Can computer-based cognitive training improve cognition in patients with mild cognitive impairment or dementia? A review

O treinamento cognitivo baseado em computador pode melhorar a cognição em pacientes com comprometimento cognitivo leve ou demência? Uma revisão

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ABSTRACT
The cognitive training (CT) as well as physical interventions have the potential to enhance cognition in healthy adults and thus constitute promising approaches to prevent cognitive aging or even to delay the onset of cognitive impairment or dementia. In the milder stages of dementia, cognitive impairments are often the most disabling and distressing features for the individual and their family. The CT aims to improve specific cognitive processes or global cognitive ability, and when used as an intervention approach with clinical populations, there is also an expectation that improvements in cognition will generalise to improvements in functional outcomes.

Keywords: cognitive training, mild cognitive impairment, dementia, neuropsychology, cognition

RESUMO
O treinamento cognitivo (TC), bem como as intervenções físicas, têm o potencial de melhorar a cognição em indivíduos saudáveis e, portanto, constituem abordagens promissoras para evitar o envelhecimento cognitivo ou mesmo para atrair o aparecimento de comprometimento cognitivo ou demência. Nos estágios mais leves da demência, as deficiências cognitivas são frequentemente as características mais incapacitantes e angustiantes para o indivíduo e sua família. O TC visa melhorar processos cognitivos específicos ou capacidade cognitiva global e, quando usada como abordagem de intervenção em populações clínicas, também há uma expectativa de que melhorias na cognição generalizem para melhorias nos resultados funcionais.

Palavras-chave: treinamento cognitivo, comprometimento cognitivo leve, demência, neurofisiologia, cognição

1. INTRODUCTION
Dementia refers to a clinical syndrome characterized by progressive cognitive decline that interferes with the ability to function independently. Routine clinical practice shows that the cognitive and functional changes are typically accompanied by changes in behaviour and in personality, but these have not become core criteria as they have been considered heretofore to lack sufficient diagnostic specificity (CHERTKOW et al., 2013; MENDOZA LAIZ et al., 2018).

Dementia is an umbrella term used to describe a clinical syndrome of progressive cognitive decline, but its subtypes are classified according to the cause. The incidence rises with age making it an increasingly common phenomenon within our aging population. The association of both overt cognitive decline and underlying pathophysiological processes with normal aging complicate the
process of identifying disease processes early within the spectrum of normal aging (Cunningham et al., 2015; Mendoza Laiz et al., 2018).

The mild cognitive impairment (MCI), a stage between the expected cognitive decline of normal aging and the more serious decline of dementia, can involve problems with memory, language, thinking and judgment that are greater than normal age-related changes. The conversion from MCI to dementia can be conservatively estimated at 5% to 10% per year, and similar rates have been observed in the opposite direction. Thus, MCI is an unstable cognitive state with potential to avert progression to dementia and attendant health and societal sequelae (Hill et al., 2017; Knopman et al., 2015).

Due to the increasing prevalence of MCI, pharmacological and non-pharmacological treatments have been greatly concerned about their effects (Li et al., 2017). Cognitive training as well as physical interventions have the potential to enhance cognition in healthy older adults and thus constitute promising approaches to prevent cognitive aging or even to delay the onset of cognitive impairment or dementia (Kelly et al., 2014; Smith, 2016).

2. COMPUTER-BASED COGNITIVE TRAINING

Developing interventions to delay the onset of cognitive decline and dementia is of increasing interest. Computer-based cognitive training (CCT) is a potentially important tool for individuals at risk of dementia. The core of CCT is software designed to engage and practice cognitive functions. Some programs are explicitly aimed at a single cognitive domain, while others target an array of domains. Altogether there are three general approaches to enhance cognitive functions with the help of a computer. These include brain training programs, working memory training programs, and video game training programs (figure 1) (Boot; Kramer, 2014; Shah et al., 2016).

![Diagram of Cognitive Training Approaches](image_url)

**Figure 1.** Improvement of cognitive functions in response to a training.
CCT uses computers for the delivery of the intervention and differs from traditional Cognitive Training (CT), which usually incorporates face-to-face contact with a professional and paper-and-pencil paradigm. CCT has several advantages including cost-effectiveness, increased accessibility and ability to customise the content and difficulty of the training (GATES; VALENZUELA, 2010).

