# Influence of visual skills training techniques on the cognitive skills of school children.

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**Abstract**

***Introduction:*** Vision is an essential sense of reading and writing during formal studies and requires a basic level of visual skills. Training of visual skills to students may lead to visual skill-motor- and cognitive performance enhancement. Cognitive development in children and young teens is proposed to be one of the most important factors to focus on child development. The visual system uses '*hardware*'-skills (physical, mechanical properties) and the more trainable '*software*'-skills (perceptual, cognitive abilities) for information processing.

***Methods:*** The efficiency of a sports vision training programs was tested in school children (aged 12-18 years), during a 12-week training period. During training a vision laboratory executed battery of repeated visual skills was used and included: visual acuity, focusing, tracking, vergence, eye-hand coordination, and visualisation. A Neuro-Agility Profile™ (NAP™) was done to test the participant's Neuro-Agility, Brain-Fitness, and Neuro-Design.

***Results:*** The results obtained showed significant increases for the participant's pre-tests to post-tests for the eight visual skills. Slight increases were found for the participant's Neuro-Agility Profiles™.

***Conclusion:*** It can be concluded that visual skills training techniques improve school children's '*software*'- and '*hardware*'-skills. Visual skills may also contribute to school children's cognitive development.

Keywords: Visual skill training, cognitive abilities, Neuro-Agility, cognitive development.

**1. Introduction**

**Literature Overview:**

The human brain is divided into different cerebral hemispheres made up of the cerebral cortex, essential white matter, and three nuclei, namely: basal ganglia, hippocampus, and the amygdala[1]. These cerebral hemispheres have functions such as perception, motor functions, cognitive abilities, emotions, and memory[1]. The limbic association cortex is the region of the brain concerned with the difficult mechanisms of emotions and cognitive abilities caught up in the basal ganglia, hippocampus and amygdala[2].

One problematic talking point is the explanation of how thoughts and memories' physiological processes are defined[3], as we are not yet entirely sure how these processes work. What we do know is that memories are saved in the brain by modifying synaptic firing within neurons because of former neural activity[3]. Three classes of memories is be defined by John Hall and Arthur Guyton[3], namely: *short term memory, intermediate long-term memory, and long-term memory.* Structural changes on the synapse is possible during long-term memory formation in the hippocampus[2] (Figure 1).

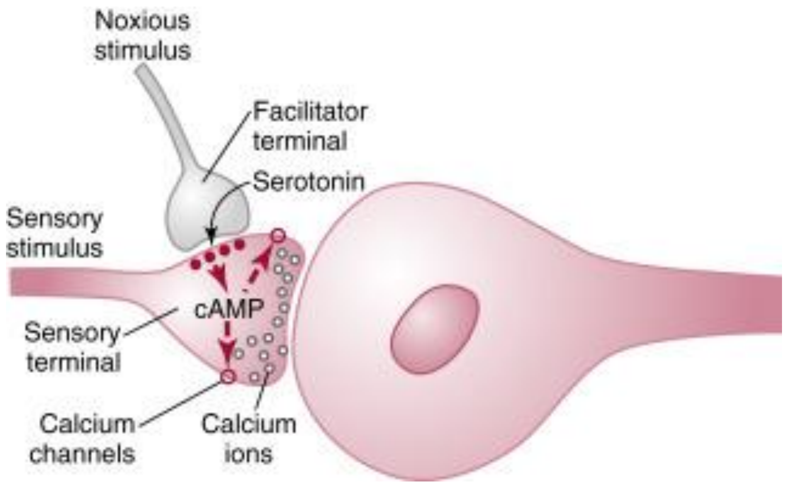


**Figure 1:** The memory system of the snail Aplysia. Cyclic adenosine monophosphate (cAMP).

Cognition is known as the distinguished function performed by the cerebral cortex. Cognition is the cerebral development of gathering information and knowledge. Novel neurons are generated daily in the hippocampus through the process known as neurogenesis[4]. Mental and physical exercise can transform neurogenesis by accumulating these novel neurons that later settle into working neurons contributing towards cognition in the adult brain[4]. This information and knowledge gathering is done by thought processes, using our senses and experiences[5]. Cognitive functioning depends highly on gaining primary functions, the primary functions can be gathered from the motor, sensory and autonomic functions, together with the person's emotional outlook[5].

**Background on the Study:**

Daily tasks such as writing and reading are important points of supplying information. One of the main methods we use to gain this important information is through sight. Vision forms part of our exclusive senses[6]. The group that first comes to mind when thinking of visual perceptions are athletes, as their sight is the most important sense they use[7]. But, non-athletes will most definitely benefit from visual skills testing, as it will improve their abilities to learn faster and process the work in hand at a faster rate[7]. Visual skills rely on our sense of vision. Vision is part of the optic pathway from our retinas through our Central Nervous System (CNS)[1], as described in Figure 2. Optical conversions use a combination of our body's visual system, including the CNS as well as skeletal-muscular system[6,8].

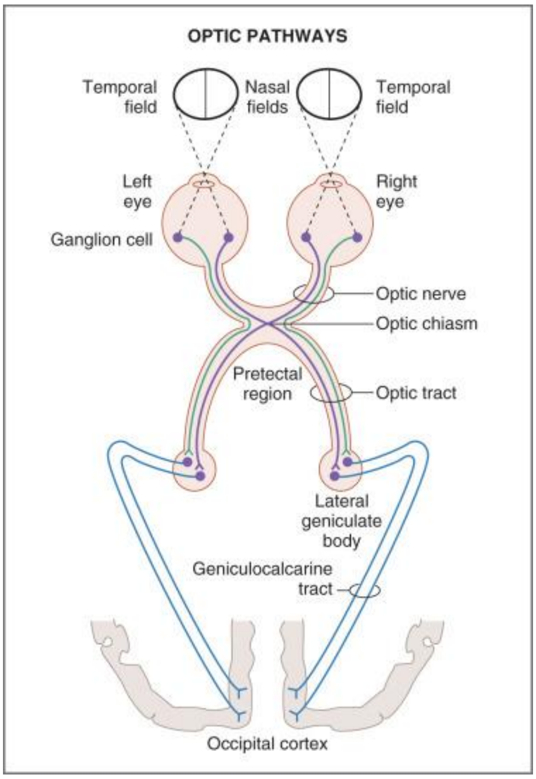


**Figure 2:** Optical Pathways Fibres from the temporal visual fields cross at the optic chiasm, but fibers from the nasal visual fields remain uncrossed.

