Visual Working Memory Capacity Can Be Increased by Training on Distractor Filtering Efficiency

PRESENTATION

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INTRODUCTION

Visual Working Memory (VWM) is a key cognitive system that temporarily holds visual information. It's essential for tasks like reading, navigation, and learning. VWM capacity varies among individuals and can limit the efficiency of cognitive processes.

Studies(for eg. done by Vogel et al. (2005)) in this paper, suggest that FE (distractor filtering efficiency) differences account for variations in VWM capacity among individuals. FE here means how effectively one can exclude irrelevant information from accessing VWM.

Research suggests that this capacity can be expanded by improving how effectively distractions are filtered out.

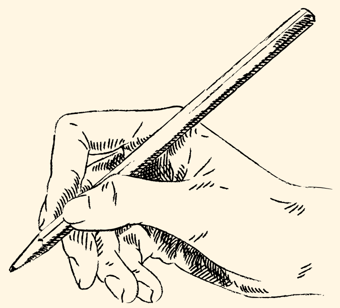
INTRODUCTION

Several recent studies included in this paper have demonstrated that training that focuses on one type of WM leads to improved performance on other not-practiced tasks, including VWM, fluid intelligence, and long-term memory.

The researchers tested whether gains in VWM can be transferred to other WM systems, particularly verbal WM, and whether the improvement affects fluid intelligence(reasoning ability). Finally, they tested whether performance improvements were maintained long-term (3 months).

They divided participants into high- and low-capacity groups based on their performance in a CDT designed to test VWM capacity, and then the low-capacity individuals received 20 days of FE training to investigate whether the WM capacity of low-capacity individuals can be improved by training aimed to facilitate FE.

KEY HYPOTHESES



The primary hypothesis was that targeted training aimed at improving the efficiency with which individuals filter out irrelevant visual stimuli (distractors) could lead to an increase in their VWM capacity.

They found out through multiple past research papers that visual and verbal WM interact, so therefore they hypothesised that visual WM training would also influence performance on verbal WM tasks.

They also aimed to explore how will FE training affect fluid intelligence and will the effect of this training be maintained long-term.

METHODOLOGY

Thirty-eight right-handed college students (mean age, 21.4 years, 13 males) from Capital Normal University were recruited to participate in the pre-training experiment. All participants included in their analysis had normal or corrected-to-normal vision and passed the Ishihara test for colour blindness.

The study was composed of four parts: a pre-training assessment, training, a post-training assessment, and a follow-up assessment. We divided the participants into high- and low-capacity (of WM) individuals using a median split of their pre-training results. Then, only the low-capacity individuals took part in FE training. WM capacity was assessed immediately after training in the post-training and at a follow-up assessment 3 months later. Training occurred in a fixed computer room and involved 20 daily sessions (5 days per week) of 50 min each day.

METHODOLOGY

These three tasks were in each assessment:

- **Change Detection Task:** To measure VWM capacity where they had to identify changes in visual arrays. This task included first showing a cue in the form of an arrow that pointed to the left or right hemifield in which the items needed to be maintained followed by a delay. Then the memory array was presented for 100ms and then after some retention interval participants were shown the test array and then they were asked to judge whether the orientations of the rectangles in the target hemifield had changed or not.
- **Verbal Working Memory Span Task:** Participants were shown math-word pairs such as “(8÷4) + 5 = 8? appearance” and asked to vocalize and judge the correctness of math statements while remembering the subsequent word. This assessed verbal working memory by combining math processing with retention tasks and response actions.
- **Raven’s Standard Progressive Matrices (RSPM):** To estimate fluid intelligence levels. In this task participants were shown items which feature abstract shapes with missing components; they select from small pictures to complete them, without time constraints.

METHODOLOGY

The training provided to the low-capacity group involved various change detection paradigms that required participants to focus on relevant stimuli and ignore distractors. These tasks were progressively adjusted in difficulty based on the participant's performance, ensuring that the training remained challenging.

