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Commentary

Training cognition: Parallels with physical fitness?☆

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In their article on memory training, McDaniel and Bugg (2012) first criticize the idea that any type of memory training will generalize to all other types; the notion that memorizing poems or speeches from plays will improve a person's memory for names or numbers, for example. We strongly agree with this criticism. Cognitive processes resemble physical skills in many respects, and few people would expect that hours of tennis practice would improve their golf game, or even that putting practice would improve driving off the tee. Memory is not one monolithic faculty. The authors of the target article then go on to advocate training methods that emphasize more specific aspects of memory performance, such as prospective memory, retrieval and recollection. We agree that this would be extremely valuable, but are somewhat skeptical that well attested methods exist at present (see Reichman, Fiocco, & Rose, 2010 for a recent review). Training strategies, with practice at applying relevant strategies to real-life problems, appears to hold out more promise for older adults, although again the present evidence is sparse. We await with interest the results of the authors' EXACT trial.

We certainly hope and expect that findings from laboratory studies of memory can be applied successfully to training regimes for older adults. McDaniel and Bugg suggest that the principles of spacing, variation and interleaving practice with various tasks and strategies may be helpful. Although they tend to lump strategy training methods together with more process-based training procedures, we feel it is important to distinguish between approaches that attempt to restore function as opposed to compensate for its absence. Although it has so far proven difficult to repair the neurobiological changes that underlie age-related declines in memory, circumventing these deficiencies by reliance on one's expertise or 'scaffolding' new learning by embedding it in within familiar contexts may be an effective line to pursue.

It is currently unclear whether short-term training programs can produce any significant lasting effects that are both measurable in the laboratory and meaningful in the real world. This is because many training studies are fraught with problems such as small sample sizes, a limited target population (e.g., only young adults, only healthy older adults), a poor control group (e.g., a no-contact control group), multi-factorial training (e.g., combined reasoning, speed, and memory training, so that it is impossible to determine the source of any observed benefit), a limited assessment of behavioral outcomes, particularly real-world assessment, and a lack of longitudinal follow up. Future studies should include large and diverse samples, one or more active-control groups, training programs that target a specific cognitive process or ability, variable training durations (so that it is possible to determine the minimal amount of training that produces optimal benefits), assessment of a wide range of outcome measures, and longitudinal follow-up assessments. The reason training studies to date have not included all of these desirable characteristics is obvious – conducting a well-designed training study is risky, costly and laborious. However, given the well-known statistics about the increasing proportions of elderly citizens in developed countries, it is vitally important for such studies to be carried out.

For the moment, two types of evidence provide some positive news: the first is that essentially all studies of memory training and

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adult learning have found that older people are capable of learning and retaining new knowledge and new cognitive skills. The brain is plastic and modifiable at all ages. The second positive aspect of the current literature on cognitive improvements in older adults is the beneficial effects of exercise referred to in the target article (e.g., Erickson et al., 2011; Kramer et al., 1999). We endorse McDaniel and Bugg's optimism about both of these developing lines of research, and wish to extend their evaluation with some comments of our own.

Activities that are known to protect against memory and cognitive decline are typically 'lifestyle' aspects, in which the relevant activities are undertaken for professional or recreational purposes, and are typically performed over many years (see Stern, 2009 for an assessment of the notion of 'cognitive reserve'). Examples include education (e.g. Bennett et al., 2003), participation in cognitively stimulating activities (Wilson, Mendes de Leon, & Barnes, et al., 2002) and bilingualism (Bialystok, Craik, & Freedman, 2007; Craik, Bialystok, & Freedman, 2010). There is also emerging evidence that such variables do not slow the accumulation of brain atrophy in medial–temporal and other brain regions, but rather provide some compensatory mechanism (cognitive or brain reserve) that offsets the cognitive decline. The current speculative assumption is that this compensation may arise from enhanced executive functions and attentional control processes that enable the person to function well despite clear signs of neural degeneration in other brain areas (Kidron et al., 1997; Luk, Bialystok, Craik, & Grady, 2011).

There is now good evidence that a course of aerobic exercise, maintained over some months can result in significant increases in brain volume in older adults – in both gray and white matter (Colcombe et al., 2006). In this study, the older participants were aged 60–79 years, were formerly sedentary, and performed sessions of aerobic walking over a 6-month period. It is interesting to note that a comparison group of young adults showed no brain changes as a result of similar exercise, so the intervention may be limited to individuals already showing signs of neural and cognitive decline. Other studies from Kramer's group have shown specific increases in hippocampal volume as a result of aerobic training (Erickson et al., 2011); also that the extent of neural growth relates positively to improvements in executive functions (Kramer et al., 1999) and in spatial memory (Erickson et al., 2011).

Several relevant lessons may be drawn from the studies of aerobic fitness. One is that the interventions lasted between 6 months and one year; much longer than the typical cognitive training course. A second point is that training appears to affect the biology of the brain in the first instance, with the cognitive benefits seen as a consequence. A third point that is still unclear concerns the necessity to maintain the exercise in order to keep seeing the cognitive benefits. Is it necessary (as with physical fitness) to keep up the training regime to maintain performance? Common sense suggests that this will be the case, and again this is in contrast to many cognitive training exercises that are one-time courses lasting only 4–6 weeks. The comparison to physical skills suggests that any benefit accruing from such short-term training would be short-lived.

One approach to developing short-term training programs that may yield transfer to everyday life is first to assess the sources of optimal performance in the real world and then use this information to design and implement a training procedure to be conducted in real world contexts – to "train for transfer" as recommended by McDaniel and Bugg. In keeping with the foregoing parallel between physical and cognitive skills, consider the domain of tennis again. Williams, Ward, Knowles, & Smeeton (2002) used eye movement data to assess how skilled tennis players anticipate the direction of opponents' shots faster than less skilled players. The study revealed that skilled players fixate on the head, shoulder, trunk, and hip regions of the body more than less skilled players, whereas the less skilled players fixate on arm, hand, racket, and ball regions more than skilled players. Using this information, the authors then trained less skilled players to focus their attention on the critical regions when anticipating a shot with either explicit instructions or self-guided training, akin to comparing explicit strategy to more process-based training approaches. Training sessions were conducted in laboratory- and field-based contexts (45 min each); pre- and post-training performance on both laboratory and field tests was compared in both control and placebo groups. Results showed that training participants to focus their attention on relevant aspects of the opponent improved anticipation skills in both laboratory and field tests (i.e., transfer to a real world context). Extending this general approach to cognitive training may be a fruitful way to produce transfer to real world contexts. For example, deep, elaborative encoding is known to benefit memory; older adults might be trained to use deeper encoding techniques in real world settings, say at a cocktail party to remember names, and tested in real world settings to assess transfer to everyday life.

To summarize, our suggestion is that purely cognitive training methods, administered over a time period of days or weeks, are very effective in training the specific skills practiced, but show limited generalization to different skills or to general cognitive functioning. On the other hand, long-term involvement in cognitively challenging activities may (like physical exercise) result in changes to brain structure and function, and such changes – analogously to an increase in cardiovascular fitness perhaps – may have a more generally positive effect on cognitive activities.

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