

# NeuroTracker Published Studies & Research

Evidence of Relevance in Enhancement and Assessment of Human Performance and Wellness

NeuroTracker evolved out of a pure science approach through decades of research at the [Faubert Lab](#) (University of Montreal). The director of the lab, [Professor Faubert](#), has been deemed to be the world's preeminent expert in visual perception. Designed to uniquely measure and enhance high-level cognitive functions, NeuroTracker has become established as a valuable research tool for understanding human performance at the perceptual-cognitive level. As such independent research entities around the globe use NeuroTracker to conduct studies across a variety of human performance and wellness domains, and across many different populations. For this reason new research is being published frequently. The scientific applications of NeuroTracker generally fall into the categories of performance enhancement or assessment.

## Enhancement

Ultimately, it's measurable improvements performance that are sought after, known to be difficult to attain with contemporary interventions. Near transfer has been demonstrated repeatedly with NeuroTracker training, revealing significant improvements with different populations in many high-level cognitive faculties, such as executive function and working memory. These are known to be essential to mental performance, and also to be typically impaired across a wide range of factors inhibiting cognitive performance. Rare evidence of far transfer to real-world abilities has also been demonstrated, for example in the ability to interpret and predict human body movements, and in the outcomes of competitive sports play.

## Assessment

NeuroTracker is a simple training exercise to do, with virtually no technique or practice required within the task itself. For this reason a unique scientific baseline of high-level cognitive abilities can be established with just 1 to 3 NeuroTracker sessions (6-18 minutes). However, performing NeuroTracker at speed thresholds evokes powerful responses in brain activity, becoming an unparalleled reference of functional neuroplasticity. Accordingly, superior NeuroTracker learning rates have been found to be a defining characteristic of elite athletes, yet have also been found to be still strong in populations such as aging and children with learning difficulties, where cognitive capacities are expected to be diminished. Mapping of neuroelectric brain functions pre and post training suggests neuroplasticity levels may be increased with NeuroTracker training. As such, NeuroTracker assessments provide a valuable new window into the evolving functional capacities of the human mind.

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This document contains summaries of research and studies completed to date, with references to the research. To inquire for further details or interpretations of the research, or to inquire about conducting your own research projects with NeuroTracker, contact [info@neurotrackerx.com](mailto:info@neurotrackerx.com)

# NeuroTracker Published Studies & Research Index

## Human Performance Enhancement

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NeuroTracker training robustly transfers to high-level cognitive gains, with boosts in brain wave activity.
- [Transfer to Soccer Performance](#)**  
NeuroTracker training provides improvements to passing and decision-making in competitive performance.
- [NeuroTracker Cognition Enhancement in Aging](#)**  
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## Human Performance Assessment

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Transfer effects of NeuroTracker training are improved with feedback, reducing attention test errors.
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NeuroTracker baselines and learning rates differentiate developments in age related cognitive function.

# 1. NeuroTracker Study on Enhancing Cognitive Function

'Enhancing Cognitive Function Using Perceptual-Cognitive Training'

[Clinical EEG and Neuroscience 1–11, 2016](#)

## Aim

To examine the effects of NeuroTracker training on standardised measures of attention, working memory, and visual information processing speed using standardized neuropsychological tests. Additionally to measure changes in brain state using functional brain imaging.

## Method

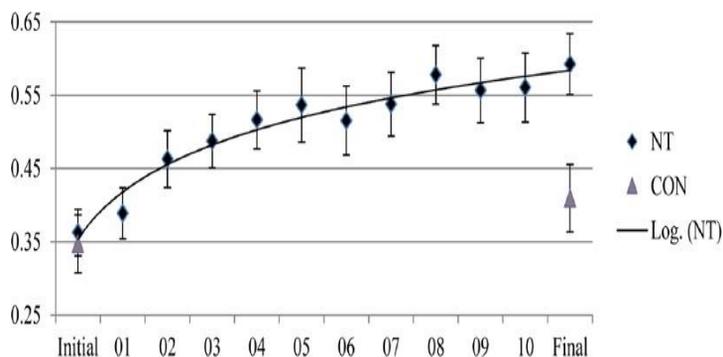
20 university-aged students were recruited and divided into an NT training group (30 sessions of NeuroTracker) and a non-active control group. Cognitive functions were assessed using standardized neuropsychological tests (IVA+Plus, WAIS-III, D-KEFS), and correlates of brain functions were assessed using quantitative electroencephalography (qEEG).

## Findings

The trained group showed strong and consistent improvements in NeuroTracker speed thresholds throughout the training period. The NT group demonstrated significantly higher scores on the IVA+Plus Auditory, WAIS Symbol Search, WAIS Code, WAIS Block Design, WAIS Letter-Number Sequence, d2 Test of Attention, and D-KEFS Color Naming, Inhibition and Inhibition/Switching subtests ( $P < .01$ ).

For qEEG measures the NT group demonstrated significant relative power increases in a range of frequencies within the beta bandwidth, with both eyes open and closed resting states. These changes were observed across frontal regions of the brain (executive function) and represented increases in brain wave speed associated with heightened brain activity and neuroplasticity.

Overall results indicated that NeuroTracker training can enhance attention, information processing speed, and working memory, and also lead to positive changes in neuroelectric brain function.