Data Analysis included:

- **Behavioural Data:** The main outcomes were accuracy and memory capacity (indexed by Cowan's K-value = S(H - F) where S is array size, H is hit rate, and F is false alarm rate), comparing pre-training, post-training, and follow-up performances.
- **Neurophysiological Data:** Analysis of CDA(contralateral delay activity) amplitudes was conducted to explore changes in neural activity associated with VWM capacity and distractor filtering efficiency. CDA here is the brain activity observed when holding information in memory, particularly when attending to one side of space.

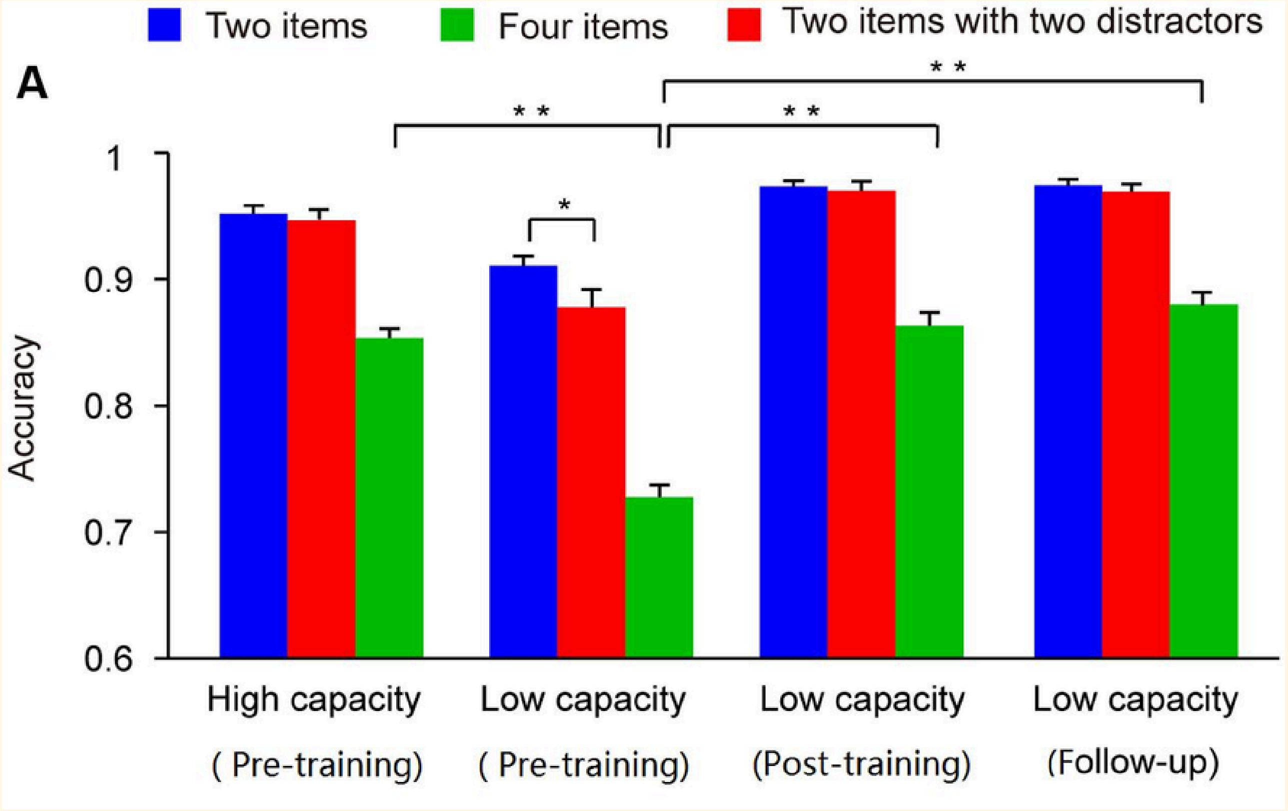
KEY RESULTS

Pre Training Assessment Results:
Behavior:

