

# Computerized Cognitive Training Is Beneficial for Older Adults

*Amit Lampit, PhD,\* Michael Valenzuela, PhD,\* and Nicola J. Gates, PhD†*

**R**esearch efforts to determine whether computerized cognitive training (CCT) benefits cognition in older adults have spanned more than two decades and dozens of randomized controlled trials (RCTs) encompassing thousands of participants.<sup>1,2</sup> The wealth of evidence from such trials allows us to determine not only whether CCT is an efficacious intervention to improve cognition, but also what cognitive domains are likely to respond and what training regimens are likely to yield the greatest effects.<sup>1</sup> Despite this empirical database, the efficacy of CCT remains controversial in the scientific community, and both sides of the debate encourage further research.<sup>3</sup> In our opinion, the “brain training debate” has become a vehicle for point scoring rather than productive evaluation of a cognitive intervention. Ideally, research should focus on establishing a coherent research agenda for clinical implementation and developing guidelines for regulation of commercial products as medical devices under federal law.

## SEPARATING QUALITY RESEARCH FROM FALSE CLAIMS

Growing consumer demand for interventions to improve cognitive function and protect against cognitive decline, coupled with heavy investments in advertising over the past several years, have created a lucrative and unregulated market for “brain training” products. Dozens of programs are currently in the marketplace. Some programs have been tested in RCTs, but many have a limited research base and, in some cases, misrepresent results of flawed or irrelevant studies lacking research rigor to support their claims.<sup>3</sup> Consequently, the commercialization of CCT and aggressive marketing of disproportionate claims have clouded proper scientific assessment of CCT efficacy. Our view is based on evidence from RCTs, not marketing or

messaging from commercial products. This evidence, and the polemical atmosphere the field finds itself in, supports our recommendation for further quality research and regulation of products in line with medical device standards.

## EFFICACY IN COGNITIVELY HEALTHY ELDERLY ADULTS

The number and quality of randomized CCT trials in older adults has increased substantially in the past decade. A mid-2014 meta-analysis of 52 RCTs with healthy older adults comparing the cognitive effects of CCT for 4 hours or more with active or passive controls encompassing 4,850 participants found that the effect of CCT intervention on overall cognitive outcome was statistically significant (effect size  $g = 0.22$ ,  $P < .01$ ).<sup>1</sup> Trials of group-based CCT showed a more-pronounced effect (32 trials, effect size  $g = 0.29$ ,  $P < .01$ ), an average improvement of approximately 1 point on the Mini-Mental State Examination. Small to moderate effect sizes were also found for memory, speed, and visuospatial cognitive domains but not for executive functions. These improvements were found in performances on independent neuropsychological measures, not trained tasks, and indicate transfer of CCT benefit. They did not depend on the type of control (no contact vs active control) or risk of bias (assessor blinding and adherence to intention to treat), and there was no evidence of publication bias across studies,<sup>1</sup> findings that counter common criticisms of CCT.<sup>3</sup> Therefore, on the basis of substantial RCT evidence, we conclude that CCT can benefit cognition in healthy older adults.

## EFFICACY IN ADULTS WITH MILD COGNITIVE DEFICITS

Adults with varying degrees of cognitive deficit have also demonstrated significant cognitive gains after CCT.<sup>4</sup> A systematic review of 16 CCT trials in people with mild cognitive impairment (MCI)<sup>2</sup> found moderate effect sizes for independent measures of attention, executive function, and memory, and these benefits persisted at longitudinal follow-up. The review also found significant positive effects on psychological well-being. Individual studies in MCI document positive effects on widely used clinical

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From the \*Regenerative Neuroscience Group, Brain & Mind Research Centre, University of Sydney, Sydney, NSW, Australia; and †Centre for Healthy Brain Aging, Faculty of Medicine, University of New South Wales, Randwick, NSW, Australia.

