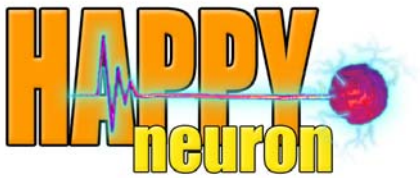

Brain Training Influence

on

Cognitive Function Effectiveness

at

Boiron Labs

By

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Abstract:

In this study the effect of brain training on the cognitive functions required when driving were tested and trained. The subjects took the PEPCo™ “Attention on the road” test twice. It is composed of a test battery with exercises measuring memory, reactivity, decision making, shared attention, and concentration skills as well as quality of visual processing. The subjects could train for a month between both tests. The training consisted of a battery of computerized cognitive exercises to test their memory, reactivity, decision making, shared attention, and concentration skills as well as the quality of visual processing. A positive effect of the training was demonstrated: The overall performance at the PEPCo™ “Attention on the road” test had significantly increased by 14%. Statistically, the increased performance is significant in terms of memory, reactivity, and concentration performance, as well as visual processing quality, but not in terms of decision making or shared attention.

Introduction:

According to the data collected by the French Road Safety department in 2004 more than 80% of road accidents are due to inappropriate driving behavior. Such behavior includes inattentiveness or insufficient vigilance. This clearly shows that attention is the main cognitive function required for driving and therefore needs to be considered if we wish to reduce the number of accidents on the road. However, even though attention appears to be the main function required to drive it is obviously not the only one. Based on this, a test was developed (PEPCo™ "Attention on the road") which allows to assess a greater number of cognitive functions required when driving, such as memory, reactivity, shared attention, concentration, quality of visual processing as well as decision making. These cognitive functions are described in the following paragraphs.

While there seems to be no link between the « memory » performance and attention behind the wheel it still needs to be assessed. Indeed, following elementary driving rules (e.g. speed limits) requires at least the short-term memorization of this speed limit. From a more long-term perspective, the main procedures required when driving a car need to be perfectly memorized and well known to ensure the safety of the driver and of the people close to the vehicle.

Even more than attention, reactivity, which corresponds to the way a person is able to (as quickly and accurately as possible) take advantage of available perceived information, influences the candidate's reaction rate in all situations requiring great vigilance. Reactivity is therefore most essential to handle all driving related emergency situations. Lacking attention may significantly increase the driver's reaction rate and therefore cause accidents.

Numerous driving situations require another type of attention called « shared attention ». As soon as a driver has to simultaneously handle several pieces of perceptive information (e.g. the course of another vehicle and the color of the traffic lights) his/her cognitive system must quickly (often within less than a second) determine a system of priorities aiming at processing each element that needs to be considered under the best possible conditions. The shared attention mechanism allows a user to select a part of the information according to relative priorities by slightly postponing the processing of the certain information.

In addition to shared attention, also measured was the level of concentration which corresponds to a person's ability to deliberately mobilize his/her cognitive resources during a task (processing perceptive or "mental" information). Concentration allows the driver to avoid a distractive environment in order to mobilize as many cognitive resources as possible for his/her action. This cognitive ability is therefore strongly required throughout driving and particularly during all steering requiring a certain level of calculation and information processing.

Independently from the intrinsic performance of the driver's visual system the cognitive visual processing component should also be taken into account. During the test it was called it "quality of the visual processing". This cognitive component gathers skills such as imaging or shape recognition mechanisms. When driving, imaging is particularly important for all course assessments or visualizing of routes to be taken. The role of the shape recognition mechanisms on the road is obvious for all aspects of detecting or taking into account elements of the environment. In a world characterized by movement, the time within which they are applied is also most essential.

