

Cognitive stimulation, training, and rehabilitation

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Cognition-focused interventions for people with cognitive impairment including mild-to-moderate dementia may be classified into three categories: cognitive stimulation, training, and rehabilitation. Cognitive stimulation, consisting of nonspecific cognition-enhancing activities often in group format, produces small improvements on some aspects of cognitive ability which can be accompanied by gains in quality of life, everyday functioning, and social interaction. Cognitive training which involves repeated practice of tasks that target specific cognitive functions, often using computers, provides improvements on trained tasks that usually do not translate to nontrained tasks and have little impact on real life. Cognitive rehabilitation represents an individual approach that focuses on disability rather than cognition per se and is helpful in terms of reaching personally relevant goals and improving day-to-day performance. Data are largely lacking to support commercial claims regarding the efficacy of video games or virtual reality and augmented reality devices. There is insufficient evidence from randomized controlled trials whether cognition-focused interventions can delay or prevent cognitive decline. However, data from prospective cohort studies strongly suggest that late-life cognitive activity is associated with a reduced risk of dementia.

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Introduction

Cognitive impairment is a key feature of dementia. The most frequent underlying causes are progressive neurodegenerative diseases. Since these pathologies affect multiple brain regions and neuronal networks, cognitive deficits are not limited to single domains such as memory, language, or perception (as in pure amnesia, aphasia, or agnosia) but simultaneously involve several functions, both on basic (attention, speed) and higher levels (executive function, social cognition). Nonpharmacological interventions that target cognitive functions address different populations, pursue different aims, and use different strategies. Prevention of cognitive decline and dementia involves asymptomatic people who are at risk of developing dementia due

to age, family history of dementia, or subjective cognitive complaints. The hypothesis here is that cognitive engagement strengthens the brain's resilience ("brain reserve" or "cognitive reserve") against neurodegenerative damage. Enhancement or maintenance of cognitive function is an important goal in people who already have some degree of cognitive impairment. The underlying assumption is that cognitive exercises improve trained functions and may transfer to nontrained domains. The practicing of compensatory strategies attempts to bypass impaired cognitive functions using internal (eg, mnemonics) or external (eg, memory aids, action prompters) tools. The concept is that people with dementia can adopt alternative strategies to reach personally important goals. Cognitive intervention strategies are usually classified into cognitive stimulation,

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cognitive training, and cognitive rehabilitation.¹ Although this classification has been called into question because the three categories are vaguely defined and many interventions comprise components of more than one category² it will be used for structuring the present article. Innovative cognitive strategies that take advantage of advanced information and computer technology and represent a rapidly growing market include video games, virtual reality, and augmented reality. Drawing mainly on systematic reviews and meta-analyses, the present article aims to provide an overview of cognition-focused interventions in cognitively healthy individuals and in people with mild cognitive impairment and dementia, and to discuss practical implications. Intervention effects are summarized in *Table I*.

Cognitive stimulation

This is a nonspecific approach where a range of different activities, usually in group format, are used to engage and stimulate the individual in order to enhance cognitive, social, and communicative functioning. Interventions often include components of reminiscence therapy, reality orientation, social activity, and sensorimotor exercises. Emphasis is on the involvement of multiple cognitive domains rather than the targeting of one specific cognitive function.¹

Cognitively healthy older adults

A review that did not clearly distinguish between cognitive stimulation and training showed that most studies targeted memory; other areas of exercise were attention and execu-

tive function. There was a large heterogeneity among interventions with regard to format (group, individual, computerized), intensity, and duration. Sample sizes were usually small. All interventions produced some significant improvements at least on single cognitive functions but had no impact on activities of daily living or quality of life.³

People with mild cognitive impairment

A meta-analysis on 17 studies concluded that cognitive stimulation programmes provided significant post-treatment benefits in overall cognition and episodic memory, as well as smaller, nonsignificant gains on executive function, semantic memory, attention and processing speed, visuospatial ability, and language.⁴ The positive effects of cognitive interventions in people with mild cognitive impairment are retained for 3 to 4 months after treatment termination.⁵

People with dementia

A Cochrane review and meta-analysis of 15 randomized controlled trials (RCTs) with varying duration and intensity, including a total of 718 participants who had mild-to-moderate stages of dementia, revealed a clear, consistent benefit of cognitive stimulation on cognitive function with a moderate effect size. The benefits of cognitive stimulation enhanced those of medication. The cognitive improvement remained evident at follow-up 1 to 3 months after the end of treatment. Benefits of moderate size were also noted on self-reported quality of life. Participants were reported to communicate and interact better than previously. No differences between treatment groups were observed