The visual pathway is one of the most important sensory pathways. It is widely accepted that vision is the primary sensory system used. Vision is used approximately 80% of the time to obtain information from our environment[1] together with trained perception to determine performance in our environments[9]. The visual system functions in the same way as shown in Figure 3. The retina of the eye (sensory system) is excited by light (stimulus) from the environment. The photoreceptors from the eye convert light energy into a nerve impulse. This impulse travels via the optic nerve (afferent pathway) to the visual cortex of the brain (integrating center) where decisions as to the appropriate response are made. Thereafter impulses travel through motor neurons (efferent pathway) to an effector organ (muscle) where a response will be executed[1].

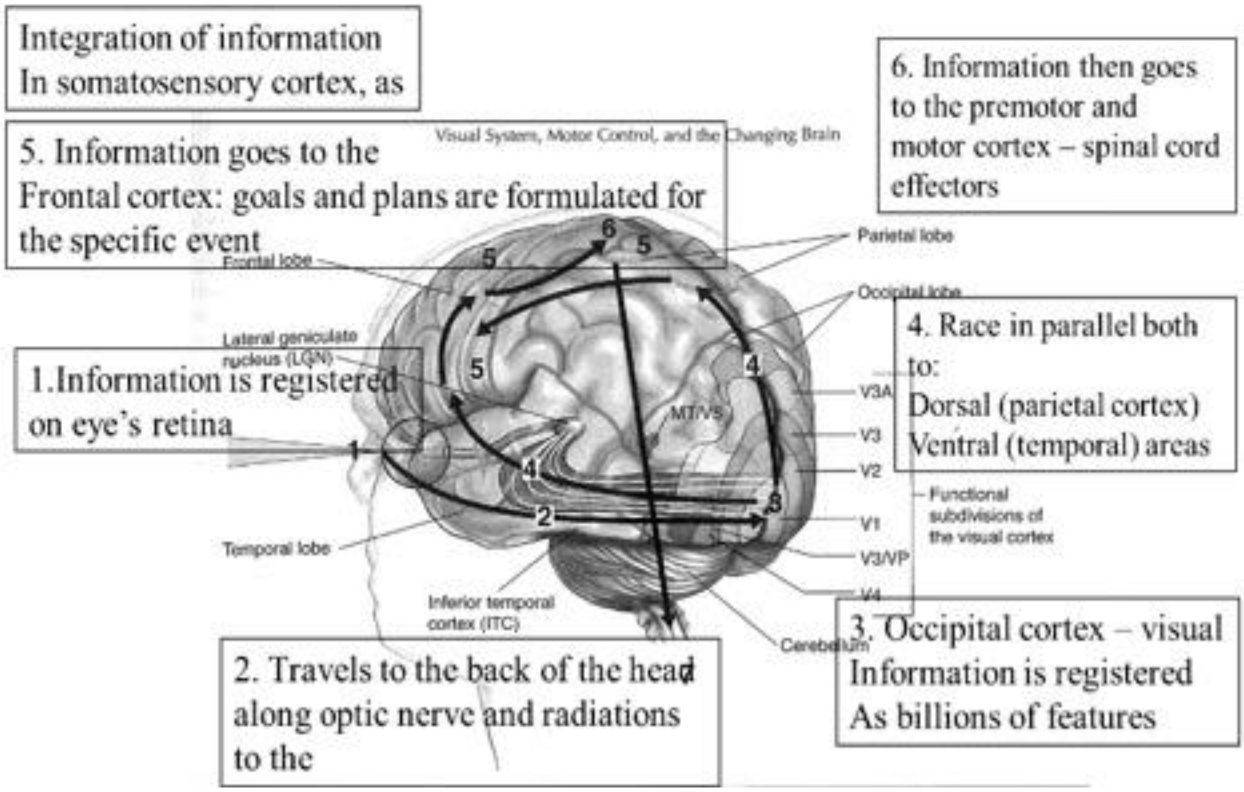


**Figure 3**: Visual pathways in motor control.

Many studies have focussed on how visual perception can be improved using visual skills in sport[6] but also how it will benefit children in their normal day-to-day functioning. As to see does not just form part of clear vision but it entails that the CNS integrates the correct motor response to form the appropriate move[6]. One aspect that will always intervene when trying to improve on cognitive abilities and self-esteem; is stress. Stress itself is defined in various ways[10]. Stress experienced by children can be classified as psychological stress. Psychological stress develops when a person discovers that the close environment overflows their adjusting volume[11].

How do we optimize the quality of information processed needed? The literature suggests that by optimizing the quality of how information is gained through vision control will have a positive effect on overall performance in cognitive abilities[6,12-13]. Research showed that by different studies focussing on visual performance, the groups that partook in the studies performed better overall than their control groups[12-13]. Mental exercises have also shown to improve cognitive abilities and trained tasks at hand[4,14-15]. Thus by improving the participant's visual cues and perception will have a comprehensive development on the participant's cognitive strength and might have a positive impact on their school marks.

With regards to vision it is essential to understand the complexity of this special sense[16]. Vision does not only entail the ability to see clearly but also the ability of the central nervous system to integrate and plan as well as execute an appropriate motor response.

## 2. Materials and Methods

### 2.1 Materials

A pre-test, post-test experimental design was conducted to test the *'hardware'* and *'software'* skills of the school children. The battery consisted of visual acuity, focusing, tracking, vergence, eye-hand coordination, visualisation, and hand-wall toss.

