Working memory improvement following web-based cognitive training

Kunal Sarkar, David Drescher, Michael Scanlon

Lumos Labs, San Francisco, CA, 94107

Bay Area Neuroscience Gathering

January 19th, 2007, San Francisco, CA

Introduction

Many studies have identified effective methods of improving cognitive abilities [1,2,3], but use of these methods is limited outside of the lab.

We developed a web-based game-like program that makes cognitive training accessible to a larger audience. The program is composed of a set of exercises designed to improve attention, working memory, processing speed, and response inhibition among other executive processes.

Since cognitive training exercises can be tedious, our exercises are structured as engaging games to encourage long-term consistent usage. Prior to this study, our novel approach to cognitive training had not yet been tested.

Working Memory

Working memory, the process of temporarily storing and manipulating information, underlies performance in many other activities. There is evidence that an individual's working memory can be improved with appropriate training [4, 5].

This pilot study evaluates the effect of our web-based training program on working memory.

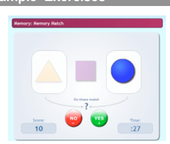
Computerized Training Program

The training program consists of a set of exercises designed to train and improve attention, working memory, processing speed and executive function.

The program is composed of five discrete exercises. Each exercise is specifically designed to train one or more cognitive abilities. Key components of the exercise program are:

- Dynamic difficulty changes to consistently challenge each user and adapt to their progression
- Game-like features and motivations (such as scoring, unlocking of levels, etc.) transform a tedious training task into an entertaining game, leading to better compliance and more effective training
- Web-based training platform ensures ease and ubiquity of access
- Simple self-instruction: No human trainer required

Example Exercises



Speeded n-back memory task for shapes and numbers

Navigate through a maze of monsters

Methods

Design

Trained Participants: Pre-test ◊ Training (daily) ◊ Post-test

Control Participants: Pre-test ◊ No training/no contact for duration of experiment ◊ Post-test

Participants

Participants' only compensation was continued access to the program after the experiment concluded

N = 32 volunteers recruited by email from various locations in US

Trained: 14 (8 female) of 20 completed all aspects of the program, mean age = 57

Control: 9 (3 female) of 12 completed both tests successfully, average age = 50

Training

One 20-minute session per day for 5 weeks (mean: 29.2 sessions)

Five exercises in each session

Each user trained without guidance using personal computer

Assessment

Tests of spatial and letter working memory

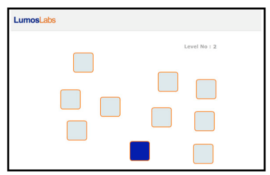
Pre-training and post-training assessment was conducted via the web-based application

Qualitative Feedback

After the experiment, users completed an online survey about how much they enjoyed the exercises. On a scale of 1 ("not fun") to 5 ("lots of fun!"), the average response was 3.6.

• Spatial working memory test

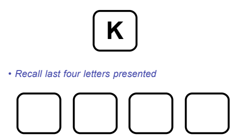
Reverse span board test: *Recall in the opposite order of presentation*



• Verbal working memory test

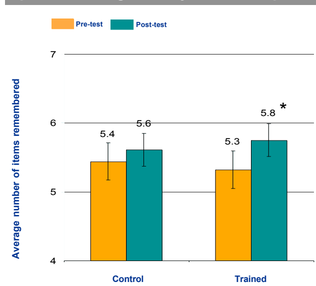
Remember the letters presented

• Letters presented one at a time



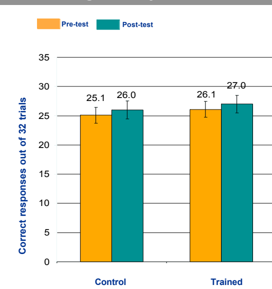
Results

Spatial Working Memory: Reverse Span Board



• Trained subjects improved in the reverse board span (p<.01, paired t-Test).

Letter Working Memory



• Four-back letter memory performance showed no improvement in either group.

Significant improvement on the reverse span board test after training suggests that the training program improves spatial working memory.

Discussion

- All participants were able to use the testing and training software from a personal computer without guidance.
- Compliance and qualitative feedback suggest that the exercise structure motivates frequent training.
- Participants in the training program improved in the non-trained measure of spatial working memory: reverse span board.
- Participants did not improve in the letter working memory test.

The results of this pilot study indicate that training and improving a fundamental cognitive ability such as working memory is possible with a web-based application. The study also demonstrates the viability of conducting an entire study online, including intervention and assessment. We intend to explore the effectiveness of a modified training program in the rehabilitation of cognitive impairment, such as that due to stroke, brain trauma, or aging. We invite other researchers to consider or discuss potential applications to their own human behavior research.

References

1. Schaie, K., Willis, S., Hertzog, C., & Schulenberg, J. (1987). Effects of cognitive training on primary mental ability structure. *Psychology and Aging*, 2(3):233-242.
2. Ball, K., Berch, D., Helmers, K., et al., Effects of cognitive training interventions with older adults: A randomized controlled trial. *Journal of American Medical Association*, 288(18):2271-2281.
3. Green, S. & Bavelier, D. (2003). Action video game modifies visual selective attention. *Nature*, 423:534-537.
4. Rebok, G., Rasmusson, D., & Brandt, J. (1996). Prospects for computerized memory training in normal elderly: Effects of practice on explicit and implicit memory tasks. *Applied Cognitive Psychology*, 10:211-223.
5. Klingberg, T., Forssberg, H., & Westerberg H. (2002). Training of working memory in children with ADHD. *Journal of Clinical and Experimental Neuropsychology*, 24(6):781-791.

The Lumos Labs cognitive training program can be accessed via http://www.lumoslabs.com/

Correspondence: mike@lumoslabs.com