Utilizing Cognitive Training to Enhance Low Working Memory Capacity

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Introduction

- Targeted, computerized working memory (WM) training involves the use of interventions designed to improve WM capacity.
- The primary question regarding such training is whether improvement on one task (i.e., the trained task) will affect performance on another, untrained task. That is, are there *transfer effects* in cognitive training studies?
- In studies involving WM training, *near transfer effects* are said to be found when training improves performance on an untrained task intended to directly measure WM capacity.
- The results of such studies have been mixed. For example, some have found positive near transfer effects (Harrison et al., 2013; Minear et al., 2016), while others have not (e.g., Thompson et al., 2013).
- In many WM training studies, participants' were trained using a traditional version of the *n*-back task. **The present study examined the effectiveness of WM training using an iPad-based, gamified version of the *n*-back task (Recall) in young adults who possess relatively low WM capacity.**
- Two control conditions were used: 1) An active control condition in which participants were trained on an adaptive contrast sensitivity task (Ultimeyes), and 2) A passive, no-contact control condition.

Method

Pre-Test

- Participants were 108 college students recruited from California State University, San Bernardino
- The following tasks were administered to each participant individually across two, one-hour sessions.

Table 1
Means for Participant Pre-Test Scores

Participant Characteristics and Pre-test scores	Mean	SD
WRAML Verbal Working Memory	23.7	6.39
WRAML Verbal Working Memory (Scaled core)	8.4	2.85
OSPAN Partial Score	35	9.20
SSPAN Partial Score	18	5.39
AX-CPT AY-BX Difference (RT)	108	103
MST	42.3	20.2

WM Capacity tasks

- **OSPAN:** participants held a set of letters in memory while simultaneously performing math problems (2 blocks)
- **SSPAN:** participants held a set of spatial locations in memory while simultaneously deciding if presented images are symmetrical or not (2 blocks)
- **Verbal Working Memory (WRAML-VWM Subtest):** participants both held in memory and reordered verbally presented lists of animal and non-animal words
- **AX-CPT:** participants held a letter in memory and then responded to a second letter (target vs. nontarget) according to a rule

Source Memory Task

- **MST:** participants encoded visually presented stimuli and then identified items as "Old', "Similar", or "New" during a subsequent recognition memory task

Training

- Participants were randomly assigned to one of two cognitive tasks and were trained over a four week period of time.

Recall the Game (N = 37)

- Recall is an adaptive gamified version of the N-Back task
- Players navigate a spaceship and collect energy pods based on a specific pattern (1-back, 2-back, etc.) of their characteristics (e.g., color, shape, or sound)
- All players begin at 1-back and progress based on individual performance
- Game play began at 30 minutes per session and slowly increased to 40 minutes for the final two sessions
- **Total training time = approximately 11 hrs**

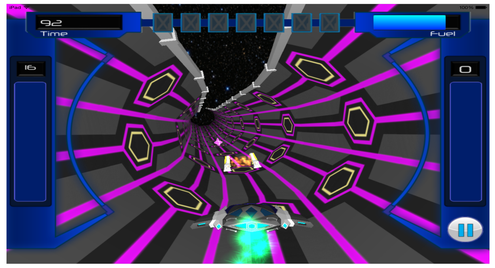


Figure 1: Image from Recall the Game

Ultimeyes (N = 37)

- Ultimeyes is an adaptive game designed to train visual contrast sensitivity
- Players use a stylus to tap on "gabors" that appear against a gray background
- Players adjust the visibility of the "gabors" that become progressively harder to see
- Game play lasted approximately 30 minutes each session
- **Total training time = approximately 10 hrs**