Pre-intervention assessment was done to determine a baseline. Brain performance and the six drivers influencing brain performance was assessed. The brain performance was tested using Neuro-Link's Neuro Agility Profile (NAP)[17]. NAP is a developmental assessment that measures brain flexibility and brain performance. This NAP testing aided in determining if visual skills training has a positive effect on cognitive abilities of school children. NAP brain flexibility measures: Relative laterality, Expressiveness/Receptiveness, Rational Thinking/Emotional Thinking, Information Processing (Cognitive abilities), Sensory learning and Intelligence preference (also cognitive abilities). NAP brain performance measures: Brain

Fitness, Stress, Sleep, Movement, Attitude and Food intake[17]. Interventions started after the pre-tests were done for 12 weeks. The intervention period consisted of the same tests that were done for the pre-tests and post-tests. The interventions were done once a week, after the participant's class at René Human extra classes. The eight intervention tests did not take longer than twenty (20) minutes to complete. After the intervention period, a post-test was done to see whether the interventions improved cognitive skills and brain performance. During each training session schoolchildren repeated all the visual skill tests used in the pre-test/post-test evaluations.

## 2.2 Methods

Visual skills that was tested include[12]:

**Vergence**

By using a pen, the participant kept their arms stretched out holding the pen. They focused on the tip of the pen and gradually brought the tip closer to their eyes, still focussing on the tip, as seen in Figure 4. The participant stopped moving the pen when the tip became blurry. The instructor measured the distance of the tip of the pen to the edge of their eyes and noted the distance.

**Figure 4:** Vergence

**Focusing**

This test needs 2 charts made up of a sequence of letters. A small chart and a large chart, shown in Figure 5. The participant stood approximately one meter from the large chart mount to a wall. The participant held the small chart in their right hand just in front of the right eye. They started to read aloud the letters starting with the small chart moving their eyes to the large chart, the letters also need to be read in a snake-like pattern. The instructor had the memorandum in their possession stopping the participant when a mistake was read. The participant had 1 minute to complete the task, reading as much as possible letters in the correct sequence.

**Figure 5:** Focussing

**Tracking**

This test requires two strips of letters spaced out approximately one-meter apart mount to a wall, presented in Figure 6. The participant stood approximately half a meter from the wall. The participant read the letters on the strips starting from the left moving to the right. The letters must be read in the correct sequence, but the participant may not move their head whilst conducting the test. The instructor has a memorandum with the correct read sequence and stopped the participant if a mistake was made. The participant had a minute to complete the task, reading as many letters in the correct fashion.

**Figure 6**: Tracking

**Visualisation**

This test focusses on memory. A set of cards numbered from 1-7 (Ace being number 1) was placed in a random sequence in front of the participant, as displayed in Figure 7. The participant had a brief moment to correctly memorize the random order of the cards. The instructor turned the cards upside-down. The participant opened up the cards in the correct order counting from 1 to 2, to 3 and so on…

The participant opened up the cards as fast as possible, whilst the instructor took their time. If a wrong number is opened by the participant, they had to close it again and open the correct one, losing time for their mistake. The time will be noted when the task was complete.

**Figure 7:** Visualisation

**Co-ordination**

This task tested the participant's hand-eye coordination. The participant used a simple ice-tray with 12 spaces, two rows of 6 spaces, as indicated in Figure 8. Each space was numbered. In space number 1 will be a 50c coin. The participant had to successfully toss the coin from space 1 to space 12 without letting the coin fall. If the coin fell the participant had to start over, whilst time was running. The instructor kept time. The participant had to complete the task in the fastest time possible.

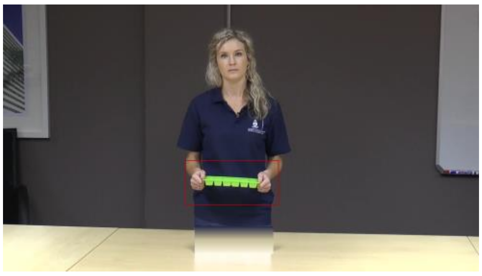

**Figure 8**: Co-ordination

**Hand-Wall-Toss**

This test will need a tennis ball and a smooth surfaced wall. The participant stood, facing the wall, approximately 1.5 meters from the wall. The participant had to throw the ball against the wall using their right hand and catching the ball with their left hand. Then switched, threw the ball with their left hand and catching with their right. The trick is the ball should not drop and the throw had been thrown with an under-arm motion. The instructor timed the participant and counted the number of successful throws in one minute.

### Visual Acuity

A simple eye chart was used to conduct this test. As presented in Figure 9. The participant stood approximately 6-8 meters from the chart that was mounted to a wall. The participant read the eye chart from top to bottom whilst the instructor observes. This visual acuity test was done 3 times: firstly, with both eyes open, secondly with one eye closed and the last time with the other eye closed. The chart is marked with vision markers for the instructor to show how well the participant's eyes are. There was no time limit on this test.


**Figure 9:** Acuity

### Eye Dominance

This test showed what eye the participant favors for visual cues. The participant stood approximately 5 meters from an object. They stretched their arms out forming a triangle with their hands, shown in Figure 10. They focussed on the object they selected looking through the triangle with both eyes open. They then first shut the one eye, then the other. They then reported back to the instructor when the object moved the most when which eye was shut. The eye that was shut will show the instructor that the other eye was their dominant eye. No time limit was present for this test.