## 2. NeuroTracker Study on Transferability to Soccer Performance

'3D-Multiple Object Tracking task performance improves passing decision-making accuracy in soccer players'

Psychology of Sport & Exercise, Vol. 22, 1-9, DOI:10.1016/j.psychsport.2016

<http://www.sciencedirect.com/science/article/pii/S1469029215000631>

### Aim

Attention and concentration are crucial abilities that affect the decision-making of athletes; e.g. during a soccer action, an athlete has to divide attention on the field (teammates, opponents, ball), to use selective attention (which player to give the ball to) and to focus attention (staring at the net to score). To this purpose, many benefits may arise from the high-level NeuroTracker conditioning technique as it stimulates active processing of dynamic visual information and trains perceptual-cognitive functions of athletes. In particular, it targets selective, dynamic and sustained attention, as well as working memory.

### Method

23 university soccer players participated in the study and were randomly allocated to three different groups.

Experimental group: performed 30 NeuroTracker Core sessions over a 5 week period

Active control group: performed 30 3D soccer videos sessions over 5 week period

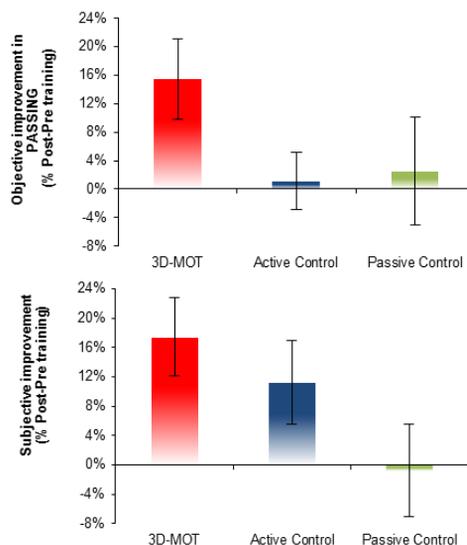
Passive control group: No particular training activity over a 5 week period.

Players' decision-making was evaluated during standardized small sided games before and after the training period. Decision-making of soccer players was objectively analysed through video recordings of the small sided games by a soccer coach blinded to the experimental protocol and using a standardized coding criteria. Subjective decision-making accuracy was directly evaluated from players' confidence levels in decision-making promptly after the games using a Visual Analog Scale (Sport Performance Scale).

### Findings

Only the NeuroTracker trained group showed an increase (15%) in passing decision making on the field after the training. Moreover, players' subjective decision-making assessment was quantitatively proportional to the improvement in decision-making accuracy rated during video analysis for the NeuroTracker trained group.

These results seem to demonstrate that passing decision-making accuracy improvement in the trained group represents a meaningful training effect. For the first time, this study demonstrates a perceptual-cognitive transfer from the laboratory to the field following a non-sport specific perceptual-cognitive training program.



### 3. NeuroTracker Cognition Enhancement in Aging

Perceptual-Cognitive Training Can Improve Cognition in Older Adults with Subjective Cognitive Decline

[Research Open](#)

#### Aim

To investigate if perceptual-cognitive training can provide a proactive intervention to enhance cognition in older adults with memory problems.

#### Method

47 healthy participants aged 60-90 with subjective memory problems were divided into active and control groups. All participants completed three robust neuropsychological assessments over a three-month period. Active participants completed these before, after and following a 7 week NeuroTracker training intervention.

#### Findings

The NeuroTracker trained group improved significantly on the task, with significant or major transfer to scores in memory tasks (e.g., CVLT-II: Immediate Free Recall; Short-Term Memory Recall, and Long-Term Memory Recall), working memory tasks (e.g., Digit Span Backward) and cognitive flexibility tasks (e.g., D-KEFS Verbal Fluency Category Switching and D-KEFS Verbal Fluency Letter Fluency). NeuroTracker scores also correlated to the scale of these improvements for processing speed, memory performance, and cognitive flexibility.

Furthermore, some increased transfer benefits were found one month after the training intervention, potentially indicating heightened neurogenesis and promise for neuroplastic cognitive rehabilitation. The overall results suggest that this form of perceptual-cognitive training can significantly enhance cognition in a sustained way, with a relatively short training intervention.

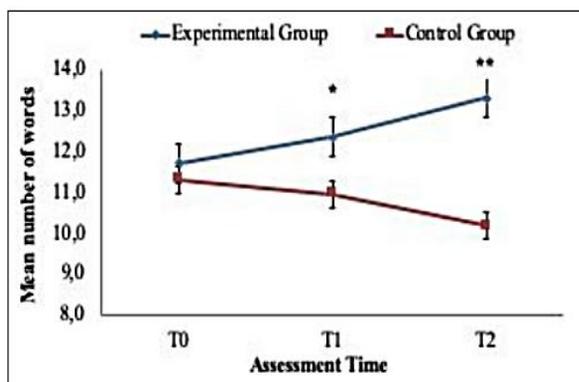


Figure 2. Linear trend analysis. Long-delay memory recall measured with CVLT-II List A/B Long-Delay.

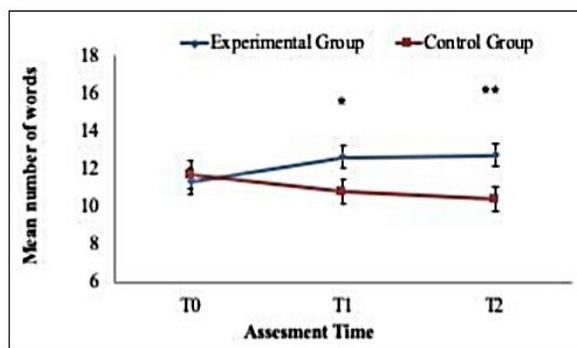


Figure 3. Linear trend analysis. Verbal cognitive flexibility measured with D-KEFS Verbal Fluency Test: Category Switching.