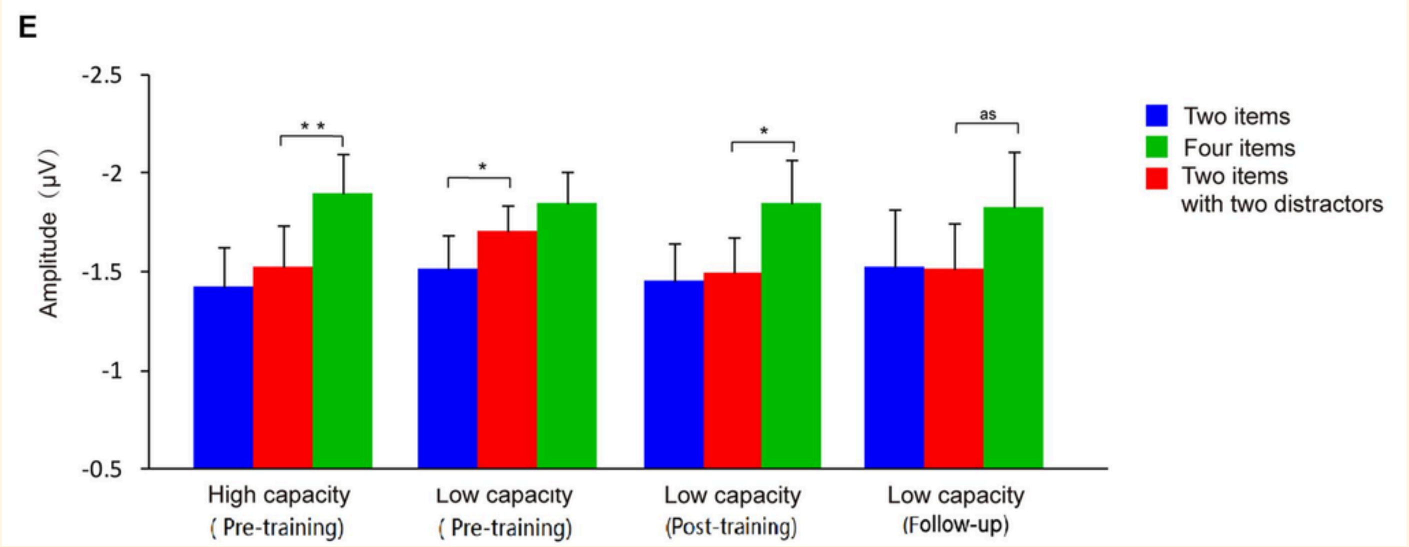
- High capacity group demonstrated significantly better working memory (WM) capacity in the four-item condition compared to the low capacity group {Graph 1}.
- Low capacity group retained more irrelevant information when presented with distractors hence differentiating more between two-items and distractor conditions as compared to the high capacity group {Graph 1}.
- Unnecessary storage (US) was negatively correlated with memory capacity, with lower US observed in the high capacity group compared to the low capacity group {Graph 3}.
- No significant differences were found between high and low capacity groups in VeWMST or RSPM test performance at pre-training {Graph 4}.

Neurophysiological Data:

- The high capacity group has a significant difference between the four-item condition and the distractor condition as compared to the low capacity group {Graph 2}. This shows high filtering efficiency of high high-capacity group.
- The low capacity group treats the two items and distractor condition differently reflecting their poor filtering efficiency {Graph 2}.



