



**Online Cognitive Training
Improves
Cognitive Performance.**

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SUMMARY

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 subscribers to an online cognitive training website after 500 completed exercises.

Methods. Happy Neuron (www.happyneuron.com) supplied forty separate exercises focused on five cognitive areas: *Memory, Attention, Language, Executive Functioning and Visuo-spatial Skills*. Developed by a team of 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 subscribers 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 bachelors degree and those with a university degree (55%; 61% for men against 51% women). At T75, the performance on *Executive Functioning* is significantly higher than the other 4 scores [$F(4,420) = 3.79, p < .005$]. At T500, performance shows considerable improvement for all cognitive domains [$F(4,420) = 290.4, p < .0001$, all t values significant at $p < .0001$]. At T500, the *Executive Functioning* score remains considerably higher than *Memory, Language* and *Visuo-spatial* scores, but no higher than the *Attention* score. On average, subscribers improved between +14% (*Memory*) and +20% (*Language*), with 16% overall improvement. Neither age, nor 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 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; Kliegel, 2004; 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), although *Reasoning* showed a slight functional decline 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 and 2006; Wilson, 2002 and 2005; Bennett, 2003).
- We report the experience of the performance development of 85 regular subscribers to a cognitive training website after carrying out 500 exercises.

METHOD

- The website www.happyneuron.com offers subscribers forty training exercises that target 5 major cognitive domains, i.e., *Memory, Attention, Language, Executive Functions and Visuo-spatial skills*.
- These exercises target independent, healthy persons.
- Exercises designed by a team of neuropsychologists and cognitive psychologists.
- The subscription principle enables subjects to regularly carry out 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 subscribers shows the majority are 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 subscribers are over 70.

Online exercises

- Exercises are regularly validated by 2 research groups (20 seniors) from the "Université Tous Ages" (Lumière Lyon 2 University).
- Each exercise is comprised of 3 parts:
 - an educational "*Example*";
 - "*Know more*", an explanation of neuropsychological relevance;
 - the "*Exercise*" itself .
- Three levels of difficulty (*easy, medium, hard*) and several thematic variants can be chosen.
- Once the exercise is completed, the "*Results*" section gives *accuracy and time scores*. Scores are standardized by age, gender and educational level (percentile).
- There is also an advice and commentary section.
- The aim is for subjects to:
 - master each exercise
 - develop an efficient strategy for each game
 - practice accuracy and processing speed
 - be reassured by comments.

The computer coach

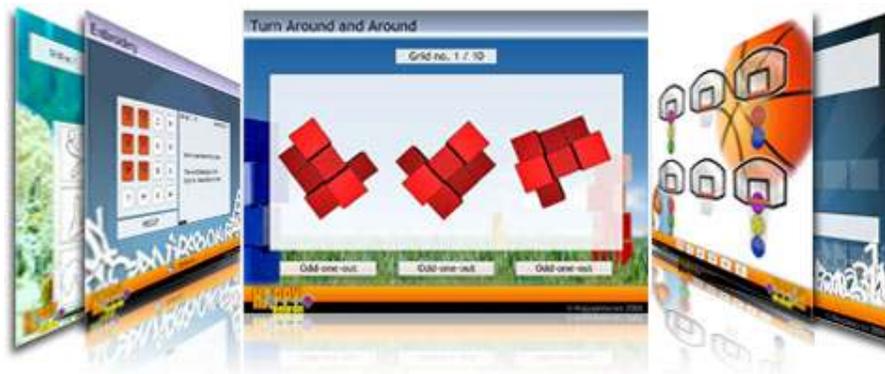
- Various cognitive parameters from each exercise contribute to combined scores for *memory, attention, language, executive function and visuo-spatial skills*.
- Taking into account the value of exercise-related cognitive indicators, a supervisor tracks the subject's performances. As the user continues training, other indicators will be populated (deduced performances from achieved scores).
- Subscribers are free to choose their training exercises.
- At each logon, however, a computer supervisor offers subjects four behavior-relevant exercises. The aim is to avoid routine and to stimulate training variety. Subscribers 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 four chosen exercises and their levels of difficulty depend on 3 criteria, each carrying the same weight:
 - exercises that train relatively weak cognitive functions
 - exercises the subscriber seldom does;
 - exercises the subscriber hasn't done for a long time.

The selection of regular subscribers

- All 85 subscribers 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 website, the performances of 85 subscribers 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. 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’ responses.
- Shapes and Colors: Memory Skills - This exercise calls upon visual short-term memory.