## 4. Enhancing Cognitive Functions in Healthy Elders

### 3-Dimensional Multiple Object Tracking Training Can Enhance Selective Attention, Psychomotor Speed, and Cognitive Flexibility in Healthy Older Adults

[Research Open](#)

#### Aim

To investigate if a short NeuroTracker training intervention could improve high-level cognitive abilities in elderly populations.

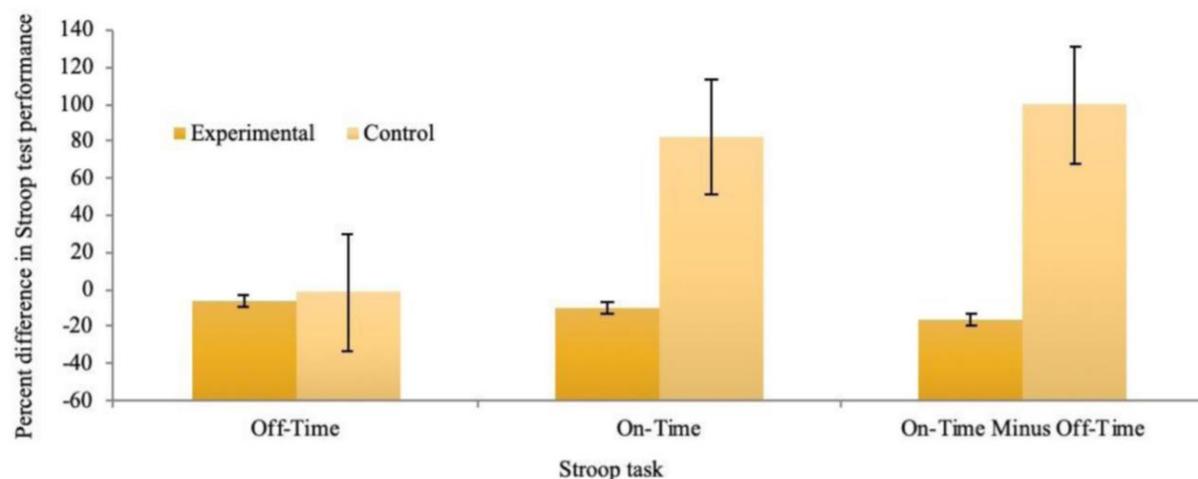
#### Method

46 participants, aged 63-87 years old completed pre-and-post neuropsychological assessments for selective attention, psychomotor speed, and cognitive flexibility. Active participants completed 21 NeuroTracker sessions (approx. 2 hours of training) over 7 weeks, between pre-and-posts tests. Controls did no training.

#### Findings

Controls showed no change in pre and post tests. In contrast the active NeuroTracker group experienced significant gains in cognitive flexibility, psychomotor speed, and selective attention, and similar improvements in a combined assessment of psychomotor speed and cognitive flexibility.

The researchers concluded that NeuroTracker presents a promising tool for recovering and improving these high-level cognitive abilities in older populations.



**Figure 4.** Percent difference in 3 Stroop test tasks between initial appointment and 8 weeks later. The experimental group completed 21 sessions of 3D-multiple object tracking training over a 7-week period. The control group received no intervention.

## 5. NeuroTracker and it's Role in Mental Resistance to Fatigue

Prior perceptual-cognitive training builds mental resistance during acute physical fatigue in professional rugby athletes

[Research Gate](#)

### Aim

To assess the inhibitory effects of physiological fatigue on cognitive function in elite athletes, and to determine if perceptual-cognitive conditioning can reduce any such effects.

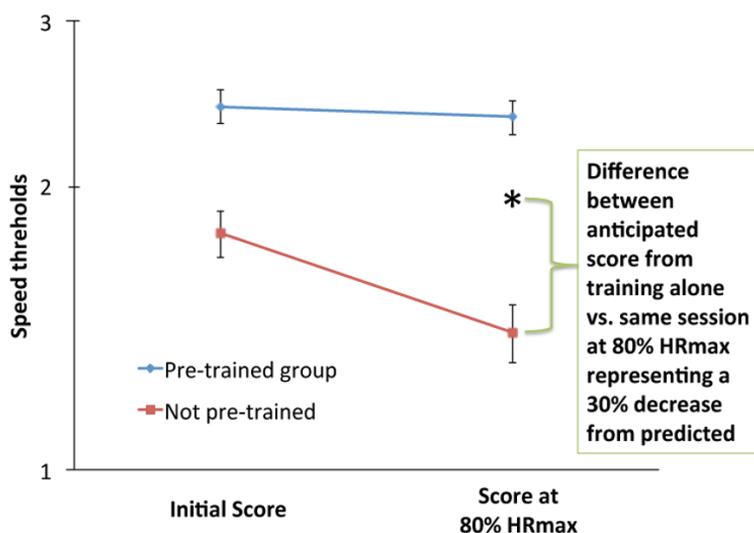
### Method

22 rugby players from the Top 14 French Professional Rugby League were divided into two groups. The trained group underwent 15 NeuroTracker Core training sessions, and the untrained group did only 3 Core sessions (sitting) to determine an initial baseline measure. All the athletes were then assessed on NeuroTracker while performing on an exercise bike at 80% of their maximum heartrate.

### Findings

For the trained group, NeuroTracker speed thresholds remained within 0.03% of the range of their baseline (performed sitting). For the untrained group, NeuroTracker speed thresholds dropped by 30% from their predicted baseline.

