a]

	Guideline recommendations to improve cognitive communication and social cognition	Grade	Reviews	RCTs	Other
Memory #1	Teaching internal compensatory strategies may be used for individuals with TBI who have memory impairments. Their use tends to be most effective with individuals who have mild-to-moderate memory impairments and/or some preserved executive cognitive skills. These strategies include instructional (eg, visualization/visual imagery, repeated practice, retrieval practice, and Preview, Question, Read, State, Test [PQRST]) and metacognitive strategies (eg, self-awareness and self-regulation). Using multiple strategies is considered effective. They can be selected separately or combined in a structured program. Strategies can be taught individually or in a group format. With severe memory impairment internal compensatory strategies that are found to be effective may be used in conjunction with external memory compensatory strategies (updated from INCOG 2014,[16] Memory 1, p. 374).	A	Raskin et al[26]	Chiaravalloti et al[37]	Lesniak et al[38] Mioni et al[30] Raskin et al[31] Sumowski et al[24]
Memory #2	Environmental supports and reminders (eg, mobile/smartphones, notebooks, and whiteboards) are recommended for individuals with TBI who have memory impairment, especially those with severe memory impairment. Individuals with TBI and their caregivers must be trained in how to use these external supports. The selection of environmental supports and reminders should take into account the following factors: • Age • Severity of impairment • Premorbid use of electronic and other memory devices • Cognitive strengths and weaknesses (eg, executive cognitive skills) • Physical comorbidities • Affordability, portability, and reliability (updated from INCOG 2014,[16] Memory 2 and 3, p. 378).	A	Charters et al[52] Kettlewell et al[60]	Gracey et al[59] Lannin et al[44] O'Neill et al[55]	Bos et al[49] Chu et al[45] Evald[46] Ferguson et al[48] Fish et al[58] Jamieson et al[50] Wong et al[54]

(*continues*)

TABLE 2 *INCOG 2.0 guideline recommendations for memory and new supporting evidence*[a] (Continued)

	Guideline recommendations to improve cognitive communication and social cognition	Grade	Reviews	RCTs	Other
Memory #3	Cognitive skills training for MS-TBI, across all levels of memory impairment, should be strategy-focused and conducted by a TBI-experienced therapist who can further facilitate the functional integration of the strategy being practiced into meaningful and practical tasks. There is little evidence for using restorative techniques such as computerized cognitive training (CCT) alone (updated from INCOG 2014,[16] Memory 7, p. 382).	B	Bogdanova et al[68] Melby-lervag and Hulme[64] Sigmundsdottir et al[69]	Voelbel et al[66]	De Luca et al[65] Ledbetter et al[70]
Memory #4	There are several key instructional practices that can promote learning for individuals with TBI memory impairments, which include: • Clearly defined intervention goals • Selection of and training of goals that are relevant to the person with TBI (ie, ecologically valid) • Allow sufficient time and opportunity for practice • Breaking down tasks into smaller components such as task analysis when training multistep procedures • Use of distributed practice • Teach strategies using variations in the stimuli/information being presented (eg, multiple exemplars) • Teach strategies to promote effortful processing of information/stimuli (eg, verbal elaboration and visual imagery) • Use of techniques that constrain errors (eg, errorless, spaced retrieval) • Consider use of behavioral memory strategies with a focus on context and imagery in the acquisition phase of learning (updated from INCOG 2014,[16] Memory 4, p. 379).	A	Barman et al[90]		Sumowski et al[24]

(*continues*)

TABLE 2 *INCOG 2.0 guideline recommendations for memory and new supporting evidence*[a] (Continued)

