Memory Training for Older Adults

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Normal ageing is typically associated with a decline in select domains of cognitive functioning, including processing speed, memory and executive functioning[1,2]. In addition, non-pharmacological interventions such as cognitive training and rehabilitation are being developed to enhance existing cognitive capacities, prolong independence in functional activities and promote healthy ageing. However, there is controversy as to whether cognitive stimulation enhances mental function[3] or decreases risk for Alzheimer's disease[4].

This chapter will present an overview of cognitive interventions that have been used with older adults, including healthy individuals with age-related memory changes, those with mild cognitive impairment (MCI), and persons with dementia, such as Alzheimer's disease (AD), and will include discussion of memory systems, metamemory, self-perceptions of memory, and interventions.

MEMORY SYSTEMS

Accumulated knowledge from studies in humans and animals has led to a widely accepted model of memory as being composed of multiple separate but parallel systems[5]. These multiple memory systems can be conceptualized as being either *declarative* or *non-declarative*[5]. Non-declarative memory is a general term for memory systems that do not involve conscious recollections but actions and performance-based tasks. Non-declarative memory is often targeted in rehabilitation interventions for skill maintenance, teaching skills, or functional abilities[6]. Declarative memory is the conscious recollection of information such as facts (*semantic memory*) and experienced single events linked to time and place (*episodic memory*)[7]. Individuals with progressive memory disorders, such as amnesic MCI and mild AD, present with deficits in declarative memory[8], which is the target of most memory enhancement strategies for non-demented persons and persons with milder forms of cognitive impairment.

Another conceptualization of memory relevant to cognitive enhancement interventions is the *levels of processing* approach, which comes from learning theory[9]. Levels of processing is the concept that memory is a function of the degree to which a stimulus is analysed. The deeper and more meaningful the analysis, the better the stimulus is remembered. In memory training, forming associations, images or stories can be considered deep processing strategies. It renders the information more distinctive, and helps integrate new information with a framework of pre-existing knowledge that provides cues for later retrieval[10].

METAMEMORY AND SELF-PERCEPTION OF MEMORY

A person's subjective understanding of their memory functioning is called *metamemory*. Most individuals have some understanding of their memory strengths, which might guide subsequent behaviours[11]. In non-depressed individuals, memory self-perceptions have been found to be accurate indicators of memory difficulties on objective tests[12], and may be indicators of underlying brain processes[13]. Several studies indicate that memory training interventions improve self-perceptions of memory ability and reduce memory complaints[14–16]. In healthy older adults, memory training may result in self-reported improvements in stability of memory functioning, and reduced anxiety and stress about memory functioning[15]. Effects of memory training on self-perceived memory are typically small, but nevertheless significant[14,17]. However, self-perceived memory ability is not always accurate. Persons with developing dementia may lose awareness of memory dysfunction as memory impairment advances[18,19].

TYPES OF COGNITIVE INTERVENTIONS

There are three primary approaches to cognitive training intervention: *cognitive stimulation, cognitive rehabilitation* and *cognitive training*[20]. The choice of approach depends on the degree and nature of deficits.

Cognitive stimulation typically involves participation in group activities and/or discussions aimed at general enhancement of cognitive and social functioning[21]. These types of interventions are non-specific to a cognitive domain, and include such activities as discussions of current events, supervised recreational activities, and group reminiscence therapies. Cognitive stimulation is typically used for demented patients and often as a control condition in studies investigating the effects of cognitive training.

Cognitive rehabilitation is an individualized intervention designed for patients with a specific brain injury or neurological disorder. Health-care providers work collaboratively with patients and their families or caregivers in order to identify personally relevant goals in day-to-day living and to develop strategies[20] that enhance functional tasks and activities of daily living, rather than increasing performance on a specific cognitive task[22].

The focus of this chapter is *cognitive training*, which involves learning and practising strategies to improve specific cognitive

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functions, such as memory, attention, or problem-solving. Cognitive training is often administered to people with mild forms of difficulties associated with normal ageing, and to clinical populations, including persons with MCI, dementia or schizophrenia. The goals of cognitive training are to maintain or improve cognitive function, and to learn to compensate for deficits. Cognitive training is based on the assumption that, with intensive training, people will apply the strategies they learn to real-life situations beyond the training session. Cognitive training typically involves teaching skills and strategies in a standardized and structured fashion to individuals or to small groups[12]. Strategies vary in difficulty level and can be traditional paper–pencil tasks, classroom instruction or computerized activities[20].