TYPE OF INTERVENTION	GROUP		
	Cognitively healthy older adults	People with mild cognitive impairment	People with mild-to-moderate dementia
Cognitive stimulation	Improves single CFs; no effects on ADL or QoL ³	Improves global CF and memory ⁴	Improves global CF, QoL, and communication; no short-term effects on ADL or PB ^{6,7} effects on ADL if maintained ⁸
Cognitive training	Improves trained cognitive tasks ^{12,14} attention, reaction time, and processing speed ¹⁰	Improves global CF, memory and attention ^{11,15} ; improves ADL if training is led by therapist ¹⁶	Improves global CF; benefits are related to frequency and intensity ¹⁷ ; no effects on ADL
Cognitive rehabilitation	No studies	No studies	Improves attainment of personally relevant goals ²⁰ ; inconsistent effects on global CF, ADL, QoL, and PB ^{19,20,22}

Table I. Effects of cognitive interventions. CF: cognitive function; ADL: activities of daily living; QoL: quality of life; PB: problem behaviors.

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regarding mood, activities of daily living, or problem behaviours.⁶ The results of the Cochrane review were confirmed by a more recent meta-analysis which showed a moderately sized effect of cognitive stimulation on general cognitive ability, a small benefit on quality of life but no impact on problem behaviors or activities of daily living.⁷ Maintenance cognitive stimulation for 24 weeks resulted in improvements of self-rated and proxy-rated quality of life and activities of daily living.⁸ The above findings were expanded in another recent meta-analysis on 33 studies involving people diagnosed with dementia. Post-intervention, a significant pooled effect size was found for cognitive stimulation versus nonactive controls using the Mini Mental State Examination (MMSE) as measure, corresponding to a group difference of 1.78 points. A smaller but still significant pooled effect size was seen versus active controls. On the Alzheimer's Disease Assessment Scale, cognitive part (ADAS-Cog), the pooled effect size was smaller, even compared with nonactive controls. The conservative threshold for clinical significance of two points on the MMSE was only reached in about half of the studies involving nonactive controls and only in two of nine studies using active controls. According to a small number of studies the favorable effects on cognitive ability were maintained at 3 months and 6 months after the end of the intervention.⁹

Cognitive training

Interventions of this kind involve guided practice of a standardized task targeting a specific cognitive function, typically without explicit teaching of memory techniques (mnemonics) or problem-solving strategies. The assumption is that repeated exercise will lead to an improvement in the cognitive domain trained, and may generalize to nontrained cognitive functions. Cognitive training is usually delivered individually, may be computerized or non-computerized, and is often adaptive, allowing an increase in task difficulty as expertise develops.¹ Since computer-based cognitive interventions are more cost-effective than traditional face-to-face formats, can be easily disseminated

and adjusted to individual performance, and overcome mobility barriers,¹⁰ they have gained considerable attention¹¹ and have triggered a “brain training” business.

Cognitively healthy older adults

A systematic review of 34 RCTs concluded that training in a particular cognitive domain using classic cognitive training tasks or neuropsychological software has the potential to improve performance in that domain compared with inactive or active control conditions.¹² According to the AC-

TIVE Study such effects may persist over 2 years or even longer.¹³ However, benefits of cognitive training do not translate into gains on nontrained functions. This also applies to computer-based online and performance-adaptive training using working memory, logic, and planning games (30 minutes per day, 5 days a week).¹⁴ In a systematic review, 38 studies on computer-based cognitive training programs in healthy older adults were evaluated. Moderate-to-large effect sizes were found on standard neuropsychological tests for attention, reaction time, speed of processing, working memory, executive function, memory, and visuospatial abilities.

Training sessions lasted from 2 weeks to 24 weeks, ranging from daily to three times weekly sessions. The studies suggest that classic cognitive training tasks are most likely to improve working memory, executive function, and processing speed. On the other hand, neuropsychological software appears to be most effective in the domains of memory and visuospatial ability. These studies also suggest that older adults do not need to be technologically savvy to benefit from computerized cognitive training.¹⁰

People with mild cognitive impairment

A review of computerized cognitive training found moderate but statistically significant effects on global cognition, verbal learning, verbal memory, nonverbal learning, working memory, attention, and psychosocial functioning. These results indicate a beneficial therapeutic role for computerized cognitive training in this population. No significant results were found for executive function (which may have been insufficiently trained), information processing

Innovative cognitive strategies that take advantage of advanced information and computer technology and represent a rapidly growing market include video games, virtual reality, and augmented reality

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speed, visuospatial skills, language, or instrumental activities of daily living. There was no difference across studies with active or passive controls.¹¹ These findings were confirmed and complemented by another recent systematic review showing that technology-based cognitive training in people with mild cognitive impairment (MCI) can provide benefits on noncognitive domains including reduced depression and anxiety. Improvements of activities of daily living or quality of life were only observed in single studies.¹⁵ According to another meta-analysis, computerized cognitive training in people with MCI does not impact measures of activities of daily living, whereas therapist-led interventions provide benefits in this regard, particularly if compensatory strategies are taught.¹⁶