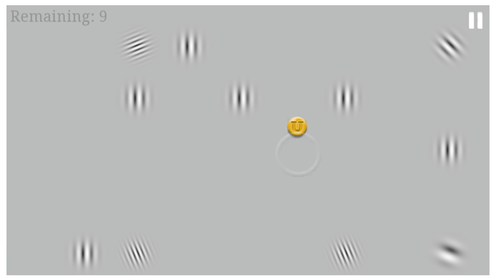


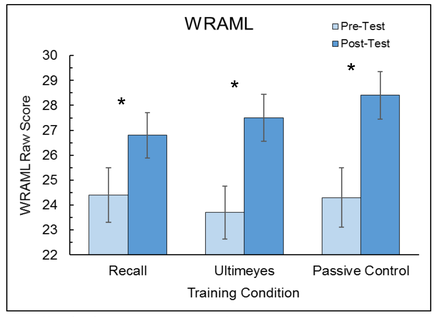
Figure 2: Image from Ultimeyes

Post-Test

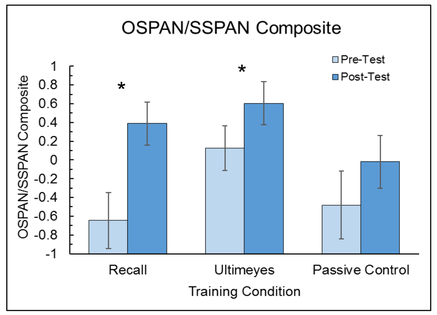
- The tasks used during the post-test phase were the same tasks that were administered during the pre-test phase.

Results

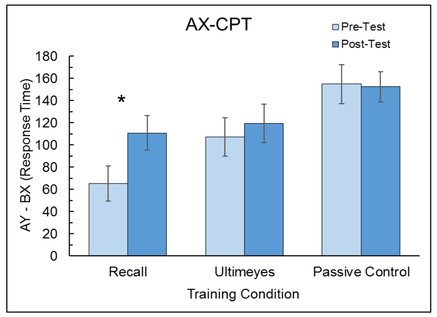
- Pre- and Post-test performance for each task was compared using a series of *t*-tests.



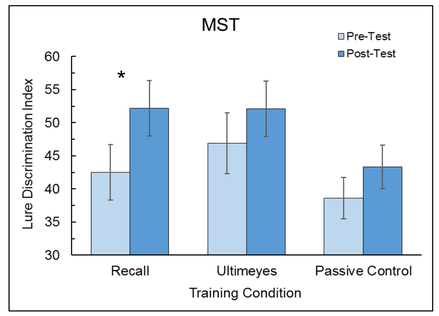
Recall: $t(35) = -2.48$, $p < .05$, $d = .40$
Ultimeyes: $t(35) = -3.89$, $p < .01$, $d = .62$
Passive Control: $t(26) = -4.73$, $p < .01$, $d = .73$



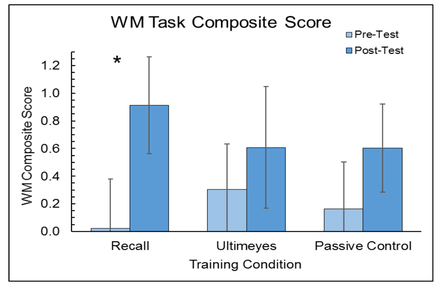
Recall: $t(35) = -3.66$, $p < .01$, $d = .64$
Ultimeyes: $t(35) = -2.28$, $p < .05$, $d = .34$
Passive Control: $t(33) = -1.87$, $p > .05$, $d = .24$



Recall: $t(33) = -2.83$, $p < .01$, $d = .50$
Ultimeyes: $t(35) = -0.63$, $p > .05$, $d = .12$
Passive Control: $t(30) = 1.70$, $p > .05$, $d = .03$



Recall: $t(25) = -2.65$, $p < .05$, $d = .46$
Ultimeyes: $t(23) = -1.14$, $p > .05$, $d = .24$
Passive Control: $t(29) = -1.69$, $p > .05$, $d = .32$



Recall: $t(35) = -2.88$, $p < .01$, $d = .47$
Ultimeyes: $t(33) = -1.29$, $p > .05$, $d = .22$
Passive Control: $t(36) = -.93$, $p > .05$, $d = .15$

Summary and Conclusions

1. Following WM-targeted cognitive training, significant near transfer effects were found in the Recall condition with all the tasks (i.e., the SPAN composite, the WRAML VWM subtest, the AX-CPT, and the MST).
2. For the control groups, near transfer effects were found in the WRAML and SPAN composite scores with the active control group, and only in the WRAML with passive control group.
3. These results provide support that playing a gamified version of the *n*-back may lead to increase in WM capacity and aspects of long-term memory retrieval.
4. Such effects may be most effective in individuals who possess a deficit in WM capacity.

References

- Available upon request.

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