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COMPUTERIZED TRAINING OF WORKING MEMORY – A CONTROLLED, RANDOMIZED TRIAL

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Background

Working Memory (WM) is the ability to hold and manipulate information for short periods of time. It draws on the integrity of the prefrontal cortex, an area of the brain which shows pronounced morphological alterations across the adult life span. Consequently, substantial age-related decline is typically observed in WM tasks. We report the effects of systematic computerized training of WM in normal older and younger adults.

Results

A. Criterion tasks

Trained older persons showed improved performance on the *critera tasks* (Span Board forward and Digit Span backward), although gains in these tasks were larger for the young. (Fig. 1A).

B. Near-transfer tasks

On the *near transfer* tasks (Span Board backward and Digit Span forward), both age groups showed similar intervention-related gains (Fig. 1B).

C. Far-transfer tasks

We also found evidence for *far transfer* of training, both in terms of attentional performance (PASAT and RT) and with regard to self-evaluation of cognitive problems in everyday life (CFQ) for both age groups (Fig. 1C).

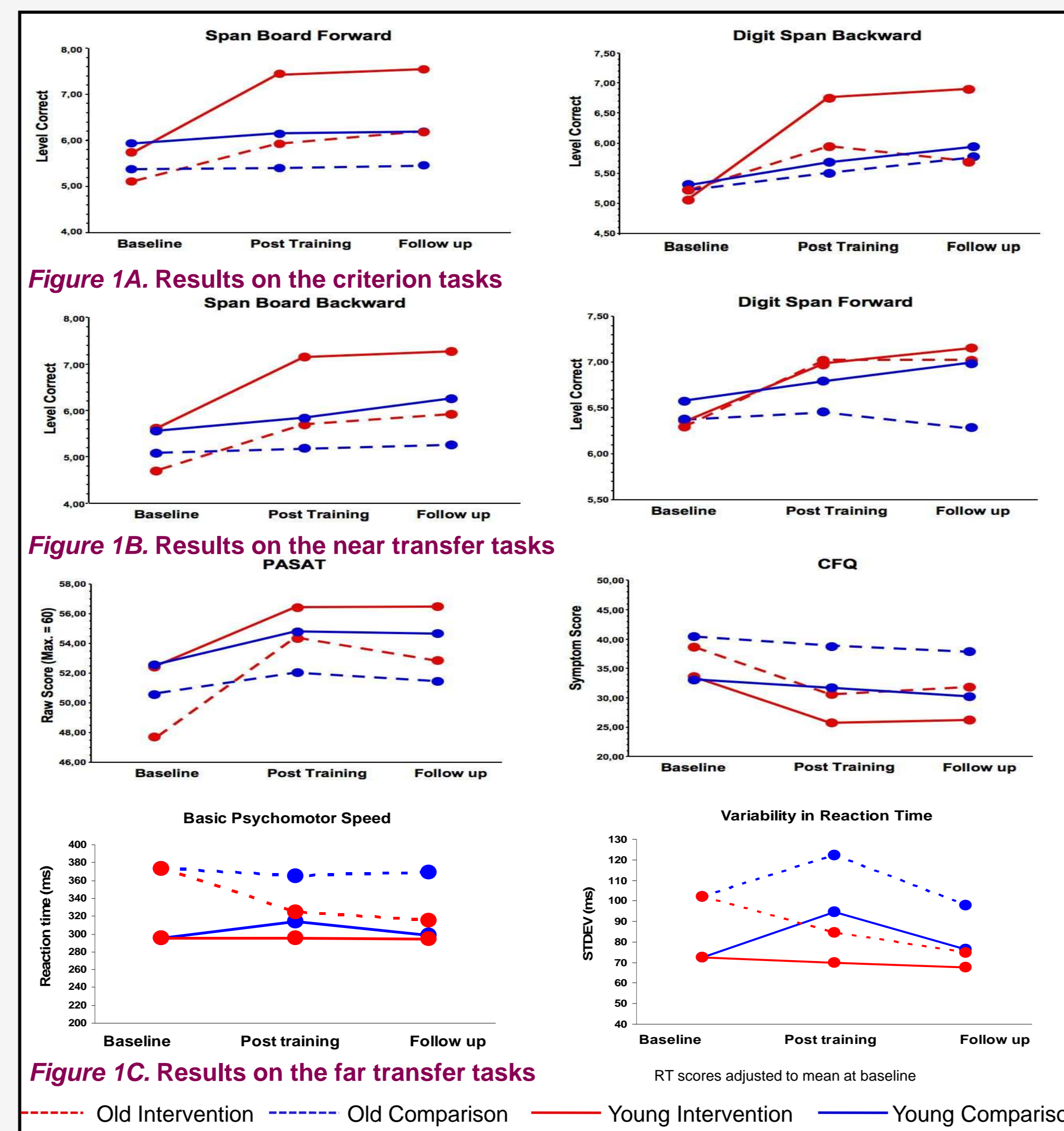
By contrast, there were no training-related gains in Stroop, RAVLT, or Raven.