Address correspondence to Nicola Gates, Centre for Healthy Brain Aging, Faculty of Medicine, University of New South Wales, Randwick, NSW 2031 Australia. E-mail: n.gates@unsw.edu.au

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neuropsychological batteries (e.g., Alzheimer's Disease Assessment Scale cognitive subscale and Repeatable Battery for Neuropsychological Status),<sup>2,4,5</sup> which represent broad cognitive abilities rather than performance of a single task, suggestive of generalization.<sup>3</sup> Finally, one small randomized delayed-start trial with longitudinal follow-up has shown that none of the participants with MCI who received paper- and group-based cognitive training converted to dementia, compared with a 25% conversion rate in a late-start control group.<sup>5</sup> Evidence is therefore mounting that CCT is effective in protecting against further cognitive decline in individuals with cognitive decline.

## FACTORS THAT MODERATE EFFICACY

Arguably, the critical question is not whether CCT works but rather what kind of training is most effective in improving cognitive function beyond trained task. Our analyses suggested that transfer from CCT tasks to cognitive domains and global cognitive index occurred after training in a group format, when sessions exceeded 30 minutes per session, and when frequency of training was limited to one to three times a week. This, therefore, ought to be the recommended "prescription" at this time for older adults. By contrast, many studies test the effect of "underdosed" training protocols, and the model typically promoted in commercial products for at-home training is similarly limited and unlikely to be effective.

## TRANSFER OF CCT BENEFIT

Concerns regarding the lack of transfer of benefits from CCT are largely unfounded. Multiple studies in healthy and cognitively impaired adults indicate that training benefits extend beyond trained task to cognitive domains and global cognition.<sup>4</sup> Far transfer, or secondary benefits, of CCT benefit to instrumental activities of daily living (IADLs) and other high-order competencies, domains of function and psychological health have also been reported.<sup>4</sup> For example, the Advanced Cognitive Training for Independent and Vital Elderly (ACTIVE) Trial found significant effects on timed IADL, quality of life, driving<sup>6</sup> and depression,<sup>7</sup> but the time-course necessary for transfer to become apparent on IADL scales was long. Current scales are largely insensitive to longitudinal change and have major ceiling problems when used in normative samples that are the subject of prevention trials.<sup>6</sup> Notwithstanding these measurement shortcomings, preliminary evidence indicates that CCT can in principle generalize across important aspects of broader function.

## OPPORTUNITY OR OPPORTUNITY COST?

Evidence from animal research, epidemiological studies (observational and prospective), and clinical trials indicate that cognitive, social, and physical activities are vital to brain health and are associated with lower dementia risk and better cognitive function. CCT provides the opportunity to engage in one form of cognitively stimulating activity, but one popular criticism of this intervention cites the opportunity cost of this activity at the expense of time on

alternative activities such as "playing with grandchildren or exercising,"<sup>3</sup> although the implicit assumption that these activities are equal to or better alternatives than CCT requires empirical examination. For example, clinical research does not support the notion that the commencement of aerobic exercise will result in "noticeable gains in cognitive performance, or attenuation of loss"<sup>3</sup> to a greater extent than CCT. Recent meta-analyses of the effect of aerobic exercise on cognition generally (29 RCTs, 22 of which included older adults)<sup>8</sup> found small cumulative effect sizes ( $g < 0.20$ ), comparable with CCT, but CCT trials generally compare CCT with an active control, thereby demonstrating benefit above other forms of cognitive activity. In contrast, the majority of exercise trials compare exercise to wait-list control, proving the truism that doing something is better than doing nothing, rather than the higher standard of evidence that physical exercise has greater benefit than physical activity. Physical exercise has a range of documented health benefits, but here the focus is on cognitive health.

Therefore, there is no strong evidence base to argue that CCT has an associated opportunity cost or has less merit than other stimulating leisure activities. Rather, the relative merits of different cognitive, social, and physical activities need to be evaluated and made widely available so the public as consumers has choice, customizing their cognitive enrichment strategies to suit their individual needs.