	Guideline recommendations to improve cognitive communication and social cognition	Grade	Reviews	RCTs	Other
Memory #5	Group-based interventions may be considered for teaching memory strategies with individuals with MS-TBI, but there is no evidence that it is more effective than individually oriented rehabilitation. Consider reducing heterogeneity in group membership, encourage participation for an adequate number of sessions, and teach generalization of learned skills (updated from INCOG 2014,[16] Memory 5, p. 381).	A		das Nair et al[94] Leśniak et al[95]	
Memory #6	The acetylcholinesterase inhibitor (AChEI), donepezil, may be considered for adults with TBI who have deficits in memory and are in the chronic stage of recovery. The effects of the medication should be assessed using objective and functional measures. Patients should be monitored for side effects such as diarrhea, stomach upset, and nausea (updated from INCOG 2014,[16] Memory 6, p. 381).	A	Bengtsson and Godbolt[96]	Brawman-Mintzer et al[108]	Campbell et al[109]
Memory #7	Transcranial direct current stimulation (tDCS) should not be used to improve memory outside of the context of a randomized controlled trial (INCOG 2022).	A	Dhaliwal et al[112]	Kang et al[117] Lesniak et al[113] Rushby et al[115] Sacco et al[116] Ulam et al[114]	
Memory #8	Methylphenidate and amantadine should not be used to improve memory (INCOG 2022).	A	Barnett and Reid[118] Chien et al[119] Mohamed et al[121]	Jenkins et al[120] Hammond et al[122]	

Abbreviations: MS-TBI, moderate-to-severe traumatic brain injury; RCT, randomized controlled trial; TBI, traumatic brain injury.
[a] Refer to Velikonja et al[16] for evidence contributing to the recommendations prior to 2014.

multiple memory systems using a structured behavioral memory intervention was demonstrated using the modified Story Memory Technique (mSMT) in a randomized controlled trial (RCT) design with MS-TBI.[37] Improvement on initial acquisition and learning using objective measures and on prospective memory tasks were found, with additional observations of reductions in disinhibited behavior.[37] Structured programs teaching strategies were also evaluated when delivered in a mixed individual/group format incorporating computerized instruction with supported individualized instruction, and showed significant improvement on functional memory measures as reported by family and participants.[38]

Memory #2: Environmental supports and reminders (eg, mobile/smartphones, notebooks, and whiteboards) are recommended for individuals with TBI who have memory impairment, especially for those with severe memory impairment. Individuals with TBI and their caregivers must be trained in how to use these supports.

The selection of environmental supports and reminders should take into account the following factors:

- *Age*
- *Severity of impairment*
- *Premorbid use of electronic and other memory devices*
- *Cognitive strengths and weaknesses (eg, executive cognitive skills)*
- *Physical comorbidities*
- *Affordability, portability, and reliability*

(updated from INCOG 2014,[16] Memory 2 and 3, p. 378). Level A evidence.

The INCOG 2014 guidelines provided an extensive review of the support for the use of external compensatory aids including assistive technology in reducing the functional burden of severe memory impairment, as well as the importance of training caregivers.[14,15,39,40] Traditionally, strategies focused on paper and pencil aids including notebooks, customized memory books, organizers, and planners.[41–43] With advancing technology there has been considerable research into the application to external memory aid systems, which has modified the current recommendation. New evidence supports the existing recommendation while adding considerations for the integration of new and advancing technologies.

Personal digital assistants (PDAs) were developed to provide structured cueing to prompt individuals to complete various tasks. Using an RCT design, individuals trained on a PDA showed improved Goal Attainment Scaling scores and subjective caregiver measures compared with those treated by an occupational therapist on nonelectronic memory aids.[44] Additional findings emphasized the importance of ensuring the device was appropriate to the individual, incorporating awareness training, and on the importance of training caregivers.[44] Increasing adoption of technology to compensate for memory impairments should also consider the affordability, reliability, and portability of the device, which can be a challenge with PDAs.[45]

Consequently, an increasing number of studies are examining implementation of smartphones with Internet-based calendars including email and social networking. Evald[46] examined the impact of a comprehensive 6-week training program in the use of smartphone technology delivered in both individual and group formats. Improvements on self-report prospective memory measures and on practical tasks were found, with most participants continuing to use their smartphone at follow-up. Qualitative analysis showed that adoption of new technology was associated with features such as their "all-in-one" capability, device availability, and their audio/visual reminders, which facilitate remembering to attend appointments, completing functional tasks as well as being associated with improved mood and increased independence. Disadvantages of smartphones identified by users included limited battery life, loss or failure of the device, and some feelings of increased dependence.[47–51] Younger individuals with more preinjury technology experience showed increased use of mobile phones when calendars, reminders, and prompting cues were integrated.[52,53] In a controlled pre-/postsurvey study, over 75% of individuals with TBI and noninjured matched controls used smartphones for communication, memory, organization, and Internet access citing portability, convenience, ease in learning, and quality of the display as key factors in adopting new technology.[54] The degree to which smartphones reduce memory demands may be the focus of future research.