MEMORY TRAINING APPROACHES

Many training techniques have been developed to specifically improve learning and recall. The techniques vary with respect to complexity, structure and application. One example is *errorless learning*, which is based on the premise that remembering new information will be more efficient if errors during learning are minimized and/or immediately corrected[23–25]. *Spaced retrieval*[26], which is also known as expanded rehearsal[27], is another common technique and involves learning and retaining new information by recalling the information over increasingly longer periods of time[28,29].

Mnemonic strategies have been one of the primary memory interventions used within clinical settings. Generally, mnemonic strategies facilitate encoding and aid retrieval by enhancing the meaningfulness or personal relevance of information. Mnemonic strategies involve organizing information in meaningful ways, forming associations, or forming visual images. Examples include: (i) verbal organization (i.e. forming acronyms), (ii) semantic clustering and elaboration (i.e. categorizing lists of words into subgroups or clusters of items that share something in common; or creating a story linking all target words on a list), and (iii) visual imagery strategies (i.e. method of loci, face-name association, creating a mental picture of a target)[11].

One of the most popular and oldest mnemonic strategies is the *method of loci* technique, which was used by ancient orators to remember long speeches. The method of loci involves imagining a familiar path and identifying unique landmarks along the path. Visual imagery is used to associate items on a list with each landmark along the imagined path. To remember the list, simply take a mental 'walk' along the path, recalling each image at each landmark.

Another popular mnemonic strategy is *face-name association*[30]. Individuals can use the face-name method for remembering someone they just met. The face-name strategy involves three steps: (i) looking at a person's face and identifying a prominent facial feature, (ii) transforming the person's name into something imaginative or that sounds concrete or meaningful, and (iii) developing a visual image integrating the prominent facial feature with the transformed name.

The efficacy of mnemonic or memory training strategies has been examined in a number of studies. Factors associated with memory improvement in one meta-analysis included younger age, higher cognitive functioning, group setting (versus individual training), shorter duration of sessions, education and 'pretraining'[17]. Pretraining allows the participant to get comfortable with visualization and move beyond their comfort zone of thinking about ordinary or logical images. In addition, the number of sessions did not appear to limit the efficacy of memory training[17]. In fact, interventions as short as 4 weeks can be just as effective as programmes that are 8 weeks, or even 6–12 months long[31,32]. Most research demonstrating effectiveness of mnemonic techniques has focused on healthy adults, both young and old, but persons over 75 years of age show less improvement[33]. The few studies of efficacy in MCI populations have yielded mixed results[34,35]. A subset of subjects from the ACTIVE study (Advanced Cognitive Training for Independent and Vital Elderly) who were identified as 'memory impaired'(comparable to MCI) showed no significant benefit from memory training when compared to a no-contact control group, but had gains in speed of processing and inductive reasoning[36].

COMPUTER-ASSISTED COGNITIVE INTERVENTIONS

With the advancement of technology, researchers and clinicians are interested in computer-assisted training interventions for both healthy older adults and people with memory impairments. Initial studies have demonstrated that computer-based cognitive training has improved learning efficiency in healthy older adults[37], and supported cognitive and functional improvements in patients with AD[38]. Computer-based software technology has also recently been introduced in rehabilitative and training settings for patients with AD and MCI. Results seemed to suggest that the individualized rehabilitative intervention could have different effects according to a patient's diagnosis[39]. Cognitively intact older adults who received computer-based training demonstrated improvements in information processing, working memory and verbal learning/memory, and these gains were maintained over a five-month follow-up[40]. In mildly demented patients, computer-based training improved immediate recall of visual information and delayed retention of topographical information[38]. Combining a cognitive seminar and computer-assisted training in demented patients resulted in short-term improvement on measures of global cognitive functioning and short-term memory, as well as behavioural and social improvements[41].