D. Maintenance testing

At follow-up, three months after the training period, the improvements were, in general, maintained.

References Raz N et al. (2004). *Neurobiology of Aging*, 25., **Wilde** NJ, Strauss E, Tulsky DS (2004). *Journal of Clinical and Experimental Neuropsychology*, 26., **Klingberg** T, Forssberg H, Westerberg H (2002). *Journal of Clinical and Experimental Neuropsychology* 24., **Klingberg** T et al. (2005). *Journal of the American Academy of Child & Adolescent Psychiatry*, 44., **Olesen** P, Westerberg H, Klingberg T (2004). *Nature Neuroscience*, 7., **Westerberg** H et al. (2007). *Brain Injury*.

Domain	Task
A. Criterion	
Similar tasks as in the training software	Span Board forward Digit Span backward
B. Near transfer	
Non-trained WM tasks	Span Board backward Digit Span forward
C. Far transfer	
Cognitive	
Non-trained task assessing other cognitive domains	PASAT (attention) Reaction time (speed and attention) Stroop (interference control) RAVLT (episodic memory) RAVEN (problem solving)
Subjective	
Self rating of memory and attention in daily living	Cognitive Failure Questionnaire (CFQ)



Methods

Participants 100 persons, 45 between 60 and 70 years of age, and 55 between 20 and 30 years were randomized for a treatment ($n = 55$) or a comparison ($n = 45$) condition.

Intervention The treatment consisted of computerized training (Cogmed QM) on WM tasks (Klingberg et al. 2002, 2005; Westerberg et al. 2007) (Fig. 2). The computer program features 90 WM trials, which take approximately 30 minutes to complete. Training was performed five days per week during five weeks. In order to optimize the cognitive demands, the difficulty level on each task is automatically adjusted close to the level of each individual's capacity. The comparison condition involved training with the same software, but there was no adaptivity - the difficulty level remained constant across the intervention period.

Outcome measures A cognitive test battery and a self rating questionnaire were administered before and after the training period, and at follow-up three months later. The tests were chosen to evaluate both *near* and *far* transfer of training (see table). The test battery included non-trained tasks assessing WM (Span-board and Digit span), attentional functions (RT, PASAT, Stroop), as well as verbal episodic memory (RAVLT) and reasoning (RAVEN). The Cognitive Failure Questionnaire (CFQ) was used to measure memory and attention in daily living.



Figure 2. Tasks included in the training software tap visuo-spatial WM (remembering the position of objects) as well as verbal WM (remembering phonemes, letters, and digits). Responses to each trial are logged on to a file on the computer and automatically uploaded to a server, so that compliance could be verified. Feedback is given once a week via the internet by a psychologist. For details on the training software (Cogmed QM®), see www.cogmed.com

Conclusions

The results indicate that systematic training of WM can improve cognitive performance in healthy adults, on laboratory measures as well as in cognitive functioning in daily life