O'Neill et al[55] discussed 2 levels of prompting, with smartphones delivering prospective prompts, and microprompting strategies supporting completion of complex tasks by organizing and cueing steps. Microprompting was incorporated into a PDA designed to resemble the scaffolding of instructions provided by caregivers during complex tasks. Using an RCT design, the microprompting device was found to reduce the number of support workers required by participants. The device would deliver prompts to which it would await certain responses and without input would deliver prompting questions.[55] These positive findings were consistent with prior work.[56,57]

Integrating alerting cues/reminders into a structured prospective memory training program improved the awareness of future tasks and strengthened functional outcomes.[58,59] The use of electronic reminder systems is supported as an external memory aid and combined with internal compensatory techniques to optimize compensation of memory impairments. More high-quality studies are still required to understand implementation and functional impact.[52,60]

Memory #3: Cognitive skills training for MS-TBI, across all levels of memory impairment, should be strategy-focused and conducted by a TBI-experienced therapist who can facilitate the functional integration of the strategy being practiced into meaningful and practical tasks. There is little evidence for using restorative techniques such as computerized cognitive training (CCT) alone (updated from INCOG 2014,[16] Memory 7, p. 382).

Level B evidence.

Restorative approaches were developed based on the theory that repeated or mass practice trials of a specific cognitive process would engage mechanisms of neuroplasticity to strengthen or restore the impaired process with the hope of achieving functional improvements.[61,62] Initially, this started with paper and pencil tasks,[63] which have been largely replaced, through technological advances, by computerized cognitive training (CCT). Prior evidence showed that, when applied as a singular treatment, improvements were confined to the trained task with poor generalizability to functional outcomes.[64,65]

This was supported by recent evidence using controlled trial studies in the TBI population when CCT was delivered as an isolated task.[66,67] Findings from systematic reviews show no compelling findings for memory improvement beyond subjective reports in the TBI population.[68,69] A retrospective chart review evaluating the ThinkRx computerized program, requiring completion of increasingly difficult game-like tasks with a clinician present to facilitate implementation of strategies, showed some improvement in functional long-term memory tasks.[70] No compelling evidence has emerged to change this recommendation.

Memory #4: There are several key instructional practices that can promote learning for individuals with TBI memory impairments, which include:

- *Clearly defining intervention goals*
- *Selection of and training of goals that are relevant to the person with TBI (ie, ecologically valid)*
- *Allowing sufficient time and opportunity for practice*
- *Breaking down tasks into smaller components such as task analysis when training multistep procedures*
- *Use of distributed practice*
- *Teaching strategies using variations in the stimuli/information being presented (eg, multiple exemplars)*
- *Teaching strategies to promote effortful processing of information/stimuli (eg, verbal elaboration and visual imagery)*
- *Use of techniques that constrain errors (eg, errorless, spaced retrieval)*
- *Consider the use of behavioral memory strategies with a focus on context and imagery in the acquisition phase of learning*

(updated from INCOG 2014,[16] Memory 4, p. 379).

Level A evidence.

There has been no evidence to change this recommendation from the INCOG 2014 guidelines, which summarized the evidence related to the instructional techniques associated with effective learning when teaching skills, specific information, the use of internal and external compensatory strategies, and prospective memory tasks.[71–76] Important teaching principles including breaking down specific instructional sequences to teach completion of a functional task,[74] using spaced retrieval,[24,77,78] and distributed practice recall[79] remain relevant. Further, employing multiple instructional methods was effective when teaching a variety of functional tasks.[28,80] Systematic instruction using approaches such as task analysis is effective in teaching functional tasks. Structured cognitive training programs, developed to teach specific prospective memory skills, are associated with good generalization of learned skills.[75,81] Ensuring that instructional training is errorless or constrains errors[82–89] was further supported in a recent review article.[90]

Memory #5: Group-based interventions may be considered for teaching memory strategies with individuals with MS-TBI, but there is no evidence that it is more effective than individually oriented rehabilitation. Consider reducing heterogeneity in group membership, encourage participation for an adequate number of sessions, and teach generalization of learned skills (updated from INCOG 2014,[16] Memory 5, p. 381).

Level A evidence.