Graph 1 | Mean Accuracy vs Condition Graph | *p<0.05 **p<0.01



Graph 2 | CDA Amplitude means vs Condition Graph | *p<0.05 or **p<0.01

KEY RESULTS

Post Training Assessment Results:

Behavior:

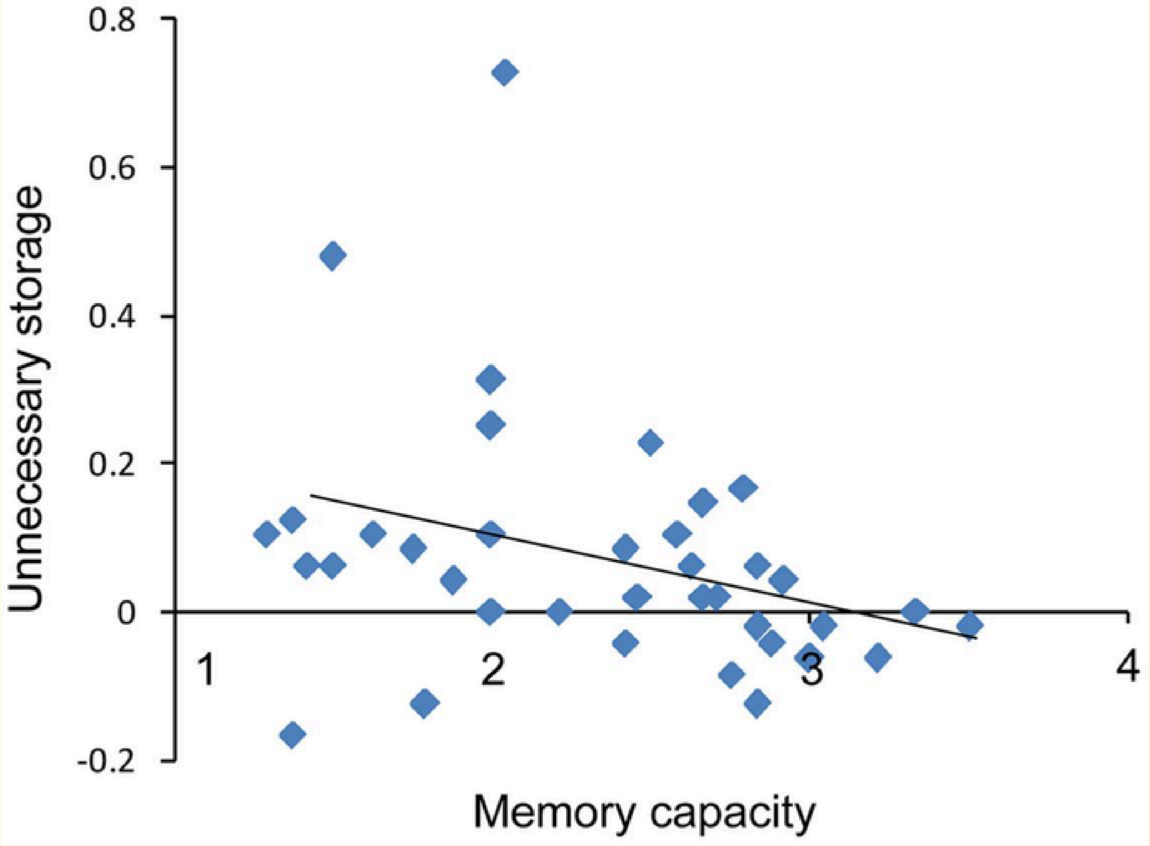
- Low capacity group demonstrated significantly better visual working memory (WM) capacity in the four-item condition compared to its results in the pre-training assessment {Graph 1}.
- The low capacity group undifferentiated between two-items and distractor conditions reflecting lesser unnecessary storage and hence more visual WM {Graph 1}.
- There was a significant increase in the verbal WM capacity as the performance on VeWMST significantly increased {Graph 4}. There was no significant difference between RSPM test performances.