Posit Science has developed a cognitive training program that contains increasingly difficult tasks of stimulus recognition, discrimination, sequencing and memory. Participants with mild cognitive changes associated with age demonstrated a significant increase on all computer tasks, with maintenance of improvements in attention over three months, when compared to active and no-contact controls[42]. In a subsequent larger trial, the Improvement in Memory with Plasticity-based Adaptive Cognitive Training (IMPACT) study[43], subjects demonstrated improvement in auditory memory and attention as compared to a general cognitive stimulation program that functioned as the active control condition.

Additionally, pilot studies have evaluated a computerized program, Brain Fitness by Dakim, which provides cognitive training and stimulation in language, visual processing, and memory domains. Results indicated improvement in memory functioning for those who could participate in the higher levels of the program, in addition to improved encoding and delayed recall for verbal pairs after just 10 sessions[44,45]. Presently, a clinical trial is underway to investigate the short- and long-term impact of this computer program on memory functioning in a larger sample of older adults with mild memory complaints as compared to wait-list controls.

As people become more technologically aware, computer programs are likely to become an important conduit for simulating real-life environments and integrating goal-directed behaviours in order to increase ecological validity[38]. These newer computer-based cognitive training interventions, however, have both advantages and

limitations. Many of the tasks included in these interventions are laboratory based and likely lack ecological validity for functional activities. Moreover, many older adults have not had regular exposure to modern technology and thus may be hesitant or cautious in using them. Some of the advantages to using computer-assisted cognitive training programs are their flexibility and ability to tailor interventions to specific aspects of cognitive impairments, as well as the ability of the computer to provide immediate and specific feedback regarding performance[40].

The effects of computer-based training on brain function have not been widely studied. To date, one study has shown that computer use (via internet searching) may involve more than a two-fold increase in brain activation (as measured by functional magnetic resonance imaging) for the areas of the brain that are associated with vision, complex reasoning and decision making[46].

COMPREHENSIVE PROGRAMMES

Comprehensive or 'multifactorial' memory training programmes address non-cognitive factors in addition to teaching cognitive enhancement strategies. Non-cognitive factors include: (i) self-efficacy, expectations, and beliefs about one's ability to improve cognition; (ii) anxiety; and (iii) general education about memory[10,14,17,47,48]. Comprehensive training programmes may include interventions for stress or anxiety reduction, and cognitive restructuring to counter negative and self-deprecating thoughts about memory ability. Most programmes include pre-training because this facilitates learning more complex cognitive techniques. Overall, these integrative approaches take into account the multiple factors that impact an individual's receptiveness, or response to cognitive enhancement interventions.

There is recent evidence that the role of lifestyle and environmental factors can be neuroprotective and possibly lower the risk for developing AD[49]; therefore, some researchers have developed comprehensive healthy lifestyle programmes that incorporate aspects of diet, physical exercise, relaxation strategies and mental exercise[50]. Small and colleagues[51] developed a 14-day lifestyle programme consisting of memory mnemonics, mental puzzles, cardiovascular exercises, diet and recipe suggestions and relaxation strategies. Subjects in the healthy lifestyle intervention group demonstrated significant improvement on objective measures of verbal fluency, and FDG-PET imaging revealed a 5% decrease in activity in the left dorsolateral pre-frontal cortex, an area associated with working memory, semantic organization skills, anxiety and verbal fluency. This decrease in activity was interpreted as greater cognitive efficiency. This 14-day programme was then expanded into a classroom-based Memory Fitness curriculum, which has recently been implemented and studied in retirement homes[52,53]. Participants in the memory fitness programme had fewer memory concerns and better performance on immediate and delayed recall measures as compared to controls.

Researchers have developed similar programmes for individuals with amnesic MCI[34,35]. These programmes are typically comprised of multifaceted group-training sessions that include relaxation techniques, education regarding memory and ageing, memory skills training, cognitive restructuring of memory-related beliefs, information regarding appropriate diet and recreational activities, and availability of community resources[35]. Intervention programmes for those with MCI typically focus on improving memory for daily tasks and maintaining a level of functional independence[54]. A four-week multi-component rehabilitation programme resulted in improvement in activities of daily living, memory functioning and mood compared to a wait-list control group[55]. An additional programme utilized occupational therapy and behavioural training with computerized cognitive training; results showed improvement in cognitive and affective status of patients with MCI and mild dementia[56].