The INCOG 2014 recommendation related to group-based interventions summarized the level A evidence supporting such interventions. Studies were conducted at least 1 year post-injury with primarily MS-TBI, and were shown to successfully instruct the use of external compensatory strategies,[91] structured and individual internal compensatory strategies, metacognitive memory strategies while fostering social support and reducing affective symptoms.[92,93]

This recommendation was modified based on new evidence. This included a review of the efficacy, and cost of group-delivered cognitive rehabilitation was examined in a multi-center, 2-arm, parallel-group, pragmatic RCT.[94] The intervention was a manualized 10-week group memory rehabilitation program (ReMemBrin) that included attention retraining (letter cancellation task), instruction in internal strategies to deepen the encoding process, and assistance in choosing external compensatory aids. Instruction emphasized errorless learning and the use of strategies based upon functional needs. The intervention group was compared to a control group receiving "usual care" that involved limited memory training. Study results showed no significant difference between the 2 groups on behavioral and subjective memory measures, or on quality-of-life analysis. The lack of treatment effect was considered in the context of practice effects associated with

test-retest administration, which has been shown on memory measures to produce moderate effect sizes in control groups.[2,43] Participants were quite heterogeneous in terms of acuity and severity with inclusion commencing at 3 months post-injury, and with participants "who attended not to obtain help but for altruistic reasons." The recruitment strategy precluded description of TBI severity, as participation was based upon the ability to attend the same day at a specific venue. Finally, attendance was variable with about 77% of participants attending at least 4 or more sessions of the 10.

Leśniak et al[95] conducted an RCT comparing the efficacy of group and individual memory rehabilitation to a no-treatment control. Participants were mixed TBI (49%) and cerebrovascular accident, encephalitis patients (51%) with memory impairment either diagnosed by a professional, observed by a family member, or reported by the patient, with no classification of impairment severity. Participants' average pretreatment Rivermead Behavioural Memory Test (RBMT) scores appeared to be at a relatively mild impairment level. Both treatment groups received structured memory training over 15 sessions with differences in delivery of strategies. Group intervention was a structured program with access to a facilitator and an emphasis on members sharing strategies. Individual intervention involved computerized practice of memory strategies with supervised training of strategy implementation. Significantly improved posttreatment RBMT scores were found for all 3 groups, with the intervention groups showing greater relative improvement, but not significantly greater to that of the control group. Again, control group improvement was considered in the context of studies demonstrating a treatment effect in memory rehabilitation studies, with similar effect sizes found in the current study. Participants with individual instruction performed better on computerized outcome measures whereas those in the group intervention showed greater improvements on practical tasks, likely a reflection on how memory strategies were practiced. These findings further support the recommendation to consider reducing heterogeneity in group membership and that strategies should be generalizable to functional tasks. Prior studies that produced less equivocal results in a group setting ensured that participants had similar levels of memory impairment, members completed required sessions, and all participants were in the chronic stage of recovery post-TBI.

Memory #6: The acetylcholinesterase inhibitor (AChEI), donepezil, may be considered for adults with TBI who have deficits in memory and are in the chronic stage of recovery. The effects of the medication should be assessed using objective and functional measures. Patients should be monitored for side effects such as diarrhea, stomach upset, and nausea (updated from INCOG 2014,[16] Memory 6, p. 381).

Level A evidence.

Cortical mechanisms mediating episodic memory consolidation involve medial temporal lobe structures and are regulated by the cholinergic neurotransmitter system. Acetylcholinesterase inhibitors (AChEI) have been associated with improvement in objective measures of memory performance in the chronic adult TBI population. A recent systematic review examined the effects of AChEI on cognition for individuals with MS-TBI.[96] Due to the lack of well-controlled studies, inclusion criteria were modified to include less severe injury, a minimum of 5 participants, and participants taking centrally activating drugs. The review yielded 3 studies, all of which were included in the previous INCOG 2014 guideline, noting modest effects of rivastigmine and donepezil on self- report, but not standardized, measures of memory.[97–100] Previous evidence also included the RCT by Zhang et al[101] demonstrating improvement in short-term memory recall with donepezil, as well as open-label studies showing very modest results on standardized memory measures in the more chronic phases of TBI recovery.[102–107] More recently, the use of rivastigmine was assessed in individuals with MS-TBI in a randomized double-blind, placebo-controlled trial study across 5 Veterans Centers.[108] Of the 96 participants, about two-thirds had mild TBI and the remaining had MS-TBI. Results showed no significant improvement across a range of standardized memory measures including the subgroup of participants with MS-TBI.[108]

The use of donepezil in acute and subacute TBI populations was not supported in a study by Campbell et al,[109] who employed a retrospective longitudinal analysis of nonrandomly prescribed donepezil with 55 participants with MS-TBI compared with 74 controls receiving standard TBI treatment. No significant differences were found on standardized memory measures or on the Disability Rating Scale or Functional Independence Measure scores. This evidence would support donepezil being considered for use in the chronic stage post-injury.