The last aspect assessed was decision making skills. The measuring of the decision making skills gathers all cognitive abilities of PEPCo™ "Attention on the road" likely to intervene when making quick decisions that are sometimes necessary when driving. More

accurately, these calculation, logical, and action planning elements occur before the stimulation of the cognitive skills directly required when driving. The decision making process is based on the perceptive analysis of the situation and of cognitive elements (aim of the behavior) which justify, or not, maneuvers. Despite the fact that a glaring mistake or excessive slowness when making a decision are less important in PEPCo™ "Attention on the road" than the perceptive analysis (see quality of visual processing) or reactivity, both can still have major consequences on the performance and safety of the driver.

The aim of this study is to determine in how far brain training can improve the effectiveness of cognitive processes required to drive and assessed by means of our PEPCo™ "Attention on the road" test.

Experiment

Method

Participants

Forty-nine sales representatives (14 men, 35 women) from the BOIRON Laboratories, the French homeopathy group, took part in this study as part of a training course on the prevention of risks resulting from inattentiveness behind the wheel.

Material

PEPCo™ "Attention on the road" test was used as well as the CD-Rom "Test and train your attention behind the wheel", both developed by the company SBT/HAPPYneuron. They have the 6 following exercises in common:

1. *The Sense of Speed.* This exercise consists in gauging the speed at which the vehicles are passing, then in determining the fastest and the slowest. The subjects face all types of driving situations: day and night, good or bad weather with rain or fog. This exercise helps measure concentration, reactivity, and memory skills as well as the quality of the visual processing.

2. *Points of View.* Based on an observation point on a plan with several shapes, the subject has to deduce which view the observer really has. This exercise measures the quality of the visual processing as well as the concentration and decision making skills. Ref: http://www.happy-neuron.com/games/visual-spatial/Points-of-View.html

3. *Dance with the Fireflies.* Among 4 possible trajectories the subject has to find the one described by several fireflies moving around on the screen. This measurement gives information about the reactivity, concentration, and decision making skills as well as the quality of visual processing. Ref: http://www.happy-neuron.com/games/attention/Dance-with-the-Fireflies.html

4. *Shapes and Colors.* The subjects first have to memorize a series of 10 shapes presented one after the other (each one for 6 seconds). They then have to recognize each presented shape among 3 distracters. This is how we measure memory and concentration skills. Ref: http://www.happy-neuron.com/games/memory/Shapes-and-Colors.html

5. *Chase.* This exercise represents a double task. After familiarizing with a simple task consisting in visually following targets and then another task of auditory categorization the subjects have to carry out two simultaneous tasks. In this exercise we measure the shared attention, concentration, reactivity, and decision making skills as well as the quality of visual processing.

6. *Mach 2*. In this exercise the candidates have to determine as quickly as possible whether the plane crossing the screen corresponds to the target plane memorized beforehand. This exercise allows to measure the concentration, and reactivity skills, as well as the quality of the visual processing.

In appendix A, a reference table between the exercises used and the assessed cognitive functions is presented.

Procedure

The subjects took the PEPCo™ "Attention on the road" test once, then a second time after a month of independent training. For both trials the percentage of correct

answers as well as the response time were measured. In order to obtain reliable measurements a single cognitive function is measured in several exercises, as shown in description of the exercises used.

Results

The results are graphically presented in figures 1 and 2. The global average scores obtained during the pre-test and post-test and the standard deviations are presented in Table I.; the average scores for each of the assessed cognitive functions and the corresponding standard deviations are presented in Table II.