Firstly, the findings suggest that physical fatigue can significantly reduce high-level cognitive functions elicited by the NeuroTracker task, even with seasoned professionals. Secondly, the results also indicate that such effects can be mitigated with prior perceptual-cognitive conditioning, with as little as 90 minutes of distributed training.



## 6. Multi-Sport Performance Training

'Perceptual-cognitive Training with the NeuroTracker 3D-MOT to Improve Performance in Three Different Sports'. [Educació Física i Esports](#) (in Spanish)

### Aim

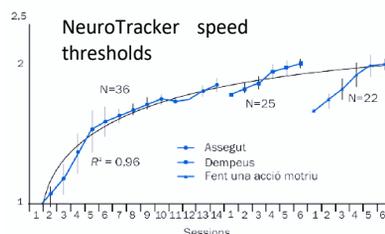
This study analysed the effectiveness of NeuroTracker to improve sports performance related measures across 37 elite athletes, including water polo (13), taekwondo (12) and tennis athletes (12), with a total of 20 athletes rigorously completing all assessment protocols.

### Method

26 NeuroTracker sessions completed with these difficulty progressions:

14 seated, 6 standing up, 6 in an integrated balancing position

Large gains in visual tracking speeds occurred across the groups.



### Assessments

**Performance assessments** involved both coaches and athletes using a visual analogical scale questionnaire to objectively assess the athletes' visual concentration, perception speed and peripheral vision as references to on-going levels of performance. These assessments took place frequently throughout the NeuroTracker training program, including pre and post training. **Visual assessments** were measured pre and post NeuroTracking training and included a range of standardized optometric tests:

- **Static and dynamic visual acuity** (Palomar disk)
- **Visual contrast sensitivity** (personal clinic software FSC)
- **Saccadic fixations near/far** (Les Taules de Hart)
- **Response-time to peripheral stimulus** (AcuVision 1000, International AcuVision Systems Intl.)
- **Stereopsis** (Titmus-Wirt test at 40cm)
- **Selective focused attention** (d2 test of attention)

### Findings

The training program led to a statistically significant pre-post improvement in most visual skills: static visual acuity, stereopsis, spatial contrast sensitivity, saccadic ocular movements, selective attention on the d2 test. No improvement was found on reaction time to a peripheral stimulus or dynamic visual acuity. Transfer to sports performance was found through both coach and athlete subjective assessments with significant improvements across 'Concentration', 'Perception speed', 'Peripheral vision'. Athletes tended to rate their performance higher than coaches, but their ratings followed the same progression (significant correlation).

#### Performance ratings

Athletes (black line)  
Coaches (blue line)

Concentration (left)  
Perception speed (center)  
Peripheral vision (right)



Across 26 NeuroTracker sessions

## 7. NeuroTracker Study on Biological Motion Perception

'Training 3D-MOT improves biological motion perception in aging: evidence for transferability of training'

[NeuroReport](#)



### Aim

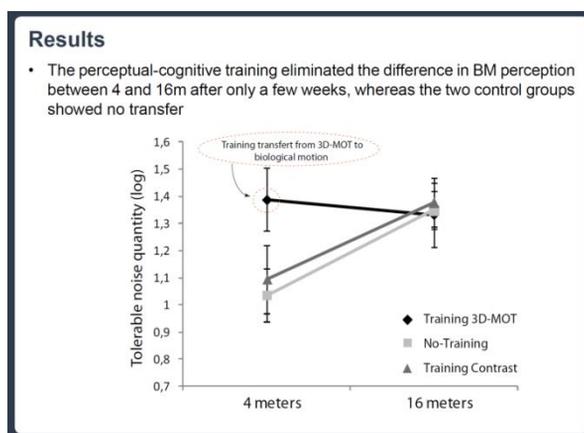
To investigate if age related cognitive decline in functional capacities can be reversed with a short cognitive intervention (NeuroTracker training). Biological Motion Perception (BMP) involves complex interpretations of human-based movement and body language, essential for interpreting social stimuli and managing complex scenes such as in crowds or sports activities. Young adults cannot read BMP at less than 1 meter, whereas with healthy older people it is typically lost at 4m (a critical risk for collision avoidance). This research focused on testing if the capacities of young adults could be regained.

### Method

41 older adults with mean age of 68yrs old were divided into trained, active control (placebo), and passive control (no training) groups. They were measured on a standardised BMP post training, which consisted of 15 NeuroTracker sessions distributed over 5 weeks.

### Findings

Only the NeuroTracker trained group showed transfer to BMP, who demonstrated substantial improvements in processing BMP at 4m. The conclusion was a clear and positive transfer of perceptual-cognitive training onto a socially relevant ability in the elderly.



## 8. NeuroTracker Study on Working Memory Span

'3D Multiple Object Tracking Boosts Working Memory Span: Implications for Cognitive Training in Military Populations'

[Military Psychology](#)



### Aim

Working Memory (WM) capacity has been linked to performance on a wide range of elementary and higher order cognitive tasks. Due to evidence suggesting that NeuroTracker speed thresholds are an indicator of the quality of high-level brain function, and because it is an adaptive task, the researchers selected NeuroTracker to investigate whether training could improve WM capacities. A further reason was to test a training approach with short intervention times for practical military implementations for the Canadian Armed Forces.