Memory #7: Transcranial direct current stimulation (tDCS) should not be used to improve memory outside of the context of a randomized controlled trial (INCOG 2022).

Level A evidence.

This is a new recommendation and is based on studies examining the application of the noninvasive neurostimulatory and neuromodulatory techniques of transcranial direct current stimulation (tDCS) in MS-TBI when standard rehabilitation has been ineffective.[110] tDCS applies low-amplitude direct current to focal scalp regions inducing cortical excitability.[111] A systematic review[112] found 2 controlled trial studies using tDCS to determine the impact on memory in a severe TBI population. The first RCT pilot study[113] of participants

with severe TBI applied 15 sessions of computerized memory training along with tDCS compared with sham. Large effect sizes for treatment and sham groups were reported with no between-group differences. The second RCT study by Ulam et al[114] examined the application of repeated sessions of tDCS on electroencephalogram (EEG) oscillations and neuropsychological tests (including immediate and delayed memory for verbal and visual-spatial material). EEG findings after 1 session of tDCS demonstrated increased cortical excitability, which was associated with cognitive performance improvements; however, no difference between the active and sham groups on standardized cognitive tests including memory was found. Rushby et al[115] addressed possible methodological challenges of using a sham control by employing a single-blind, randomized, within-group, crossover design with 30 participants with MS-TBI. In this protocol a single session of tDCS was applied while performing a working memory task (N-back) with no impact for active treatment.[116,117] Currently, there are a number of methodological differences and issues related to the application of tDCS for cognitive rehabilitation[116,117] and it should not be considered beyond experimental trials.

Memory #8: Methylphenidate and amantadine should not be used to improve memory (INCOG 2022).

Level A evidence.

This is a new recommendation based upon investigations of the impact of these medications on memory. The results of a systematic review did not show compelling evidence to support the use of methylphenidate to improve memory in individuals with TBI.[118] A meta-analysis of 17 studies,[119] reviewing the evidence for cognitive improvement following administration of methylphenidate to individuals with TBI relative to controls, found no impact on memory measures. Jenkins et al[120] included measures of episodic memory in his RCT study assessing the impact of methylphenidate on cognition by stratifying patients based on dopamine transporter binding. No effects for memory were found.

One meta-analysis reviewed the effects of amantadine on cognition following TBI synthesizing data from 20 eligible studies.[121] Very modest generalized improvements in cognitive functioning were reported relative to the control group across studies, but no conclusions could be made for memory as it was an embedded measure in the computerized protocols.

Finally, Hammond et al[122] assessed the impact of amantadine on memory in an RCT of 200 mg (twice daily) of amantadine for 60 days with 119 participants at least 6 months post-TBI. Memory-related results showed improvement in both control and treatment groups. This was posited to indicate strong practice effects, with results demonstrating that amantadine did not improve memory performance.[122] In combination, the studies published to date examining the use of methylphenidate and amantadine do not provide sufficient evidence for their use in ameliorating memory impairments post-TBI.

Algorithm

Clinicians are encouraged to follow the decision algorithm in the Figure 1 that highlights how to navigate through this series of guidelines.

Audit tool

Table 3 outlines the items that could be audited from the chart. Clinicians and organizational leaders are encouraged to use these tools in review or audit of individual patient charts to determine degree of adherence to the recommendations. This is most successful in changing practice when these audit results are fed back to the team for discussion of opportunities for improvement.