## DEMENTIA PREVENTION

Multiple risk factors for dementia have been identified, including low mental activity<sup>9</sup> and MCI. CCT is one form of cognitively stimulating activity for older adults that may help address these risks as a preventative intervention to increase cognitive reserve and a restorative measure to improve cognition.<sup>4</sup> In adults with healthy and impaired cognitive function, CCT has been shown to improve cognitive function, thus combating the hallmark feature of dementia—cognitive decline—but whether CCT or any alternative intervention can cure or prevent dementia or outweigh the cumulative and multiple dementia risk factors (not least advancing age) is not the point. Rather, the working hypothesis is that, by improving and protecting cognitive function, CCT may delay onset of cognitive symptoms. At a population level, delay of symptoms is synonymous with prevention of the syndrome. This is not the same as preventing dementia in a specific individual. Although this remains an open empirical question, there is encouraging research that shows this may be possible, but more large-scale research is required on this vital public health issue.

## BEYOND CONTROVERSY

The Alzheimer's Association urges rapid development and testing of cognitive training given its potential as an effective and accessible cognitive intervention to delay and potentially prevent clinical dementia.<sup>10</sup> Well-designed training programs can deliver significant benefits to cognition,<sup>1,2</sup> daily function,<sup>5</sup> and psychological well-being.<sup>6</sup> In light of recent recommendations by the Alzheimer's

Association to prioritize trials of cognitive training along with other promising interventions,<sup>10</sup> we recommend that researchers embark on a productive dialogue on how to advance clinical application, in particular, how best to maximize the return on future CCT trials, with priority for large, long-term studies using symptom-relevant and person-centered endpoints, clarifying dose-response relationships, investigating methods for effective delivery, and maintaining benefits in the long term. Complimentary innovative studies aimed at elucidating the mechanisms of transfer and identifying the nature of accompanying neurobiological changes are also warranted. In the interim, the evidence base supports group-based CCT for older adults of at least 30 minutes per session one to three times per week. In sum, cognitive benefits in addition to technical simplicity, accessibility, and lack of side effects make CCT one of the most promising interventions in the field of cognitive aging.

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# Why Cognitive Training and Brain Games Will Not Prevent or Forestall Dementia

*Edward Ratner, MD, and David Atkinson, MD*

What do you get if you combine a common and frightening health condition (dementia), the theory of neuroplasticity, and the Internet? The answer is the creation of a rapidly growing, already \$2 billion per year industry.<sup>1</sup> By advertising “brain health,” the creators of on-line brain games have made many people believe that cognitive training will prevent or forestall dementia. This article will describe the fallacy of that premise, because there is no reasonable theory or empirical evidence to support it. In addition, leading experts in the field of neuroscience have reacted strongly against these efforts to mislead the public.

Even before Alois Alzheimer described the clinical and autopsy features of his eponymous disease more than 100 years ago, dementia was considered a pathological disorder caused by one of a variety of diseases. As understanding of neuroscience has grown, new diseases have been associated with dementia, such as human immunode-

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ciency virus infection and amyotrophic lateral sclerosis. Neuroplasticity, described as the ability of the brain to form new neural connections to enhance (or maintain) cognitive performance, may be useful in rehabilitation from stroke and some other acute onset brain diseases but is not as relevant in the types of degenerative diseases most commonly causing dementia. In addition, aging in the absence of disease is not considered a degenerative cognitive process that leads to loss of daily functions (dementia or, more precisely, using current nomenclature, major neurocognitive disorder).<sup>2</sup>

The complexity of cognition is increasingly recognized. Many different domains of cognition have been identified, some linked closely with specific neuroanatomical regions. Studies of cognitive training have addressed various domains, including memory, reaction time, executive function, processing speed, visual and auditory attention, manual control tasks, spatial ability, and reasoning. Many of these domains and others have been shown to contribute to loss of ability to manage daily activities.<sup>3</sup>