



# Online Cognitive Training Improves Cognitive Performance

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## ABSTRACT

**Objective:** Several studies of healthy individuals have found that training can improve cognitive performance in several areas of mental functioning. In this study, we analyzed the performance of 85 members of an online cognitive training website after 500 completed exercises.

**Methods:** HAPPYneuron ([www.happy-neuron.com](http://www.happy-neuron.com)) supplied forty separate exercises focused on five cognitive areas: Memory, Attention, Language, Executive Function and Visuo-spatial Skills. Developed by a team of neurologists, neuropsychologists and cognitive psychologists, these exercises were designed for healthy subjects living independently without overt cognitive pathology. They were initially tested and validated by students at the Université Tous Ages in Lyon, France. The performances of 85 online users were analyzed from the 75th (T75) through the 500th (T500) completed exercise. For each exercise, various cognitive parameters, including response time and accuracy, contribute to summary scores for each of the five cognitive domains. In a pre-test, post-test design, results were analyzed by repeated measures ANOVA, using Fischer protected t-tests for post hoc evaluation of changes in the five domain summary scores. Analyses of covariance examined the contributions of age, gender and education.

**Results:** The average age of the participants is 53.5 years  $\pm$  14.8. Thirty-six percent (36%) of participants are over 60 and 14% are over 70. The sample is nearly evenly divided between women (58%) and men (42%). In terms of education, the group was divided into 3 groups: those with a secondary school degree, those with an unfinished bachelor's degree and those with a university degree (55%; 61% for men against 51% women). At T75, the score for Executive Function is significantly higher than the other 4 scores [F(4,420) = 3.44,  $p$  = 0.009, post hoc Fischer test]. At T500, performance shows considerable improvement for all cognitive domains [F(4,420) = 290.4,  $p$  = 0.0001, all t values are significant at  $p$  < .0001]. At T500, the Executive Function score remains considerably higher than Memory, Language and Visuo-spatial scores, but no higher than the Attention score. On average, users improved between +13.9% (Memory) and +20% (Language), with 15.6% overall improvement. Neither age, gender nor educational level influenced performances.

**Conclusion:** Regardless of age, gender and educational level, the summary scores of 85 healthy adult participants significantly increased across the five major cognitive domains following 18 weeks of intensive cognitive training.

## INTRODUCTION

- In late adulthood, cognitive functioning gradually declines with age, a process most people wish to prevent.
- A meta-analysis showed that memory performance in healthy older adults improved with training exercises (Verhaeghen, 1992).
- Further, studies have also showed that a cognitively stimulating life-style significantly impacts personal cognitive well-being (Hultsch, 1999; Wilson, 2003).
- The ACTIVE study (Ball, 2002) showed that cognitive training considerably improved memory, processing speed and reasoning. Most improvements were maintained at 5-year follow-up (Willis, 2006), and the reasoning group reported significantly less difficulty in the instrumental activities of daily living after 5 years.
- Prospective and retrospective studies suggest that education and cognitively stimulating activities such as socialization and hobbies reduce the risk of Alzheimer's Disease (Fabrigoule, 1995; Stern, 1999; Friedland, 2001; Scarmeas, 2001; Wilson, 2002).
- We report the experience of the performance development of 85 regular users to a cognitive training website after carrying out 500 exercises.

## METHODS

The website [www.happy-neuron.com](http://www.happy-neuron.com) offers 40 training exercises that target 5 major cognitive domains, i.e., Memory, Attention, Language, Executive Function and Visuo-Spatial skills.

- The exercises were designed by a team of neurologists, neuropsychologists and cognitive psychologists.
- They are regularly validated by 2 research groups (20 seniors) from the "Université Tous Ages" ("University for Elderly People", Lyon 2 University, France).
- These exercises target independent, healthy persons.
- The cognitive training enables subjects to regularly perform a set of varied exercises that allow them to:
  - perform the exercises they are most interested in,
  - work on cognitive domains they judge to be weak.
- An analysis of 628 users shows a majority of women (64%), a predominant academic level (56%), and an average age of 41.8 years with 3 peaks: age 22, 44 and 57 (Croisile, 2006). 9% of all 628 users are over 70 years.