DISCUSSION

Memory impairment is a common consequence of TBI and requires assessment using measures of prospective and episodic memory, as well as evaluation of the impact on daily functioning. Rehabilitation goals should be developed that realize meaningful and practical outcomes. This can be achieved by implementing singular or multiple internal and metacognitive compensatory strategies in accordance with the type of memory impairment and generalized to practical situations. Structured visual imagery is the most commonly used internal compensatory strategy with episodic and prospective memory impairment and has the most effective functional outcomes when integrated with metacognitive techniques such as awareness training. Technological advances have improved the choices in external compensatory strategies. Mobile/smartphone technology is being increasingly selected as a reminder strategy based upon comfort, experience, and consideration of availability, portability, reliability, and cost efficiency. Paper and pencil organizational systems remain relevant for those not comfortable with technology. Both are effective prospective prompting systems that reduce forgetfulness of future intentions or tasks. The use of a PDA for microprompting is effective for completion of complex tasks where reduction of support staff may be required; however, accessibility and cost may be challenging. Well-established problems of generalizability to practical tasks remain a limitation for restorative techniques such as CCT.

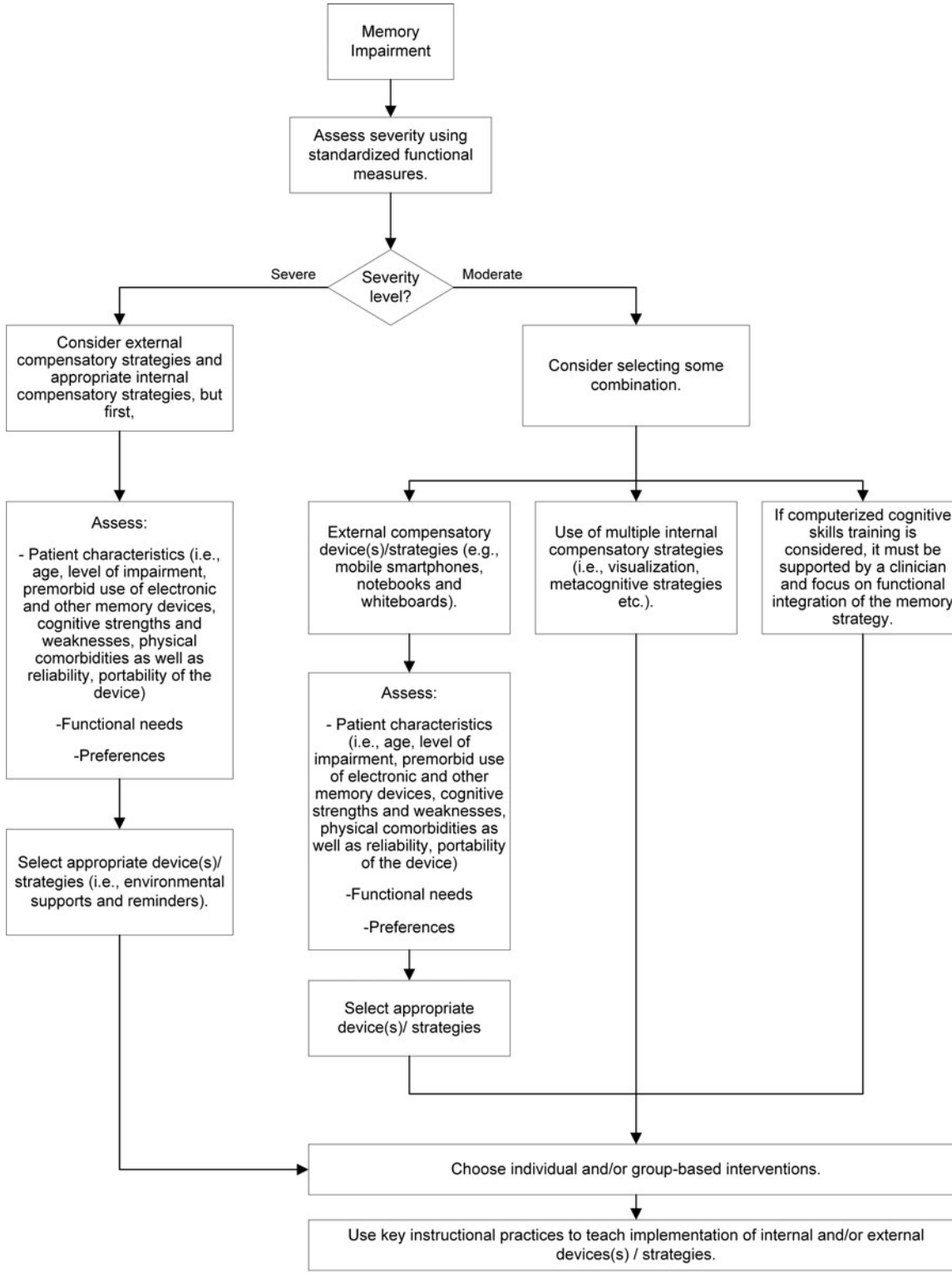

Figure 1. Memory algorithm.