RESULTS

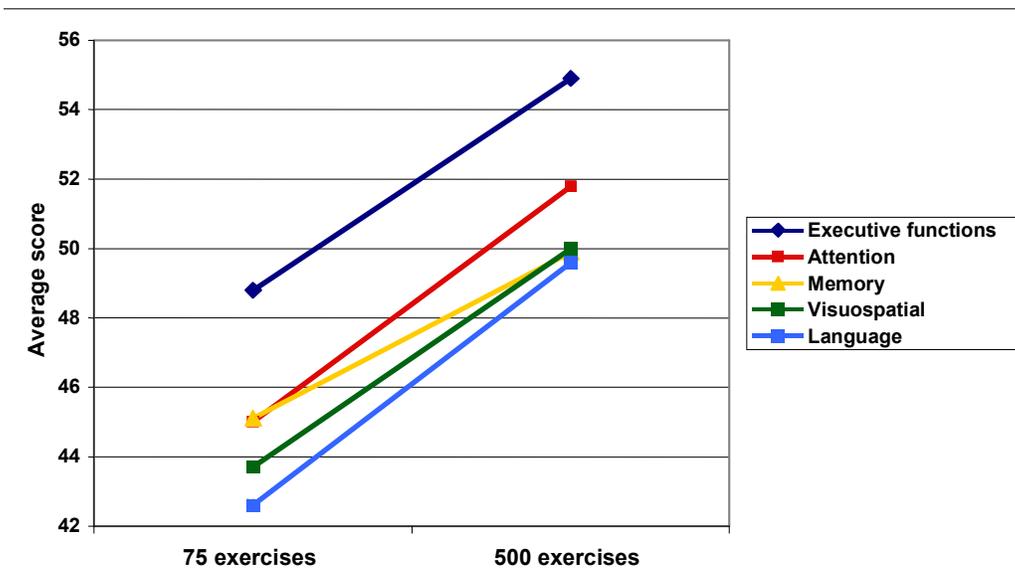
- Average age of the 85 subscribers = 53.5 years \pm 14.8 (23-81)
- 36% of subscribers over 60y; 14% over 70y, thus, exercises are suitable for seniors.
- Subjects include a majority of women (58%).
- College graduates predominate (55%), more so for men (61%) than women (51%).
- At T75 the score for *Executive Functioning* is significantly higher than the other 4 scores [F (4,420) = 3.44, p = 0.009, post hoc Fischer test].
- At T500, performances show improvement for each of the five cognitive domains [F (4,420)= 290.4, p = 0.0001, all Fischer protected t-tests significant at p < .0001].

Cognitive Domains	Protected t-test, df = 84	p
<i>Memory</i>	- 6.47	0.0001
<i>Attention</i>	- 9.21	0.0001
<i>Language</i>	- 7.84	0.0001
<i>Executive Functioning</i>	- 7.04	0.0001
<i>Visuo-spatial Skills</i>	- 7.69	0.0001

- Overall improvement of subscribers is +15.6%
- .Average improvement for each area is +13.9% (*Memory*), +15.8% (*Executive Functioning*), +18.3% (*Attention*), 18.4% (*Visuo-spatial*) and +20.0% (*Language*).

RESULTS (Con't)

- At T500, Executive Functioning scores remain considerably higher than *Memory*, *Language* and *Visuo-spatial* scores, but no higher than *Attention* [$F(4,420) = 3.55, p < .008, \textit{post hoc}$ Fischer).
- Neither age, nor gender or educational level had an influence on subscribers' performances.



Training results for five cognitive domains; N = 85 subscribers

DISCUSSION and CONCLUSION

- Working memory, processing speed and attention weaken and decline with age.
- Moreover, elderly persons suffer negative stereotypes, e.g. they are more isolated and less adventurous. Nonetheless, they are creative and curious, demonstrating wisdom and experience.
- For all 85 regular subscribers training improved overall cognitive scores resulting from their exercise performances.
- *Executive Functioning* is the most improved area.
- This cognitive training has a triple aim:
 - to show that it is possible to improve performances
 - to apply acquired strategies to daily activities
 - to enhance self-esteem.
- In addition to common hobbies that afford cognitive stimulation, cognitive training with Happy Neuron games allow people throughout the lifespan to better understand their weaknesses and to work on them in an enjoyable way.

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