## METHODS (cont.)

### Online exercises

- Each exercise consists of 3 parts:
  - an educational "Example";
  - "Know more", an explanation of neuropsychological relevance;
  - the "Exercise" itself.
- Options: Three difficulty levels (easy, medium, hard) and several thematic variants
- Accuracy and Time scores are standardized by age, gender and educational level (percentile).
- "Advice and Commentary" section offers training recommendations.

### The Virtual Coach

- Various cognitive parameters from each exercise contribute to combined scores for memory, attention, language, executive function and visuo-spatial skills.
- Taking into account the value of exercise-related cognitive indicators, a computer supervisor tracks the subject's performances. As the user continues training, other indicators will be updated (deduced performances from achieved scores).
- Users are free to choose their training exercises.
- At each logon, however, the computer supervisor offers each subject four exercises. The goal is to avoid routine and to stimulate training variety. Users are free to start one or more exercises in whichever order they wish.
- The supervisor also suggests a variant and a level of difficulty for each exercise.

### The Selection Process

- All 85 users were chosen according to the following criteria:
  - over age 20,
  - training period longer than a month,
  - at least 5% of exercises in each cognitive domain,
  - no more than 50% of exercises in one domain.
- In order to skip the stage of initial familiarization with the program, the performance of the 85 users were analyzed from the 75th (T75) to the 500th (T500) exercise.

### Exercise examples

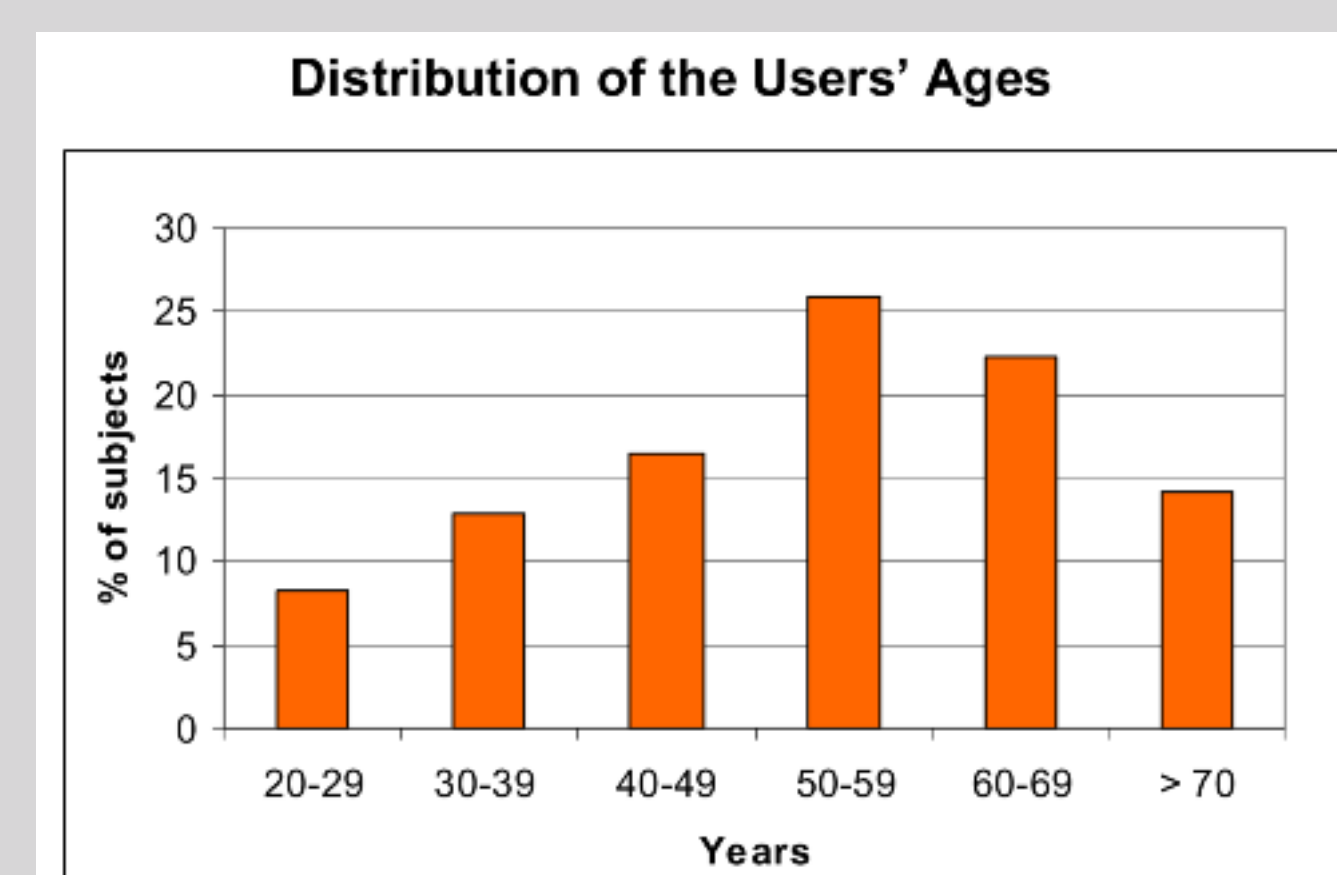
These are examples of games in the Happy Neuron program.