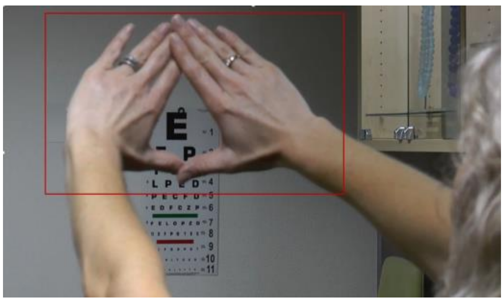

**Figure 10:** Eye dominance

## 3. Results

Informative statistical analysis was performed by IBM SPSS Statistics (2017) statistical data software. Analysis of data was done to establish the mean and standard deviation values of each variable. A normality test was conducted as the sample was larger than n=30[18-19]. Another statistical test namely the Wilcoxon Signed Rank Test was conducted as the study uses recurring testing procedures[19]. The Wilcoxon Signed Rank Test is intended for studies that use measurements on two different incidents, for example, to compare data with Time 1 and Time 2. This test is the non-parametric substitute for recurrent measured t-tests[19]. Furthermore, testing the normality of the NAP test, the usage of the Kolmogorov-Smirnov statistics shows how the NAP testing aid in the positive feedback of the visual skills on the participants[19].

Table 1 and 2 shows the means and standard deviations of the Pre- and Post-testings for the different tests that were conducted on the participants.

**Table 1.** Mean and standard deviation of Pre-testing on participants (N=34).

| **Statistics** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Coordination Time Pre | Coordination Space Pre | Vergence Pre | Hand-Wall Toss Pre | Focussing Pre | Tracking Pre | Visualisation Pre |
| N | Valid | 34 | 34 | 34 | 34 | 34 | 34 | 34 |
| Mean | | 46.09 | 9.00 | 8.471 | 19.24 | 30.50 | 43.62 | 14.7935 |
| Std. Deviation | | 16.792 | 3.339 | 3.2215 | 12.903 | 21.559 | 19.900 | 10.45051 |

**Table 2.** Mean and standard deviation of Post-testing on participants (N=34).

| **Statistics** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Coordination Time Post | Coordination Space Post | Vergence Post | Hand-Wall Toss Post | Focussing Post | Tracking Post | Visualisation Post |
| N | Valid | 34 | 34 | 34 | 34 | 34 | 34 | 34 |
| Mean | | 20.53 | 11.85 | 4.559 | 45.56 | 82.09 | 77.59 | 5.5176 |
| Std. Deviation | | 14.439 | .610 | 2.4642 | 11.068 | 13.067 | 11.410 | 2.80243 |

Together with the tests conducted to show the means standard deviations (±) of the different tests done, descriptive statistics also accompanied these statistical analysis to show that the minimum and maximum ranges correspond to the above-mentioned means and standard deviations of all tests supervised.

**Table 3.** Descriptive statistics for all the variables (pre and post-tests).

| | N | Minimum | Maximum | Mean | Std. Deviation |
|---|---|---|---|---|---|
| Coordination Time Post | 34 | 7 | 60 | 20.53 | 14.439 |
| Coordination Space Post | 34 | 9 | 12 | 11.85 | .610 |
| Vergence Post | 34 | .0 | 10.0 | 4.559 | 2.4642 |
| Hand-Wall Toss Post | 34 | 20 | 66 | 45.56 | 11.068 |
| Focussing Post | 34 | 57 | 113 | 82.09 | 13.067 |
| Tracking Post | 34 | 46 | 97 | 77.59 | 11.410 |
| Visualisation Post | 34 | 2.50 | 17.00 | 5.5176 | 2.80243 |
| Coordination Time Pre | 34 | 10 | 60 | 46.09 | 16.792 |
| Coordination Space Pre | 34 | 2 | 12 | 9.00 | 3.339 |
| Vergence Pre | 34 | .0 | 15.0 | 8.471 | 3.2215 |
| Hand-Wall Toss Pre | 34 | 0 | 48 | 19.24 | 12.903 |
| Focussing Pre | 34 | 7 | 76 | 30.50 | 21.559 |
| Tracking Pre | 34 | 10 | 80 | 43.62 | 19.900 |
| Visualisation Pre | 34 | 4.50 | 50.00 | 14.7935 | 10.45051 |
| Valid N (listwise) | 34 | | | | |

Normality testing is important to note with samples larger than 30, this is shown with the different variables tested for both the pre-tests as well as the post-tests. To support the normality of each individual test (pre and post) the figures below (figures 11-17) shows a Normal Q-Q Plot, these plots are customarily used to show the experimental value for each score marked against the expected value from the normal distribution[19]. We can assume that these tests are normally distributed as each figure for the Normal Q-Q Plot shows little to no deviation from the expected straight line.