People with dementia

A recent systematic review included 31 RCTs and a total of more than 2000 participants with a clinical diagnosis of dementia in Alzheimer disease (AD), mostly of mild severity. The review concluded that cognitive training, alone or when combined with other intervention methods, improved at least one cognitive outcome in 2/3 of the trials. Higher frequency (twice weekly or more) and intensity of training (24 sessions or more) were associated with greater benefits. Positive results were most often observed in global cognition (eg, assessed using the MMSE), but were rarely observed in specific cognitive domains. Many trials reported improvement limited to tasks in the same domain as training, but only three studies found a generalization of effects to other domains than trained. Effects on activities of daily living or quality of life were not reported. No clear evidence was found that combinations of cognitive training with other strategies are superior to cognitive training alone.¹⁷ A review focusing on computerized cognitive training identified 12 studies encompassing 389 participants with dementia. The overall effect on global cognition was weaker in this group than in individuals with MCI and was statistically nonsignificant. Interestingly, clinically meaningful effects were found only for studies that used non-traditional approaches to cognitive training such as virtual reality and exergaming (see opposite page).¹¹

Cognitive rehabilitation

This is a more individualized approach to helping people with cognitive impairments. Cognitive rehabilitation does not set out to train or improve cognition but uses a goal-

oriented approach to facilitate the management of functional disability.¹⁸ This type of intervention has only been used in people with mild-to-moderate dementia.

People with dementia

In people with early dementia in AD eight individual sessions consisting of personalized interventions to address pre-defined relevant goals supported by compensatory strategies significantly improved goal performance but had no effect on measures of cognition.¹⁹ In a small group of people with mild to moderate dementia training of instrumental activities of daily living (twice weekly for 6 months) which incorporated techniques of error-free learning and spaced retrieval resulted in significant improvements of the directly observed trained activities which were maintained after 3 months. The intervention had no effects on general cognitive ability, memory, quality of life, or behavior.²⁰ In another study on a small sample of people with early-stage Alzheimer dementia, 8 sessions of cognitive rehabilitation (60 minutes per session, once weekly) were compared with an active control condition. The intervention resulted in significant improvements on pre-defined individuals goals, general cognitive ability (MMSE), and self-rated quality of life.²¹ In a large, long-term RCT individualized cognitive rehabilitation was compared with cognitive training using standard tasks, reminiscence, and a passive control condition. Interventions were provided in small group format (exception: cognitive rehabilitation) in weekly sessions over 3 months followed by maintenance sessions every 6 weeks for 21 months. After 2 years, cognitive training and reminiscence had no effect on cognition, activities of daily living, behaviour, quality of life, or depression. On the contrary, the individualized cognitive rehabilitation therapy provided modest but clinically significant improvement; in particular, it reduced functional disability and delayed institutionalization.²²

Video games

Most video games have not been designed to improve cognition and are not targeted towards specific cognitive domains. A review of 8 studies on commercially available video games in cognitively healthy older adults found low-to-moderate effects on global cognition, reaction time, processing speed, executive function, and attention. Exercises lasted for 2 to 11 weeks and from 2 to 5 hours per week. Thus, video game training appears to have an impact on

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measures of reaction time and processing speed with less consistent results regarding measures of executive function and memory.¹⁰ In people with mild dementia, benefits of video games have also been reported on mood and behavior.²³ The combination of games and physical exercises has been termed “exergaming.” A very small number of studies in people with dementia have shown small effects of such combined interventions on episodic memory, instrumental activities of daily living, and physical performance.²⁴ There are no data regarding the comparison of video games and other cognitive interventions.

Virtual reality

This technology is defined as interactive virtual image displays to convince users that they are immersed in a synthetic space. The technology has been suggested for use in the areas of diagnosis and training for people with cognitive disorders and dementia. Virtual reality applications focus on navigation, orientation, face recognition, and instrumental activities of daily living. A characteristic which is particularly helpful in people with cognitive impairment is the high level of interaction that can be achieved using devices such as joysticks, gloves, and surfaces. Most current virtual reality systems for training concentrate on performing activities that are related to autobiographical memory or instrumental activities of daily living, such as cooking, driving, or shopping.^{25,26} To date, only small-scale studies have been conducted to explore virtual reality interventions in people with mild cognitive impairment or dementia, and no conclusions on their efficacy can be drawn.²⁷ Initial results confirm the feasibility of virtual reality interventions in older adults²⁸ and demonstrate improvements of cognitive functions even in people with questionable dementia.²⁹ However, transfer to real-world abilities appears to be a challenge.³⁰ Future development of virtual reality application needs to consider the particular needs of people with cognitive deficits and their carers and provide easy transfer into in-home and nursing home environments.