### Method

41 soldiers in the Canadian Armed Forces volunteered for the study. First they were tested on three WM span tasks: word (verbal) span, matrix span, and visual span, establishing a baseline measure for each test. Participants were then distributed evenly into 3 groups based on demographic and cognitive factors,

**Experimental group:** performed 10 NeuroTracker Core sessions over a 2 week period

**Active control group:** performed an adaptive dual n-back task over a 2 week period

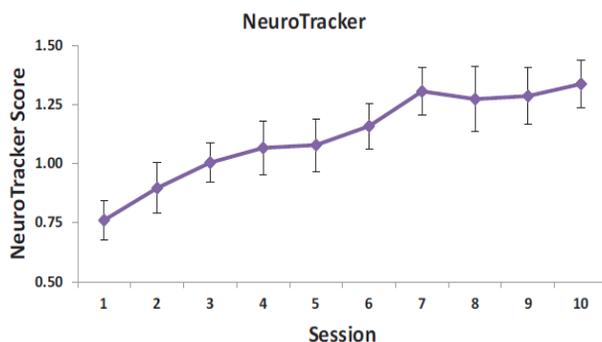
**Passive control group:** No activity over a 2 week period

At the end of the two weeks, the three WM span tests were retaken.

### Findings

For the NeuroTracker group, speeds thresholds increased considerably over the 10 sessions, and training resulted in a significant pre-post increase in word span, matrix span, and visual span, with medium to large effect sizes. In contrast, for the active control, group training did not alter any of the WM span measures. Similarly, WM span measures did not alter for the passive control group.

The researchers concluded that a short amount of NeuroTracker training can benefit WM capacity in a military sample. Additionally, the consistent NeuroTracker improvements across each type of WM span reflect a primarily domain-general construct (a generality of WM capacity).



## 9. Learning Abilities in Healthy Aging

'Healthy older observers show equivalent perceptual-cognitive training benefits to young adults for multiple object tracking'

[Frontier in Psychology](#)

### Aim

This study measured the capacity of older participants to improve their tracking speed thresholds (NeuroTracker), to investigate if age related cognitive decline can be reversed with a training intervention known to be directly relevant to the effects of healthy aging.

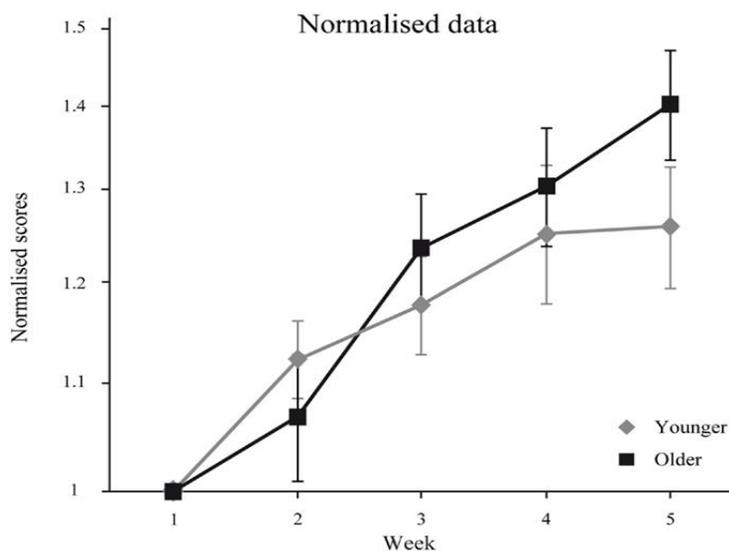
### Method

20 healthy younger adults (mean age 24 years old) and 20 healthy older adults (mean age 67 years old) performed 15 NeuroTracker training sessions distributed over 5 weeks.

### Findings

Both groups obtained benefit from training with a similar rate of progression. Though the older group started off at a significantly lower level than the younger group, they obtained speed thresholds that were similar to those of untrained younger adults by the end of the training program. Furthermore, towards the end of the training program the rate of learning appeared to have slowed for the younger group, yet the older group still showed a strong learning curve, suggesting greater improvements with continued training.

In conclusion, although healthy older people show a significant age-related deficit in the NeuroTracker task, they respond strongly to training effects and demonstrate an ability to fully reverse age-related functional decline with a short intervention of NeuroTracker training.



## 10. Reducing Fall-Risk in the Elderly

‘Examination of the Training Effect of the Three Dimensional Multiple Object Tracking Task on Community Dwelling Elderly’

[Physiotherapy Science](#) (in Japanese)

### Aim

To investigate if NeuroTracker training could positively influence a number of assessments known to be reliable indicators of fall-risk in older adults.

### Method

25 elderly residents (av. 80 years old) of a day care facility were divided into active and control groups. The active group completed a NeuroTracker (3D-MOT) training intervention over 5 weeks, along with a battery of pre and post training assessments relevant to fall-risk. The control group did no NeuroTracker training, but also completed all the pre and post assessments. These included the Mini Mental State Examination (MMSE), Trail Making Test A (TMT-A), 5 meter walking ability, dynamic balance ability, the Timed Up and Go test (TUG), and the Function Reach Test (FRT).

### Findings

Overall the participants improved significantly on NeuroTracker scores (+32%), demonstrating a clear learning capacity for this task in old age. The MMSE (a screening test) showed no significant changes for both groups. The NeuroTracker group experienced significant or large post-test improvements on TMT-A, 5 meter walking time, TUG and FRT. In contrast, controls experienced a moderate or significant decline in TMT-A, TUG and FRT, but a significant improvement in walking time.

Overall the researchers conclude that NeuroTracker training offers an effective intervention for preventing falls in an elderly community dwelling.