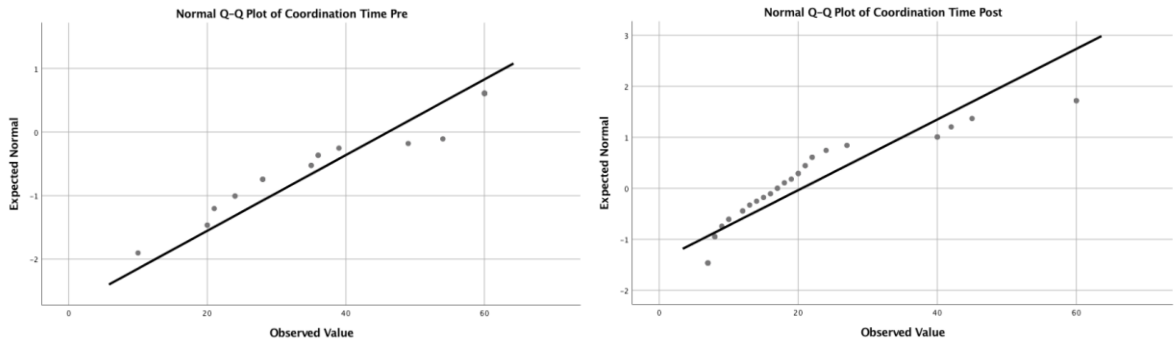


**Figure 11:** Normality test for Pre and Post coordination time test

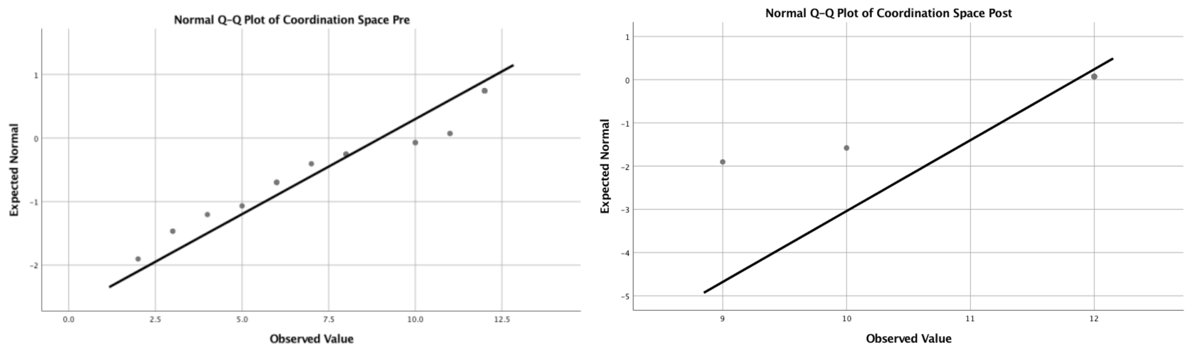


**Figure 12:** Normality test for Pre and Post coordination space test

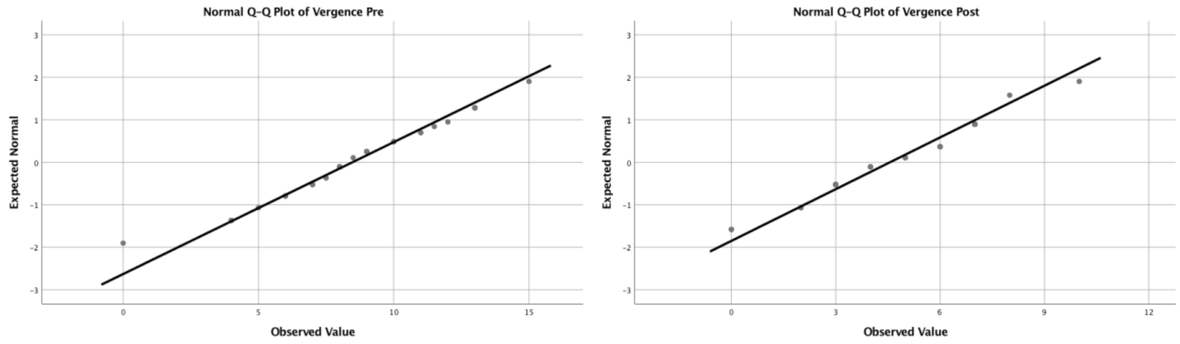


**Figure 13:** Normality test for Pre and Post vergence test

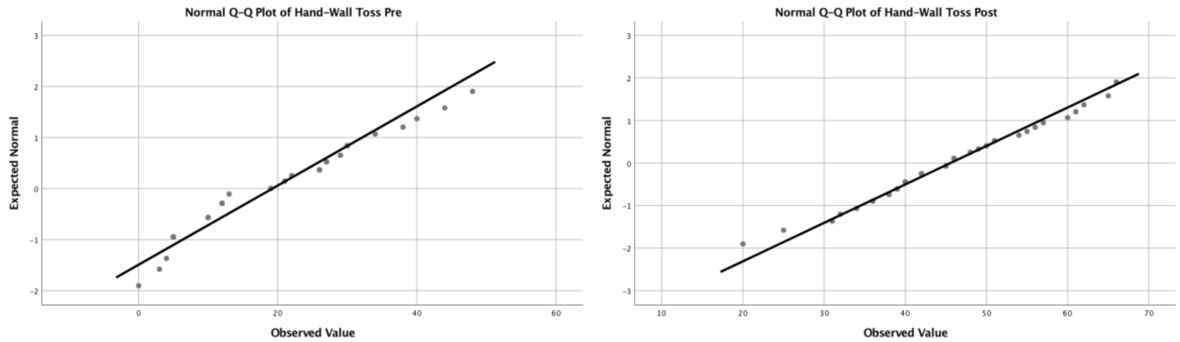


**Figure 14:** Normality test for Pre and Post hand wall toss test

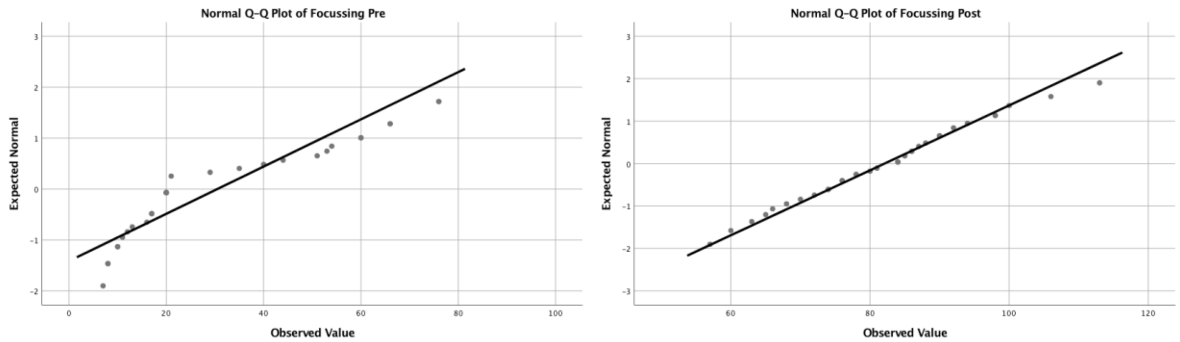


**Figure 15:** Normality test for Pre and Post focussing test

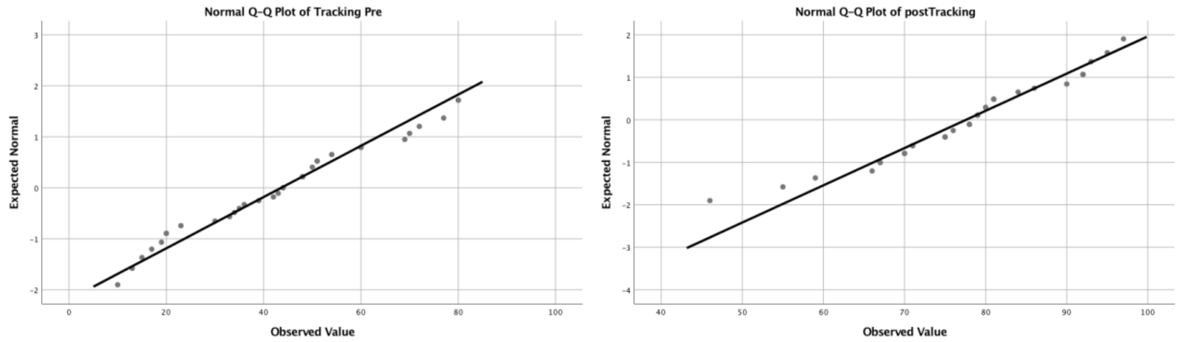


**Figure 16:** Normality test for Pre and Post tracking test

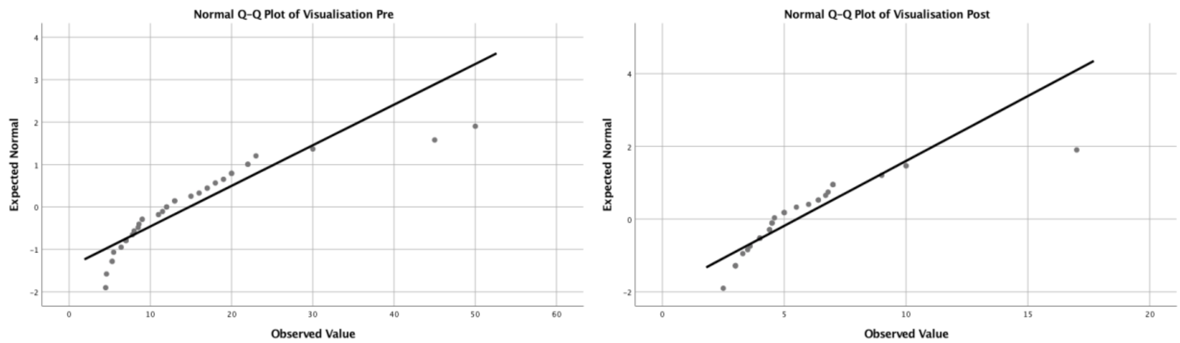


**Figure 17:** Normality test for Pre and Post visualisation test

Non-parametric statistics, like the Wilcoxon Signed Rank Test, are generally conducted to show what the differences are between the distinctive times of a single test[19]. Non-parametric methods do not have strict prerequisites to make assumptions about the underlying population distributions[19].

**Table 4.** Wilcoxon Signed-Rank Test.

| Test Statistics[a] | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Coordination Time Post - Coordination Time Pre | Coordination Space Post - Coordination Space Pre | Vergence Post - Vergence Pre | Hand-Wall Toss Post - Hand-Wall Toss Pre | Focussing Post - Focussing Pre | Tracking Post - Tracking Pre | Visualisation Post - Visualisation Pre |
| Z | -4.901[b] | -3.833[c] | -4.950[b] | -5.070[c] | -5.087[c] | -5.087[c] | -5.090[b] |
| **Asymp. Sig. (2-tailed)** | **.000** | **.000** | **.000** | **.000** | **.000** | **.000** | **.000** |
| a. Wilcoxon Signed Ranks Test | | | | | | | |