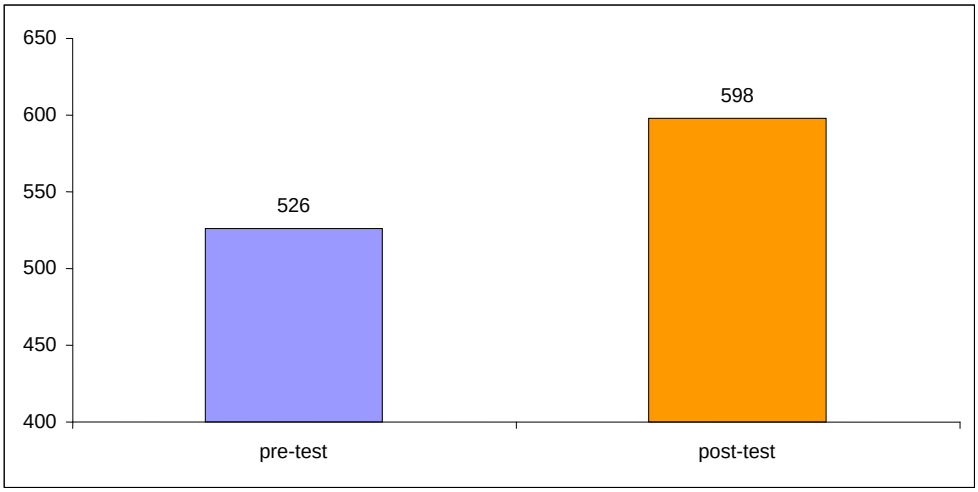


Figure 1: Global average score (out of a 1000) at pre- and post-tests

TABLE I: Global average score (out of 1000) and standard deviations for the pre-test and post-test

	Global average score
Pre-test	526 (*189*)
Post-test	598 (*194*)
Progression	72
% Progression	14%

A significant increase of the global average score was observed between the pre-test (526) and the post-test (598), $t_{(48)} = 3.53$; $p<.001$. The global performance has thus improved by 14%.

According to a more detailed analysis of the data, the 14% global increase of the average performance can be broken down as follows: 71.4% of sales representatives have significantly improved their performance by 29% (pre-test average: 501; post-test average: 649) [$t_{(34)} = 10.05$; $p<.001$] and 28.6% have significantly reduced their performance by 19% (pre-test average: 588; post-test average: 477) [$t_{(13)} = 5.08$; $p<.001$].

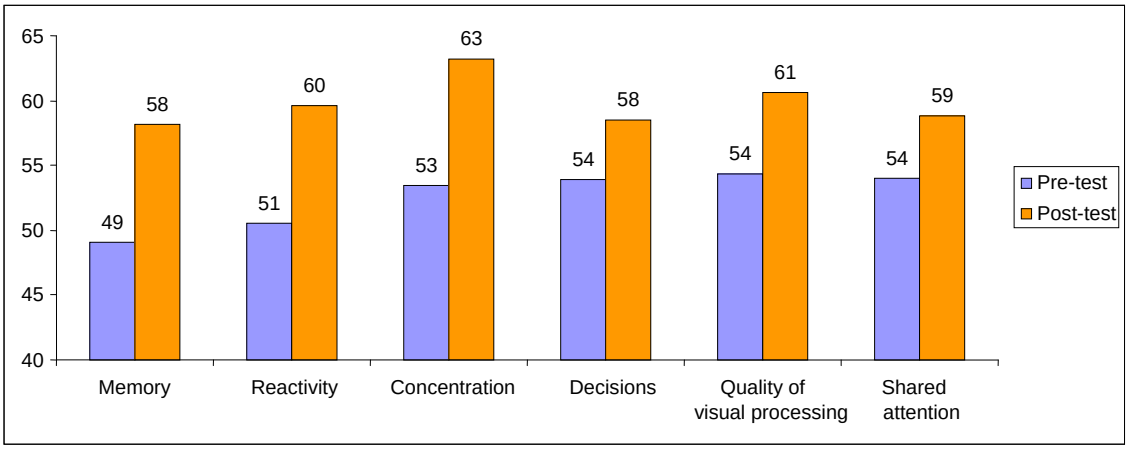


Figure 2: Average score (out of 100) for each function assessed during the pre- and post-tests

TABLE II: Average score (out of 100) and standard deviation for each function assessed during the pre- and post-tests

	Memory	**Reactivity**	**Concentration**	**Decision making**	**Quality of Visual processing**	**Shared attention**
Pre-test	49 (*24*)	51 (*23*)	53 (*24*)	54 (*22*)	54 (*22*)	54 (*25*)
Post-test	58 (*24*)	60 (*22*)	63 (*23*)	58 (*24*)	61 (*25*)	59 (*26*)
Progression	9	9	10	5	6	5
% Progression	18%	18%	18%	9%	11%	9%