	The control group ( n = 11 )		The intervention group ( n = 11 )		
	Initial evaluation	Final evaluation simple primary effect	Initial evaluation	Final evaluation simple primary effect	
MMSE (point)	25.5 ± 2.9	26.8 ± 7.8	27.1 ± 2.5	26.9 ± 1.9	
TMT-A (Seconds)	210.3 ± 80.7	228.3 ± 81.6	242.8 ± 110.5	201.9 ± 98.6	*
5 m Walking (in seconds)	7.9 ± 4.0	7.4 ± 2.7	8.1 ± 2.2	7.7 ± 2.0	
TUG (Seconds)	17.1 ± 5.1	17.4 ± 5.1	19.5 ± 11.6	17.8 ± 11.8	
FRT ( cm )	26.8 ± 7.8	24.3 ± 4.0	26.5 ± 7.4	27.2 ± 6.1	

The average value ± standard deviation. \*: p <0.05.

# 11. NeuroTracker Transfer to Elite Volleyball Performance

Off-Court Generic Perceptual-Cognitive Training in Elite Volleyball Athletes: Task-Specific Effects and Levels of Transfer

[Movement Science and Sports Psychology](#)

## Aim

To investigate the effectiveness of NeuroTracker training with elite volleyball players as a form of off-court cognitive performance training.

## Method

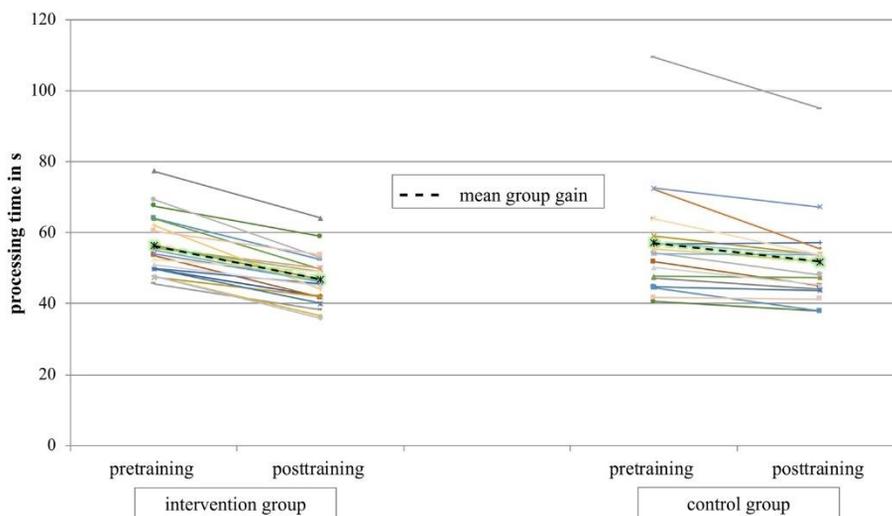
43 elite volleyball athletes performed pre—post NeuroTracker baselines, along with several transfer tests. The active group completed an 8-week NeuroTracker training program in-between pre-post tests, which also included volleyball specific dual-tasks. The control group did no NeuroTracker training, but completed regular volleyball training.

## Findings

Controls showed no change in pre-post NeuroTracker baselines, while the active group approximately doubled their NeuroTracker speed thresholds.

2 near transfer tests (letter read out and memory span) showed no significant changes for both groups. However near transfers tests for sustained attention and processing speed showed significant gains for the NeuroTracker group only.

The researchers concluded that NeuroTracker provides an example of an effective method for improving athletic cognitive capacity with an off-court training intervention.



## 12. NeuroTracker with Motor and Perceptual Dual-Tasks

'Combining 3D-MOT with motor and perceptual decision-making tasks: conception of a life-sized virtual perceptual-cognitive training paradigm'

[Perceptual and Motor Skills](#)

### Aim

To investigate the effects of motor and perceptual dual-task NeuroTracker training over time, and in particular to see if performing prior NeuroTracker consolidation training significantly influences these effects.

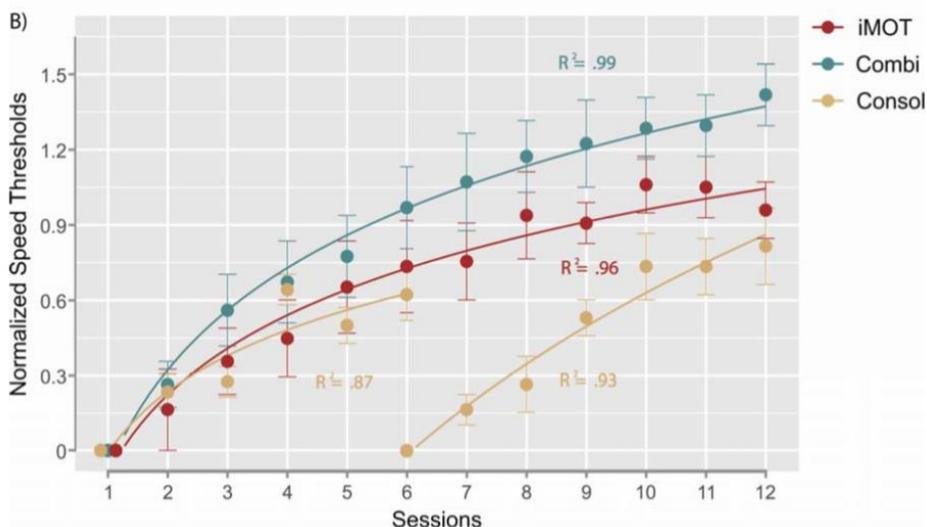
### Method

71 participants were assigned either just NeuroTracker training (iMOT), NeuroTracker with a decision-making task (Combi), NeuroTracker consolidation training then with a decision-making task (Consol), or an isolated decision-making task (iDM). The decision-making task involved a motor-response reaction to a simulated birdie with a real badminton racket. Performance was measured through NeuroTracker speed threshold, decision accuracy, and reaction time.