| b. Based on positive ranks. | | | | | | | |
| c. Based on negative ranks. | | | | | | | |

The significance level of the test statistic was set at ($p<0.05$). Looking at Table 4 and assessing the row labeled Asymp. Sig. (2-tailed) we can conclude that all the tests conducted by the participants are significant, meaning these sets of scores are significantly different, as all the values are less than ($p<0.05$).

The test for normality towards the NAP assessments are given in table 5 below. Although the significance is higher than the assumed value of ($p<0.05$) and thus not statistically significant, we can assume that the three drivers of the NAP (Neuro-Agility, Brain-Fitness, and Neuro-Design) are normally distributed if each individual driver is evaluated on the Normal QQ-Plot as shown in the Figures 18-20. The significance of each test does not mean no increase in each participant's individual NAP did not occur.

**Table 5.** One-Sample Kolmogorov-Smirnov test for the NAP tests.

| One-Sample Kolmogorov-Smirnov Test | | | | |
|---|---|---|---|---|
| | | Neuro-Agility | Brain-Fitness | Neuro-Design |
| N | | 12 | 12 | 12 |
| Normal Parameters[a,b] | Mean | 62.42 | 57.42 | 67.08 |
| | Std. Deviation | 6.201 | 11.277 | 7.501 |
| Most Extreme Differences | Absolute | .235 | .159 | .155 |
| | Positive | .235 | .146 | .141 |
| | Negative | -.155 | -.159 | -.155 |
| Test Statistic | | .235 | .159 | .155 |
| Asymp. Sig. (2-tailed) | | .066[c] | .200[c,d] | .200[c,d] |
| a. Test distribution is Normal. | | | | |
| b. Calculated from data. | | | | |
| c. Lilliefors Significance Correction. | | | | |
| d. This is a lower bound of the true significance. | | | | |