Another area of research to consider is the combination of medication with a computer-based cognitive training programme, suggesting that a combination of pharmacological and non-pharmacological treatment in MCI might maximize the effects of acetylcholinesterase inhibitors and delay memory deterioration and conversion to AD[32,57,58]. Gains may be maintained for approximately six months to one year, but individuals tend to experience a gradual deterioration by year two[57]. Although the effects are time limited, these findings suggest a complementary relationship between cognitive interventions and drug therapy for both cognitive and psychosocial disturbances.

LONG-TERM OUTCOMES

Few studies have evaluated the long-term effects of cognitive interventions in healthy older adults. Overall, the effects of memory training interventions have been found to last from six months to five years[59–62], although the benefits tend to attenuate over time. The largest clinical trial to date is the ACTIVE study ($n = 2832$), which evaluated the effectiveness and durability of cognitive interventions on objective cognitive tests and on subjective and objective instrumental activities of daily living (e.g. financial management, driving)[62,63]. This longitudinal study incorporated 3 cognitive training groups receiving a 10-session training programme for memory, reasoning, or speed of processing, and a wait-list control group. Subjects also received periodic refresher courses, called 'booster sessions', on the skills initially trained. Follow-up results from two[63] and five years[62] revealed that the cognitive interventions in each group helped increase performance on objective measures of cognitive ability for which they were trained. According to self-report measures, this effect was significant only for the reasoning group, although the effect sizes for memory and processing speed were similar in magnitude to the reasoning effect sizes. Performance-based results demonstrated significant speed of processing benefits after additional booster sessions[62]. It is important to note that the lasting impact of cognitive interventions is still dependent on the individual's effort and motivation to maintain the use of the strategies. Future research in this area may consider factors such as motivation and maintenance in order to preserve treatment gains.

FUTURE DIRECTIONS

Overall, cognitive interventions are effective in improving cognition in subjects with mild age-related cognitive declines. However, there are important aspects of cognitive training that deserve more scrutiny. For instance, there is a need for more studies of persons with mild cognitive impairment and additional longitudinal studies in healthy older adults, in order to address whether cognitive training can delay dementia onset. Future studies should include functional outcome measures, to better address whether training can generalize beyond laboratory tests and improve practical, day-to-day functions[34,35]. In addition, there are still unaddressed questions, such as how engaging in stimulating everyday activities (also called an engaged lifestyle) is as effective as specific cognitive training[64,65].

Another important area for study is non-compliance, which may partially account for the lack of generalization and maintenance of cognitive strategy use. The key to long-term benefit appears to be continued use of cognitive strategies after initial training ends[60]. One solution to improve compliance is the implementation of periodic 'booster sessions', which may further help individuals use techniques with greater consistency and in more generalized situations (e.g. daily 'to-do' lists)[62,63].

Another limitation is the knowledge-base for the impact of 'brain games' and programmes targeted at stimulating cognition (e.g. crossword puzzles, sudoku problems, hand-held computerized games) on facilitating memory improvement. Although epidemiological studies suggest an association between engaging in cognitively stimulating activities and lower dementia risk[4,66], these studies do not prove a cause and effect relationship.

Finally, the effect of cognitive training on brain function has received minimal attention. In the few studies available, cognitive training does affect brain activation or resting state brain activity, including areas associated with encoding and retrieval[50,67,68], and training may also result in changes in neurochemistry[69]. Including brain function outcome measures will be important in addressing the more direct effects of cognitive training on neural circuitry and the mechanisms of action in cognitive enhancement interventions.

CONCLUSIONS

In sum, the research to date suggests that cognitive training is beneficial to individuals with memory complaints associated with normal ageing. The effectiveness in demented individuals is less consistent compared to persons with normal ageing. Even less is known about the effects of training on persons with MCI. There are a number of factors to consider before implementing a treatment trial, including the design of the training, the duration of the training, long-term compliance and the possible necessity of concurrent medication for those with cognitive impairment. Many options and designs are available to tailor programmes to the needs of individuals, or to develop programmes for small groups. Additional studies on the effectiveness of cognitive training in persons with MCI will help clarify the outcomes for this growing patient group.

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