Augmented reality

This technology enhances a real environment by superimposing synthetic elements into the user’s perception. In contrast to virtual reality systems, users of augmented reality applications face real physical locations upon which additional virtual elements are introduced.³¹ To date, only

a few systems have been developed to assist people with cognitive impairment. An example is an ambient annotation system which notifies persons with dementia of digital tags or notes placed on objects or furniture by their carers.³²

Does cognitive training or stimulation prevent cognitive decline or dementia?

According to prospective cohort studies, cognitively stimulating activities are associated with a reduced risk of dementia,³³ while randomized controlled trials have demonstrated that cognitive stimulation or training provides cognitive long-term improvements.³⁴ Therefore it is tempting to assume that continuous cognitive activity or training may delay or even prevent cognitive decline and dementia. A putative neurobiological mechanism is that cognitive engagement may increase the brain’s resilience against neurodegenerative disease (“brain reserve” or “cognitive reserve”).³⁵ However, there is currently insufficient evidence regarding whether cognitive stimulation or training reduces the risk of future cognitive impairment or dementia.¹² In a nonrandomized 3-year study on cognitively healthy older adults, habitual levels of cognitive activity in combination with any degree of physical activity—but not without physical activity—were associated with a reduced incidence of MCI after 3 years.³⁶ A randomized comparison of physical activity, cognitive activity, the combination of both, and social activity as an active control several times per week over 1 year in older adults with MCI showed significant cognitive improvements in all four groups at study end point, but no differences between groups with regard to overall cognitive status or instrumental activities of daily living.³⁷ The prospective randomized FINGER Study started cognitively unimpaired older adults on a combination of cognitive training with other lifestyle modifications (diet, exercise) and vascular risk monitoring which improved executive functions and processing speed, but not memory, at 2-year follow-up.³⁸ The recently completed randomized MAPT Study compared a nutritional program with a multi-component intervention including group cognitive training with placebo in a large sample of nondemented older adults with cognitive complaints. The rate of cognitive decline after 3 years did not differ between the groups.³⁹ These findings confirm that cognitive activity, alone, or in combination with other intervention modalities, may preserve or even improve cognitive functions over extended periods of time. There is insufficient

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evidence to date, however, that cognitive interventions have a potential to delay or even prevent the incidence of cognitive impairment or dementia.

Discussion

Cognitive stimulation, ie, nonspecific cognition-enhancing activities, produces small improvements on some aspects of cognitive ability in cognitively healthy older adults, in people with mild cognitive impairment and in people with mild to moderate dementia. These gains are maintained for 3 to 6 months post-intervention. While the clinical significance of the effects of short-term cognitive stimulation remain questionable, maintenance cognitive stimulation over longer periods has been shown to enhance quality of life and activities of daily living. Because cognitive stimulation is usually performed in group format, it also provides benefits in social interaction and communication. Therefore, cognitive stimulation is recommendable as part of the management of people with any level of cognitive impairment excluding advanced dementia, in different settings. In contrast, cognitive training, ie, repeated practice of tasks that target specific cognitive functions that is often computer-based, provides improvements on trained tasks which do not translate to gains on nontrained tasks and usually have no impact on everyday performance or quality of life. The poor ecological validity could be due to the fact that cognitive training commonly addresses memory, speed, or perception, whereas everyday functioning is most closely associated with executive abilities such as inductive reasoning,⁴⁰⁻⁴² and self-rated or carer-rated quality of life is not predicted by memory or other cognitive abilities.⁴³ There are no data showing that cognitive training

is superior to cognitive stimulation in people with cognitive impairment. Cognitive rehabilitation is a therapist-intensive individual approach which targets disability rather than cognition per se. It improves the attainment of personally relevant goals as well as performance on day-to-day tasks in people with dementia, and may even delay institutionalization, but has little impact on cognitive abilities. There are no convincing data on the efficacy of video games, virtual reality, and augmented reality in people with cognitive impairment. Therefore, commercial claims regarding the benefits of these kinds of interventions must be met with caution. As yet, there is also no evidence from randomized controlled trials that cognitive interventions can delay the onset of cognitive impairment or dementia in people at risk. Randomized and controlled studies with long follow-up intervals are needed to demonstrate such preventive effects. Since it is not clear whether treatment programs combining multiple modalities are likely to provide additional benefits over single-component strategies, interventions in preventive trials need not be limited to complex variants. While conclusive evidence from randomized trials is still awaited, a large body of data from prospective cohort studies shows that greater participation in late-life cognitive activities is associated with a lower incidence of dementia. This strongly suggests that a cognitively active lifestyle including cognitive stimulation or training may offer some reduction in risk of dementia. More research is needed to better characterize the type, duration, intensity, and timing of cognitive activities before more specific recommendations can be developed.⁴⁴ ■

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