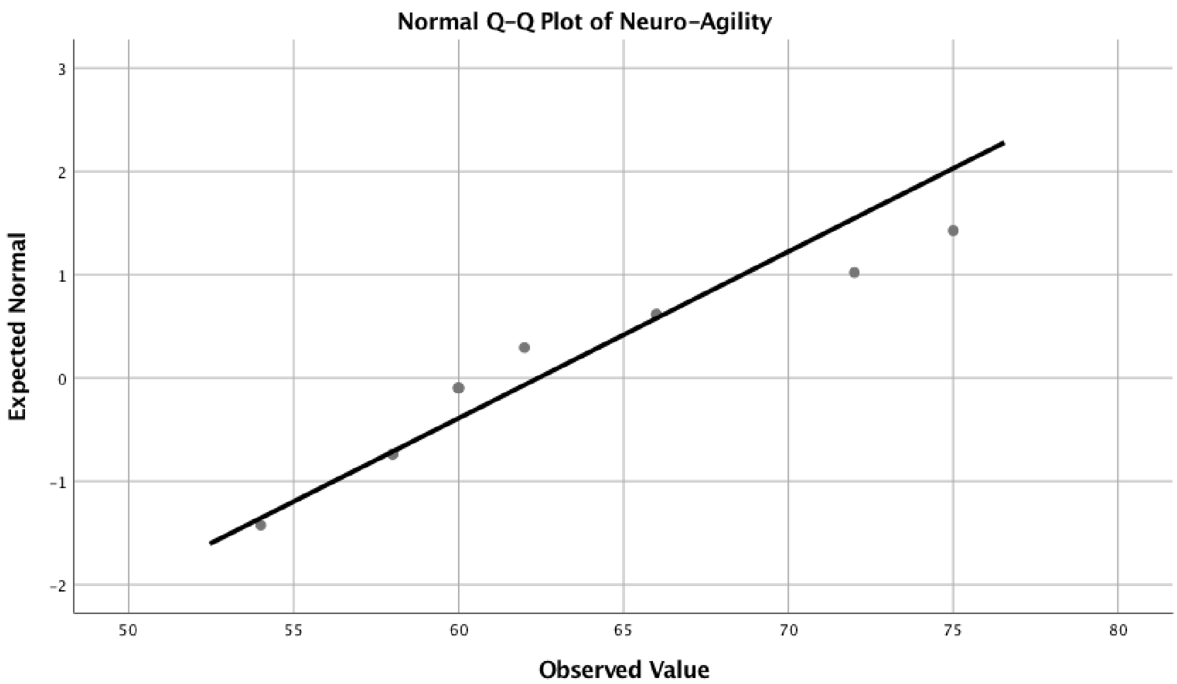


**Figure 18:** Normality for Neuro-Agility

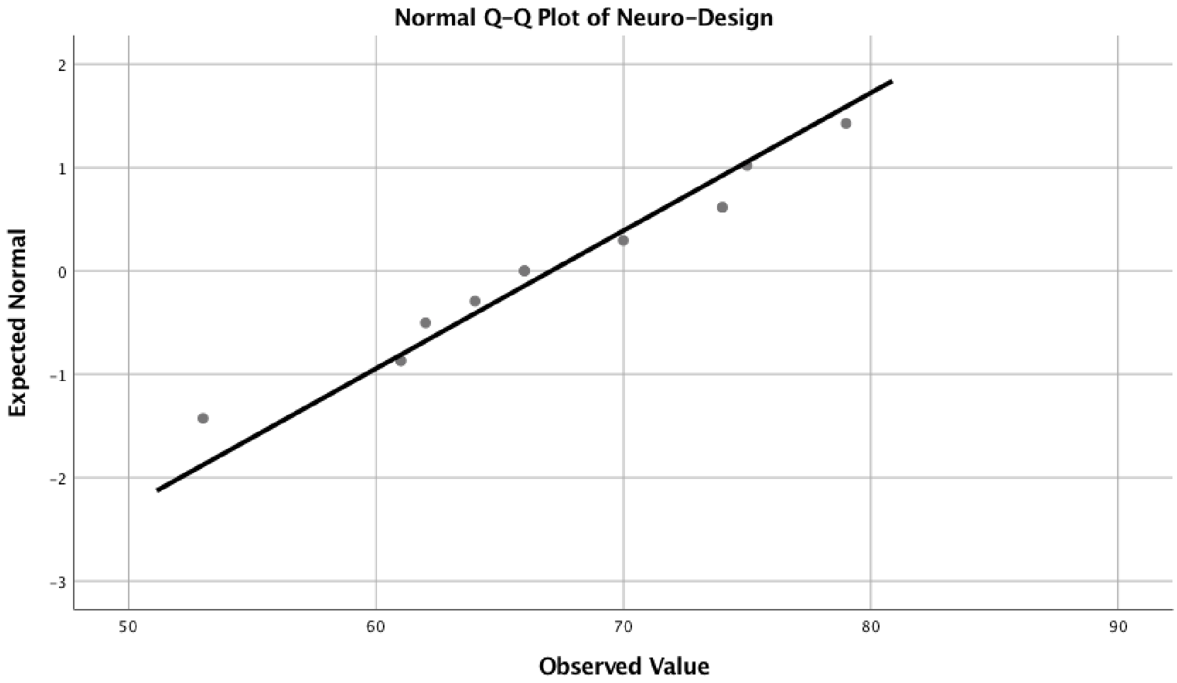


**Figure 19:** Normality for Neuro-Design

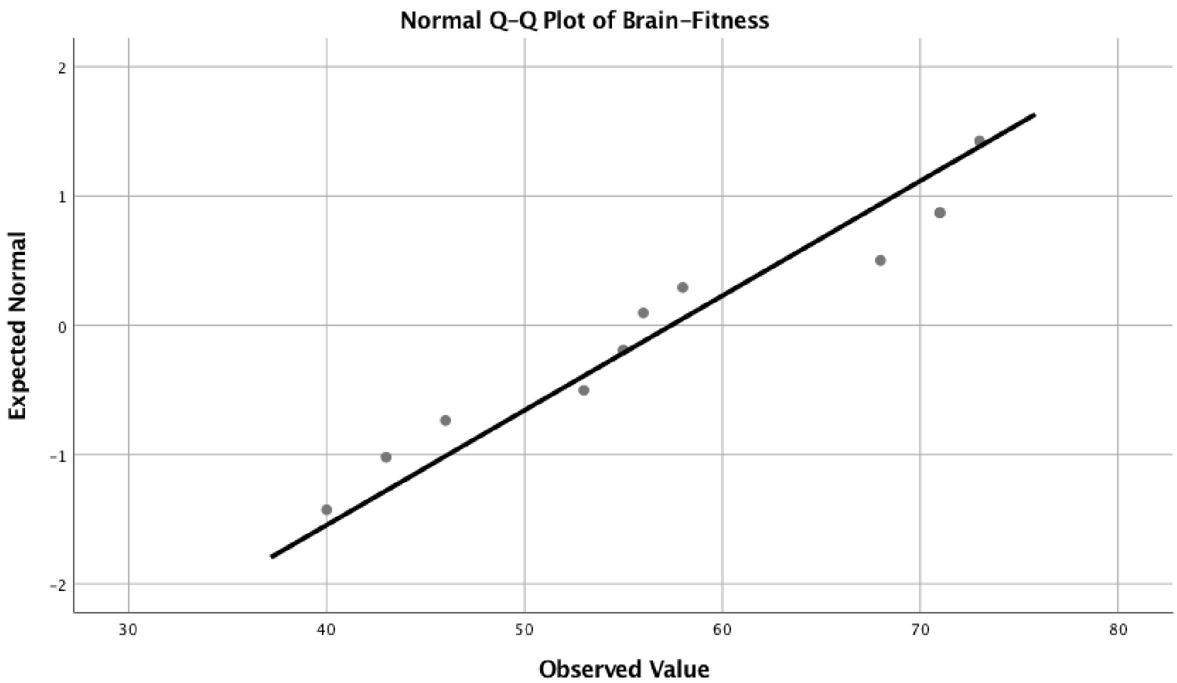


**Figure 20:** Normality for Brain-Fitness

## 4. Discussion

Vision is a fundamental sense and essential for any school pupil's ability to retrieve information for their whole academic school career[16]. Results gained by this study looked at 34 school children, tested over a period of 12 weeks, who participated in the visual skills training techniques. These visual skills used 'hardware'-skills (physical and motorized properties) as well as 'software'-skills (cognitive and perceptual properties) to process information.

Comparing each individual test with regards to the pre-testing and the post-testing significant increases are shown all-around. The hand-eye coordination test has 2 separate variables tested. The time taken to complete the task and the spaces inside the ice-tray. The times taken to complete the task significantly increased from the pre-test to the post-test; with a mean of 20.54 seconds (±14.439) for the time taken in the post-test compared to the mean of the pre-test of 46.09 (±16.792). The mean spaces completed for the post-test was noted to be 11.85 (±0.610) contrasted to the pre-test of the coordination spaces mean to be 9.0 (±3.339). The data for the hand-eye coordination visual skills test shows noteworthy improvements for the participants.

The vergence test, that emphasises the participant's ability to focus on close details without putting constraint on their eyes, also showed substantial improvements. By evaluating the post-test to the pre-test of the vergence technique showed that the post-test had a mean of 4.559 centimeters (±2.4642) to the pre-test's mean of 8.471 centimeters (±3.2215). These mean centimeters from the participant's eyes showed a significant increase in the participant's eye focusing abilities.

Focussing visual skills method tested the participant's capabilities to focus on objects near and far with precision and accuracy. The focussing method's post- and pre-tests showed magnificent improvements in the data. The post-tests mean increased to 82.09 letters per minute (±13.067) related to that of the pre-test to be 30.50 letters per minute (±21.559). The amount of letters read per minute by the participant's increased momentously after their 12 week intervention period.

The visual skill method of tracking tests the participant to fast track reading abilities from left to right without the need to move their heads. Another remarkable improvement can be noted by the data. The post-test tracking mean showed 77.59 letters read per minute (±11.410) contsasted to the pre-test mean of 43.62 letters read per minute (±19.900). This shows that the mean participant's tracking abilities improved from the pre-test to the post-testing.