### Findings

Firstly the results demonstrated that the dual-task component significantly affects NeuroTracker speed thresholds. Secondly that this effect is reduced with training over time. Thirdly that this effect is reduced further when consolidation training on just NeuroTracker is completed beforehand.

Additionally, decision-making speed, reaction time and accuracy improved with dual-task training. Again this improvement was improved via prior consolidation training. Overall this study provides evidence that NeuroTracker consolidation training is an effective method for accelerating learning rates across multiple performance domains.



### 13. NeuroTracker Transfer to Subjective Elite Athlete Performance

‘The effects of Perceptual-Cognitive training on Subjective Performance in Elite Athletes’

[The Sport Journal](#)

#### Aim

To investigate if a NeuroTracker training intervention could subjectively improve performance outcomes with elite athletes across a range of different sports.

#### Method

54 elite athletes from boxing, wrestling, women’s handball, women’s soccer, orienteering, biathlon, alpine skiing, sled hockey, badminton and table tennis completed at least four NeuroTracker sessions per week over a 5 week period. The athletes trained independently from the researchers, using personal NeuroTracker accounts. They were also not given any instructions on the training, to avoid potential biases.

This NeuroTracker protocol used was the NeuroTracker Guided System, which starts at 2 targets and adapts up to 4 targets, according to current baseline scores. All the athletes completed pre and post Athlete Satisfaction Questionnaires (7 point Likert scale), to self-assess their current performance status.

#### Findings

Almost all the participants completed at least the minimum of 4 NeuroTracker sessions per week, indicating a high compliance. On average the athletes experienced an improvement in normalized NeuroTracker speed thresholds of 39% by the end of the 5 weeks. The results of Athlete Satisfaction Questionnaires showed an improvement from a rating of 18.9, to 19.2.

The researchers concluded that the study showed a significant training effect from NeuroTracker, and that the potential transfer to elite sports performance warrants further research.

*Means, standard deviations (SD) and p-values for the group using t-test on pre- and post-test scores.*

Variable	Pre-test		Post-test		p
	Mean	SD	Mean	SD	
1. NT scores (Initial and current baseline scores)	2.33	.47	3.24	.78	*
2. Subjective performance	18.9	4.22	19.2	4.63	

# 14. Cognitive Enhancement of Football Performance

[German Football Association \(DFB\) Academy](#)

## Aim

To review the existing perceptual-cognitive research and outline the relevance of NeuroTracker for the performance assessment and enhancement of competitive soccer abilities.

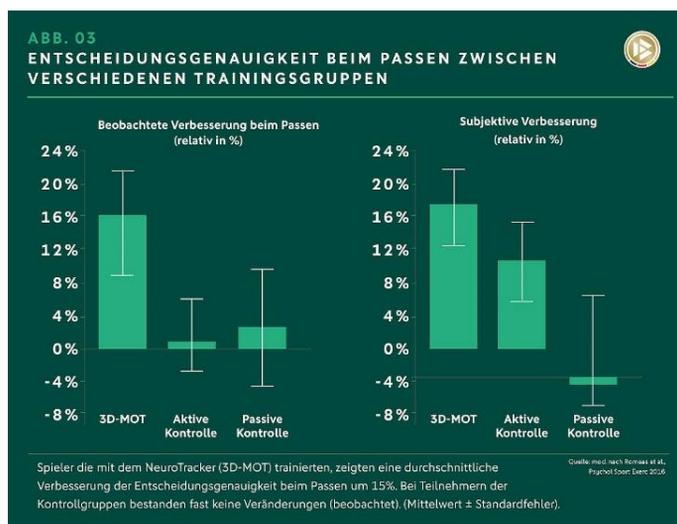
## Method

Several papers published on NeuroTracker were reviewed, including ‘Perceptual-Cognitive Training of Athletes’, ‘3D-Multiple Object Tracking task performance improves passing decision-making accuracy in soccer players’, ‘Visual tracking speed is related to Basketball-specific measures of performance in NBA players’, and ‘Enhancing Cognitive Function Using Perceptual-Cognitive Training’.

## Findings

The combined existing research provides significant evidence for the usefulness of perceptual-cognitive training to assess and enhance soccer abilities. Cognitive abilities are a significant feature of athletic excellence, and elite soccer players differ in their superior perceptual abilities in comparison to amateur players. NeuroTracker training has been found to improve high-level cognitive abilities known to be central factors in predicting soccer performance. Specifically, research has demonstrated that after just 3 hours of 3D multiple object tracking training, soccer players’ experienced a dramatic reduction in passing errors, from an error rate of 47%, down to just 28%.

Considering the accessibility and practical nature of this training approach, NeuroTracker is deemed to be a role model tool for improving soccer performance, providing rare evidence of far transfer in this domain.