TABLE 3 *Audit guidelines for priority recommendations: Memory*[a]

Intervention (guideline recommendation)	Specific activities, devices, or tools	Assessment of need and effectiveness	Patient characteristics	Discipline
Implementing internal compensatory memory strategies Teaching internal compensatory strategies may be used for individuals with TBI who have memory impairments. Their use tends to be most effective with individuals who have mild-to-moderate range memory impairments and/or some preserved executive cognitive skills. These strategies include instructional (eg, visualization/visual imagery, repeated practice, retrieval practice, and Preview, Question, Read, State, Test [PQRST]) and metacognitive strategies (eg, self-awareness, self-cueing, self-generation, and self-talk). Using multiple strategies is considered effective, selected separately or in a structured program, and strategies can be taught individually or in a group format. With severe memory impairment internal compensatory strategies that are found to be effective may be used in conjunction with external memory compensatory strategies (Memory #1; updated from INCOG 2014,[16] Memory 1, p. 374; level A evidence).	• Visualization/visual imagery • Repeated practice • Retrieval practice • Preview, Question, Read, State, Test (PQRST) • Metacognitive strategies (eg, self-awareness, self-cueing, self-generation, and self-talk)	• Assessment of memory severity and executive cognitive skills • Training provided • Assess transfer of strategy to functional tasks • Assess appropriateness for group intervention if this format is being considered	• Mild to moderate memory impairment—psychometric assessment • Describe aspects of executive cognitive functioning that may be preserved	• Neuropsych • SLP • Rehab Psych • OT • Other

(*continues*)

TABLE 3 *Audit guidelines for priority recommendations: Memory*[a] (Continued)

Intervention (guideline recommendation)	Specific activities, devices, or tools	Assessment of need and effectiveness	Patient characteristics	Discipline
External memory compensatory strategies: Environmental supports and reminders (eg, mobile/smartphones, notebooks, and whiteboards) are recommended for individuals with TBI who have memory impairment, especially for those with severe memory impairment. Individuals with TBI and their caregivers must be trained in how to use these external supports. *Note*: The selection of environmental supports and reminders should take into account the following factors: • Age, • Severity of impairment, • Premorbid use of electronic and other memory devices, • Cognitive strengths and weaknesses (eg, executive cognitive skills), • Physical comorbidities, and • Affordability, portability, and reliability (Memory #2; updated from INCOG 2014,[16] Memory 2 and 3, p. 378; level A evidence).	• Mobile/ smartphones • PDA—microprompting device • Notebooks • Whiteboards • Other applicable aids	• Assess individual characteristics and needs of patient • Training provided to care-givers/support staff • Assess usability or functional uptake of the strategy for patient	• All severity levels of memory impairment including amnesia and/or severe memory impairment—psychometric assessment	• Neuropsych • Rehabilitation Psych • SLP • OT • Other
Group-based instructional formats: Group-based interventions may be considered for enhancing memory capacity with individuals with mild-to-moderate memory deficits following TBI (Memory #5).	Appropriate group setting and materials	Assess patients' suitability for group-based intervention	Mild to moderate memory impairment—psychometric or functional assessment	• SLP • Neuropsych • Rehabilitation Psych • OT • Other

(*continues*)

TABLE 3 *Audit guidelines for priority recommendations: Memory*[a] (Continued)