- Bird Songs: Visual Spatial Skills - This game challenges the user to develop a memorization strategy to distinguish the name, appearance and songs of different birds.
- Basketball in New York: Executive Function – This is a problem-solving exercise. It consists of mentally calculating the necessary moves for successful outcome. It trains mental calculation skills.
- Split Words: Language Skills - This exercise helps the subscriber to practice quickly retrieving words from his or her verbal repertoire, avoiding the 'tip of the tongue' re sponses.
- Shapes and Colors: Memory Skills - This exercise calls upon visual short-term memory.

## RESULTS

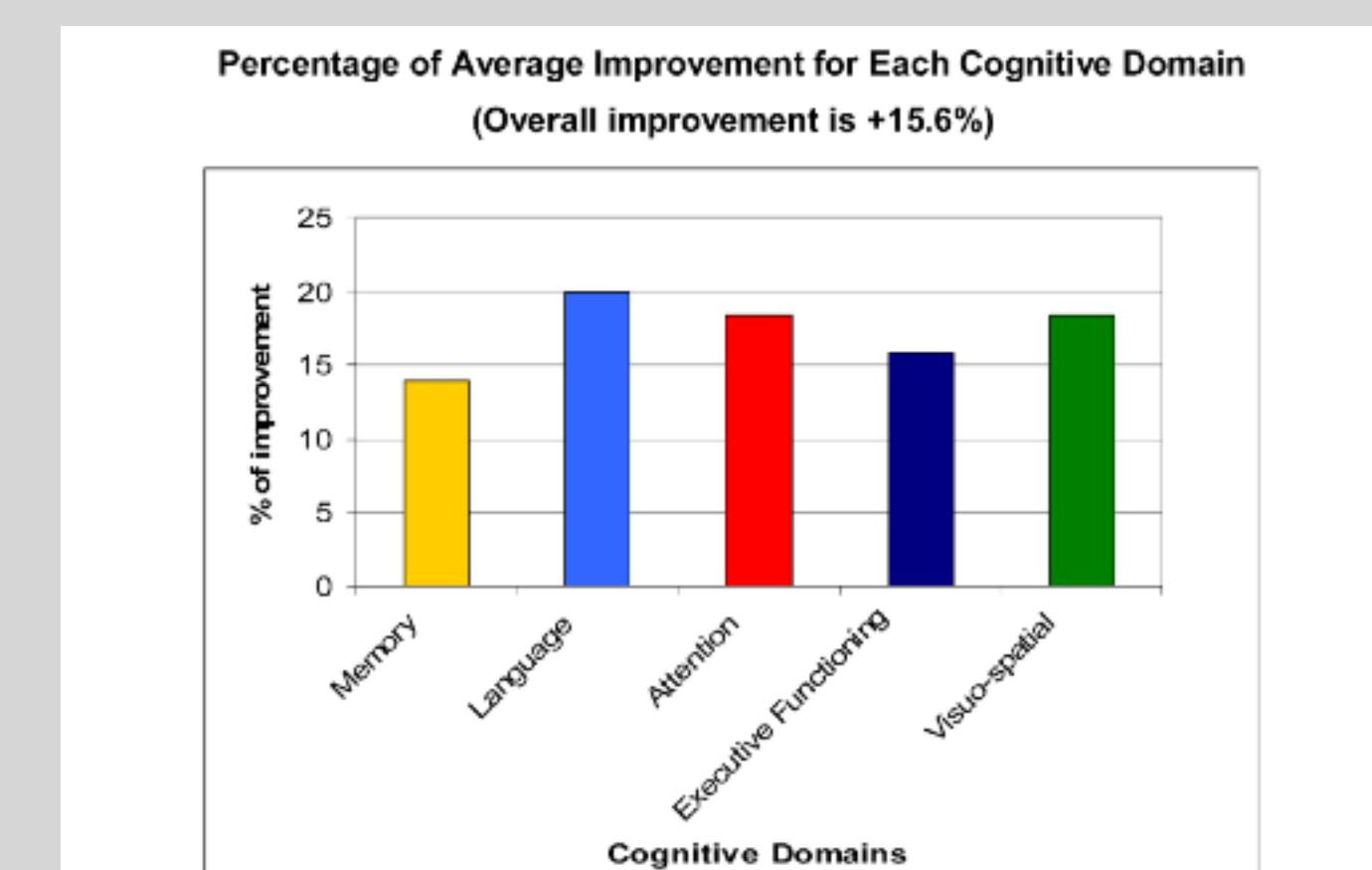
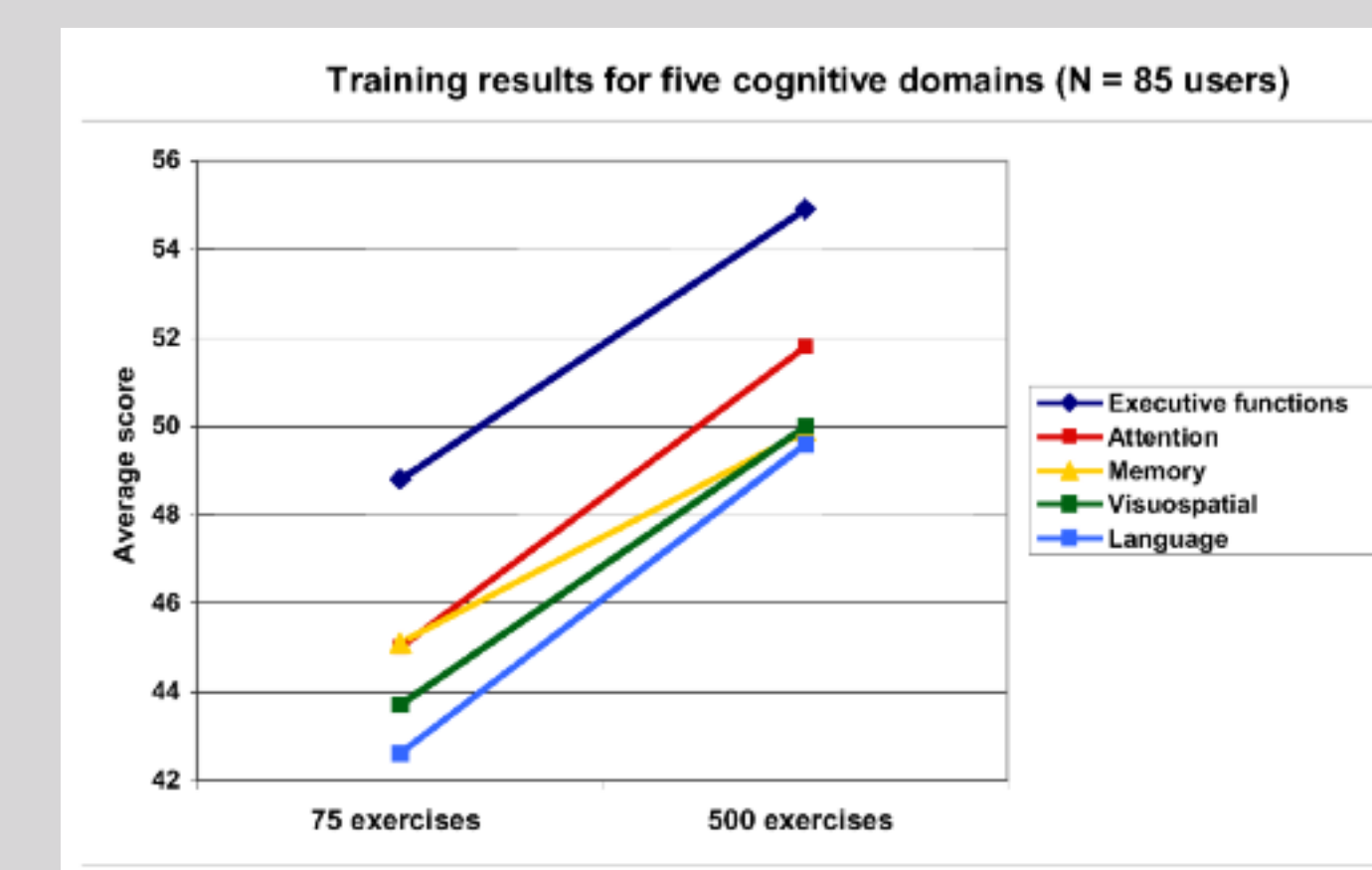
- Average age of the 85 users is 53.5 years  $\pm$  14.8 (range, 23-81 years)
- 36.5% of users are over 60 years and 14.2% over 70 years, thus, exercises are suitable for seniors.