Some CCT interventions also include the interaction with trained facilitators. One role of a facilitator is to provide coaching to help improve training performance. Other add-ons to CCT include training of metacognitive strategies and strategic monitoring. The value added of these add-on CCT activities is not fully understood, but they are believed to, at a minimum, enhance engagement in the CCT program. (HARVEY et al., 2018; SHAH et al., 2016).

The CCT is a promising strategy to promote healthy cognitive aging, and is also a feasible strategy for those who are limited in their abilities to participate in other lifestyle strategies, such as exercise. Cognitive interventions are diverse treatments based upon the distinct theoretical constructs of maintenance and improvement for the purposes of preventing decline, restoring reduced function, and compensating for impairment (TEN BRINKE et al., 2018).

3. COGNITIVE TRAINING IN CLINICAL POPULATIONS

The CT aims to improve specific cognitive processes or global cognitive ability, and when used as an intervention approach with clinical populations, there is also an expectation that improvements in cognition will generalise to improvements in functional outcomes (figure 2). The underlying premise of CT is that intensive cognitive exercises may build up or restore brain and cognitive reserve, providing greater resilience against neuropathology and maintaining function (LIBERATI; RAFFONE; OLIVETTI BELARDINELLI, 2012).

Figure 2. Effects of Cognitive Training Interventions.
It has been further suggested that cognitive stimulation may result in neural plasticity and neural compensation, that is, in the development of compensatory networks maintaining cognitive performance and potentially masking or preventing the clinical manifestation of neurocognitive disease (GATES et al., 2019; GRADY, 2012).

An important assumption of CT is that any effects of practice will generalise beyond the immediate training context. In other words, improved performance on a given task should lead to improved performance on other, related tasks that depend on the same cognitive process or ability. Although this last assumption has not often been supported by the evidence, some have argued that failure to produce transferable benefits is related in part to problems with task design (OWEN et al., 2010; PAPP; WALSH; SNYDER, 2009).

Adults with MCI and subjective cognitive decline may possibly benefit from CCT in terms of improved cognitive function, however, studies investigating the effectiveness of CT in improving cognitive performance in people with MCI have demonstrated small to moderate improvement but existing research suffers from methodological concerns (GATES et al., 2011; REIJINDERS; VAN HEUGTEN; VAN BOXTEL, 2013).

4. APPROACHES TO IMPROVE COGNITION

The use of technologies is increasingly accepted in modern society, not only in educational settings and the general population, but also in the clinical field. There are three popular approaches to improve cognition: brain-training programs, working-memory training, and video-game training.

Some brain training (BT) platforms, BT applications and BT video game-like products are becoming very popular. The BT is a program or activity which purports to improve a cognitive ability or general capacity by repeating certain cognitive tasks over a period of time. This is supposed to produce some changes in behaviour, as well as at a neuroanatomical and functional level. It also refers to practicing core cognitive abilities with the goal of improving performance in other cognitive tasks (RABIPOUR; RAZ, 2012; SIMONS et al., 2016).

Working memory (WM) is the set of cognitive processes that work to maintain and manipulate task-relevant information during cognitive task performance, while also preventing interference from task-irrelevant information. Training of working memory as a method of increasing working memory capacity and fluid intelligence has received much attention in recent years. These trainings have been investigated in many different areas of cognition ranging from rote learning, problem solving and WM through to expertise in highly specialized domains such as chess and academic learning (BADDELEY, 1992; CLARK; LAWLOR-SAVAGE; GOGHARI, 2017; KNOPMAN et al., 2015).
Video-game training (VGT) has attracted increasing attention from both the public and from researchers, many studies found that VGT improved a variety of cognitive functions. Due to multiple cognitive domains being involved in VGT, it has gradually attracted many researchers’ interest and has become one of the main intervention types to enhance cognitive functions (GREEN; BAVELIER, 2003; KASTELEIJN-NOLST TRENITE et al., 2002).

5. FINAL CONSIDERATIONS

A number of different approaches, aiming at brain neuroplasticity, such as cognitive training and cognitive stimulation have entered the picture as potential strategies for the prevention and treatment of the cognitive and behavioural symptoms of clinical populations. Some studies presenting negative conclusions about CCT efficacy have inconsistent definitions of the treatment targets and cognitive improvement. The controversy regarding whether CCT has a benefit is based on definitional inconsistencies. The CCT can lead to the improvement of cognitive functions such as working memory and reasoning skills in particular. It is important to pay close attention to the methodological standards in future clinical studies.

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