Intervention (guideline recommendation)	Specific activities, devices, or tools	Assessment of need and effectiveness	Patient characteristics	Discipline
Cognitive skills training Cognitive skills training for MS-TBI, across all levels of memory impairment, should be strategy-focused and conducted by a TBI-experienced therapist who can further facilitate the functional integration of the strategy being practiced into meaningful and practical tasks. There is little evidence for using restorative techniques such as computerized cognitive training (CCT) alone. (Memory #3; updated from INCOG 2014,[16] Memory 7, p. 382, level B evidence) *Note: There is limited evidence to suggest that using restorative techniques such as computer-based training strategies alone is effective.*	• Therapist	• Assess for key functional goals and generalization tasks • Evaluation of functional transfer	• Mild to severe memory impairment—psychometric assessment	• Neuropsych • Rehabilitation Psych • SLP • OT • Other
Instructional practices for memory-impaired patients	• Materials for any structured programs being used • Appropriate environment and/materials for functional or ecologically valid tasks	• Assessment of memory and other cognitive skills • Training provided • Evaluation of functional integration	• Mild to moderate memory severity—psychometric or functional assessment	• Neuropsych • Rehabilitation Psych • SLP • OT • Other

(*continues*)

TABLE 3 *Audit guidelines for priority recommendations: Memory*[a] (Continued)

Intervention (guideline recommendation)	Specific activities, devices, or tools	Assessment of need and effectiveness	Patient characteristics	Discipline
There are several key instructional practices that can promote learning for individuals with TBI memory impairments, which include: • Clearly defining intervention goals. • Selection of and training of goals that are relevant to the person with TBI (ie, ecologically valid). • Allowing sufficient time and opportunity for practice. • Breaking down tasks into smaller components such as task analysis when training multistep procedures. • Use of distributed practice. • Teaching strategies using variations in the stimuli/information being presented (eg, multiple exemplars). • Teaching strategies to promote effortful processing of information/stimuli (eg, verbal elaboration and visual imagery). • Use of teaching strategies that constrain errors (eg, errorless, spaced retrieval). • Considering the use of behavioral memory strategies with a focus on context and imagery. (Memory #4; updated from INCOG 2014,[16] Memory 4, p. 379; level A evidence)				
Group-based interventions Group-based interventions may be considered for teaching memory strategies with individuals with MS-TBI, but there is no evidence that it is more effective than individually oriented rehabilitation. Consider reducing heterogeneity in group membership, encourage participation for an adequate number of sessions, and teach generalization of learned skills (Memory #5; Updated from INCOG 2014, Memory 5, p. 381; level A evidence)	• Group environment and any required materials	• Assess TBI severity and memory severity psychometrically • Assess goals	• Keep severity levels of patients in groups relatively similar • Can be used across injury severity range	• Neuropsych • Rehabilitation Psych • SLP • OT • Other

(*continues*)

TABLE 3 *Audit guidelines for priority recommendations: Memory*[a] (Continued)

Pharmaceutical interventions: Memory **Drug**	**Used**		**Indication**	**Patient characteristics**	**Found in**
Acetylcholinesterase inhibitors (AChEI) Donepezil (5-10 mg/day) may be considered for adults with TBI who have deficits in memory and are in the chronic stage of recovery. The effects of the medication should be assessed using objective and functional measures. Patients should be monitored for side effects such as diarrhea, stomach upset, and nausea. (Memory #6; Updated from INCOG 2014, Memory 6, p. 381; level A evidence)	Yes	No	• Memory impairment • Other (please specify):	• Evidence of deficits of memory • Functional outcomes measures administered	• Drug charts • MD notes • Other

Abbreviations: MS-TBI, moderate-to-severe traumatic brain injury; TBI, traumatic brain injury

[a]The audit tool items for memory—these are the items that the panel voted as the most important for implementation.

To optimize learning in individuals with TBI, specific instructional principles should be followed including clearly defining intervention goals, breaking down tasks into manageable multistep procedures, integrating practical and contextual exemplars, promoting effortful processing of information, focusing on ecologically valid goals, and constraining errors. Rehabilitation strategies can be taught in a mixed format including group and individual instruction. Delivery of structured memory rehabilitation as solely a group-based intervention should address factors maximizing cohesion including acuity and impairment level as well as ensuring that the practical components of training are applied directly to functional goals and participation.

The use of the AChEI donepezil is only weakly associated with improvement in memory and should only be prescribed in the chronic phase of recovery post-TBI, with implementation of clear functional indicators related to use. Based on the current literature, methylphenidate, amantadine, and rivastigmine have not been shown to improve memory performance. The use of tDCS may be considered in research trials but has not been shown to demonstrate improvement in memory performance to date.

Despite new evidence published since INCOG 2014, many of the recommendations and their level of evidence remain unchanged and there have been 2 new recommendations added to INCOG 2022.

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