The statistical contrasts reveal that performance had significantly improved in terms of memory skills ($t_{(48)}$ = 3.02; p<.01), reactivity ($t_{(48)}$ = 3.12; p<.01), concentration ($t_{(48)}$ = 3.92; p<.001) and the quality of visual processing ($t_{(48)}$ = 2.32; p<.05) but not significantly in terms of decision making ($t_{(48)}$ = 1.52; NS) and shared attention ($t_{(48)}$ = 1.23; NS).

General discussion

The study shows* that brain training improves the efficiency of the cognitive mechanisms required when driving. Training with cognitive exercises for a month allowed to improve the sales representatives' performance by 14% on the PEPCo™ "Attention on the road" test. More accurately, the study reveals a significant effect on the memory, reactivity, and concentration as well as on the quality of visual processing but not on the decision making and shared attention skills.

The different natures of the two functions explain the fact that it is possible to improve a person's concentration with training but not his/her attention. Concentration is a voluntary and conscious act while attention is an automatic and non-conscious mechanism. It is therefore easier to work on a person's concentration than attention. While it is not possible to directly increase attention it is still possible to improve reactivity, that is to say the efficiency with which the person will (as quickly and accurately as possible) take advantage of the available perceptive information.

As a conclusion, even if, according to several studies, attention is the main intervening function on the road it still is an automatic activity which, by definition, is more difficult to control and therefore less responsive to training. Memory, reactivity, and concentration (which, in contrast to attention, is a voluntary and conscious act) skills, however, are responsive to training and therefore lead to a better behavior behind the wheel and thus better road safety.

To summarize, a wider set of cognitive functions should be considered (without merely concentrating on attention) in order to obtain an effective risk prevention action. This preventive action should also allow drivers to develop metacognitive knowledge that is to say learn about how they themselves function. E.g. knowing that a person's attention skills are automatic thus helps to better understand why the voluntary effort to concentrate is essential on the road and why being on the phone while driving turns out to be dangerous in most driving situations.

***Important methodological notes:**

In the subsequent version of the study, the study would be repeated to add a new group of Sales representatives who would take the test twice with a month between both tests but without any training during that month. This would facilitate confirmation that the increased performance with PEPCo™ « Attention on the road » test resulted from the brain training exercise and not from a learning effect due to the test-retest proceeding.

We obtained an unexpected result: 28.6% of the subjects have significantly reduced their performance by 19% (pre-test average: 588; post-test average: 477) [$t(13) = 5.08$; $p<.001$]. The subjects used a CD-Rom for unsupervised training, implying that training was not checked and not monitored. In order to explain this result, one hypothesis may be that some people did not train.

APPENDIX A: Reference table between exercises and assessed cognitive functions – Weight of each exercise when calculating the performance for each of the assessed cognitive functions

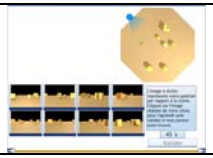
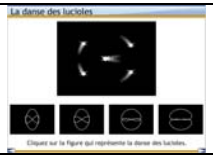
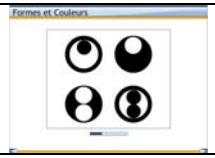
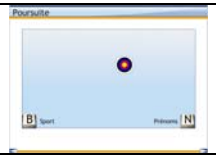
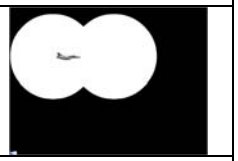
	The Sense of speed	**Points of view**	**Dance with the fireflies**	**Shapes and colors**	**Chase**	**Mach 2**
						
Shared attention					100%	
Concentration	15%	8%	8%	23%	31%	15%
Memory	15%			85%		
Decision making		33%	33%		33%	
Reactivity	33%		17%		17%	33%
Quality of visual processing	14%	44%	14%		14%	14%

Table reading order