Neurophysiological Data:

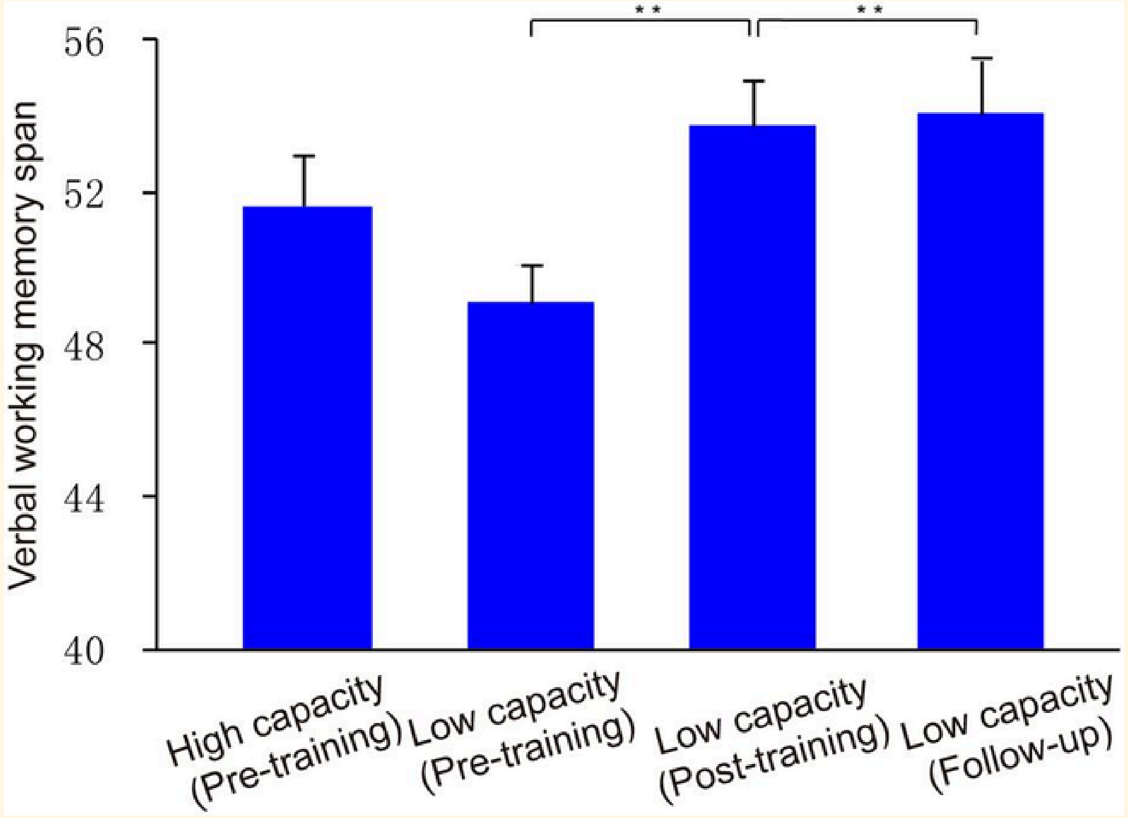
- The low capacity group differentiates between the four-items and the distractor condition significantly shows increased filtering efficiency.

Follow Up Assessment Results:

- This assessment showed similar results to post training assessment results reflecting maintained performance.
- There was still no significant difference found between RSPM test performances.



Graph 3 | US vs WMC Graph | US has an inverse relation with memory capacity.



Graph 4 | Verbal WM Performance | **p<0.01

Research LIMITATIONS

01 Small Sample Size & Specific Participant Group

With only 38 participants divided into two groups, the sample size is relatively small. This may limit the generalizability of the findings. The study involved only college students, which may not represent other age groups or populations. The effects of FE training on other demographics, like older adults or children, remain unknown.

02 Lack of Control Group

The study lacks an appropriate control group, necessary to interpret the effects of the training procedure. For example, the possibility that the observed training effect was achieved through expectancy effects, rather than the training itself cannot be ruled out.

03 Potential for regression towards the mean (RTM) effect

The method used to separate low-capacity and high-capacity subjects may have introduced biases. However, RTM analysis suggests that the increase in low-capacity performance cannot solely be due to the RTM effect so it cannot be concretely ruled out.

THANKS FOR WATCHING

If you have any questions, let us know!