- Subjects include a majority of women (58%).
- College graduates predominate (55%), more so for men (61%) than women (51%).

## RESULTS (cont.)

- At T75, the score for Executive Functioning is significantly higher than the other 4 scores [F(4,420) = 3.44,  $p$  = 0.009, post hoc Fischer test].
- Between T75 and T500, a two-way ANOVA showed a significant domain effect [F(4,420) = 3.79  $p$  = 0.005], a significant effect of training from 75 to 500 exercises [F(4,420) = 290.4,  $p$  = 0.0001] without significant interaction [F(4,420) = 1.04,  $p$  = 0.39].
- Between T75 and T500, performance shows considerable improvement for all 5 cognitive domains (all Fischer protected t-tests significant at  $p$  < .0001).
- At T500, Executive Functioning scores remain considerably higher than Memory, Language and Visuo-spatial scores, but no higher than Attention [F(4,420) = 3.55,  $p$  < .008, post hoc Fischer test].
- In this analysis, neither age, nor gender nor education influenced performance.



## DISCUSSION & CONCLUSION

- The website [www.happy-neuron.com](http://www.happy-neuron.com) offers 40 training exercises that target 5 major cognitive areas, i.e., Memory, Attention, Language, Executive Functions and Visuo-spatial skills.
- Regardless of age, gender and educational level, the scores of 85 healthy adult participants significantly increased across 5 major cognitive areas following 18 weeks of intensive cognitive training during which they carried out 425 exercises.
- All cognitive areas improved but Executive Functioning was the most improved area.
- In addition to common hobbies that afford cognitive stimulation, regular online cognitive training with HAPPYneuron games allows people to:
  - better understand their cognitive weaknesses
  - enjoy the brain training process
  - enhance their self-esteem.

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