The hand-wall toss visual skill combines both the motorised and physical methods of the brain with the cognitive and perceptual proficiencies. This visual skill helps participants to gather information using different abilities in the brain. Hand-wall toss techniques showed some improvements comparing the pre-tests to the post-test. The post-tests mean revealed 66 successful throws per minute (±11.068), whereas the pre-test mean presented 48 successful throws per minute (±12.903). The hand-wall toss technique is one of the most difficult visual skills to perform and to show significant improvements by the participants are notable.

Memorisation exercises are of the most important techniques to improve on for the brain's ability to retain information successfully. The visualisation visual skills technique tests this information-recall ability. Visualisation showed some astounding improvements in assessing the pre-tests to the post-tests. The post-test visualisation mean showed 5.5176 seconds (±2.802) to the pre-test mean of 14.7935 seconds (±10.45051). This significant improvement in the numbers of the visualisation skill shows that the participant's abilities to retain information faster, with ease and more successful.

Furthermore, the Neuro-Agility Profiles (NAP) showed that a normal distribution score can be assumed regarding the shapes of the Q-Q Normality Plots, as little deviation is seen to the normal line provided. The NAP tests merely supported the eight visual skills training techniques to show whether any cognitive changes can be seen regarding the participant's development in the 12-week visual skills interventions. If each participant's individual NAP was scrutinised then the slightest improvements can be seen on their overall brain drivers (Neuro-Agility, Brain-Fitness, and Neuro-Design)[17].

**5. Conclusion**

In this study, it can be concluded that visual skills training techniques can have an improvement on the brain's motor and physical properties as well as the cognitive and perceptive properties[6,20].

All of the participants showed significant improvements after a 12-week intervention program towards their overall visual skills evaluations[12]. After examining each individual participant's unique Neuro-Agility Profile™, small increased changes can be seen toward their overall cognitive, visual and general neuro-abilities[17].

Future testing will be done by focussing on a more holistic approach, not only focussing on visual skills but a full-body analysis toward the cognitive developments for school children. Also to assess the improvements in cognitive development, not only will assessments be done by using Neuro-Link's NAP™ tests, but evaluations on each school child's school rapports can be used to examine a more precise cognitive development.

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