## 15. Improving Reaction Time in Swimmers

'Effects of 3D Multiple-Object Tracking on Off-the-Block Reaction Time in University of Victoria Varsity Swimmers: A Pilot Study'

[University of Victoria Library](#)

### Aim

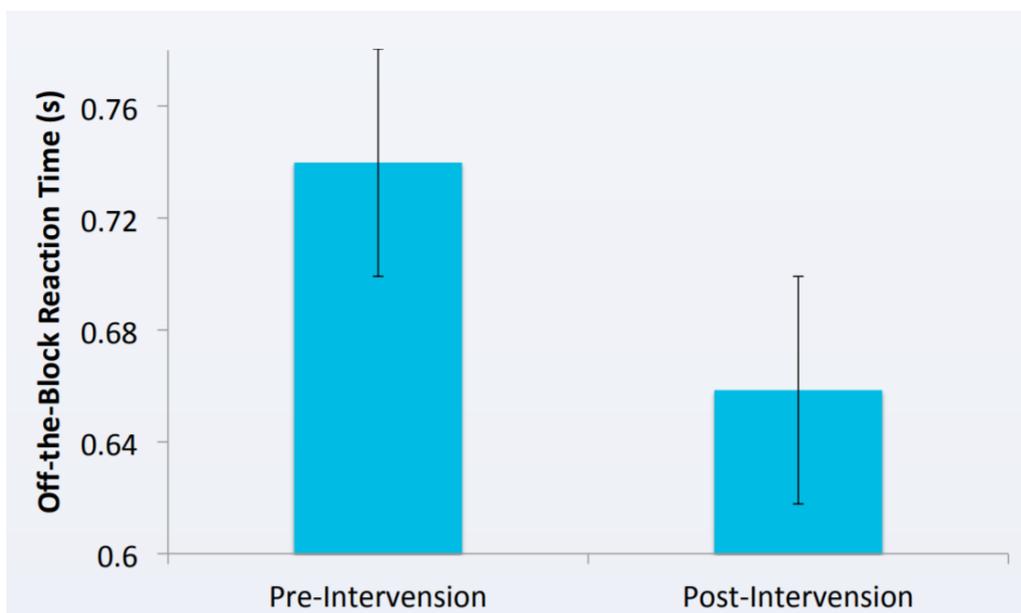
To to determine if NeuroTracker training could affect off-the-block reaction times, by improving selection attention in university athlete swimmers.

### Method

15 male and female varsity swimmers were divided into active and control groups. The active group completed a training intervention of 10 NeuroTracker sessions, controls did no training. Pre and post training the participants were assessed 3 times on for off-the-block reaction times using the Ares Omega Timing System.

### Findings

The control group showed a moderate improvement in reaction time, however the NeuroTracker trained group showed large improvement in reaction time (-11%). This pilot study indicates that selective attention may be a critical factor in reaction time performance, and that a short intervention of NeuroTracker training can significantly improve reaction times.



## 16. Gaze Strategy and Working Memory in Multiple Object Tracking

Examining the roles of working memory and visual attention in multiple object tracking expertise

[Springer](#)

### Aim

To examine the role of working memory and visual attention for tracking expertise in different sports.

### Method

Two experiments were performed. In the experiment 1 (assessment-only), 31 male and female experienced athletes (av. 22 years old) were divided into high-tracking and low-tracking sports, e.g. soccer vs swimming. They completed 3 assessment blocks (9 trials each) of the Jardine and Seiffert 2D MOT task, using 2, 3 and 4 targets at slow, medium and fast fixed speeds. Eye tracking behavior was recorded during the task.

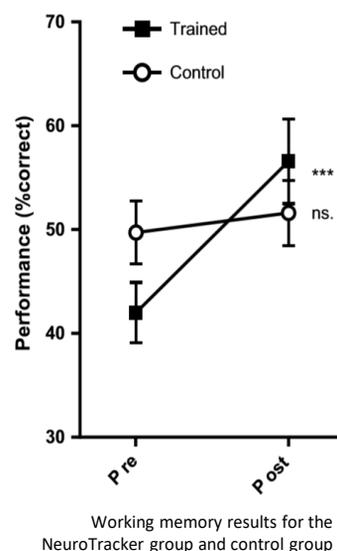
In experiment 2, 36 participants (similar to experiment 1) were divided into a control and active group. Pre and post training, both groups completed the same 2D MOT assessment with eye tracking, as well as 2 types of n-back working memory assessments (combined visual and auditory demands). The active group completed a training intervention of 4 NeuroTracker sessions (20 trials each), using adaptive speed adjustments, whereas the control did not.

### Findings

In Experiment 1, analysis of eye tracking data revealed that directing gaze towards the center of the screen (centroid strategy) was a beneficial strategy for achieving higher tracking performance. This was independent of changes in task difficulty, and there were no significant group differences in gaze strategy between low and high tracking sports. High tracking sports did show superior tracking performance overall, suggesting that tracking ability is more related to perceptual-cognitive capacities than differences in gaze strategy.

In experiment 2, the active group experienced a large improvement in both NeuroTracker scores and working memory performance post-training, including a 35% increase WM accuracy. Training also transferred to significantly improved performance on the 2D MOT assessment. Controls showed no significant changes in pre-post assessments. Gaze strategy did not change post-training, suggesting that training benefits were isolated to gains in perceptual-cognitive capacities.

Experiments 1 and 2 together suggests that tracking performance in sports is largely related to perceptual-cognitive capacities, and that NeuroTracker training dramatically improve working memory abilities. This research also provides validation support for a central gaze strategy (related to visual pivot) in sports tracking performance.



## 17. Attention Training with Children

Attention and Perceptual-Cognitive Training: Preliminary evidence for training attention-deficit populations

[Pilot Study by Neurodezig](#)

### Aim

This was a pilot study with a selection of elementary school children based on test measures showing significant attention problems and impulse control, but not clinically diagnosed as ADHD. The purpose of this pilot study was to see if NeuroTracker has the potential be an efficacious short-term intervention for young students with severe attention impairments, based on changes in standardised neuropsychological assessments.

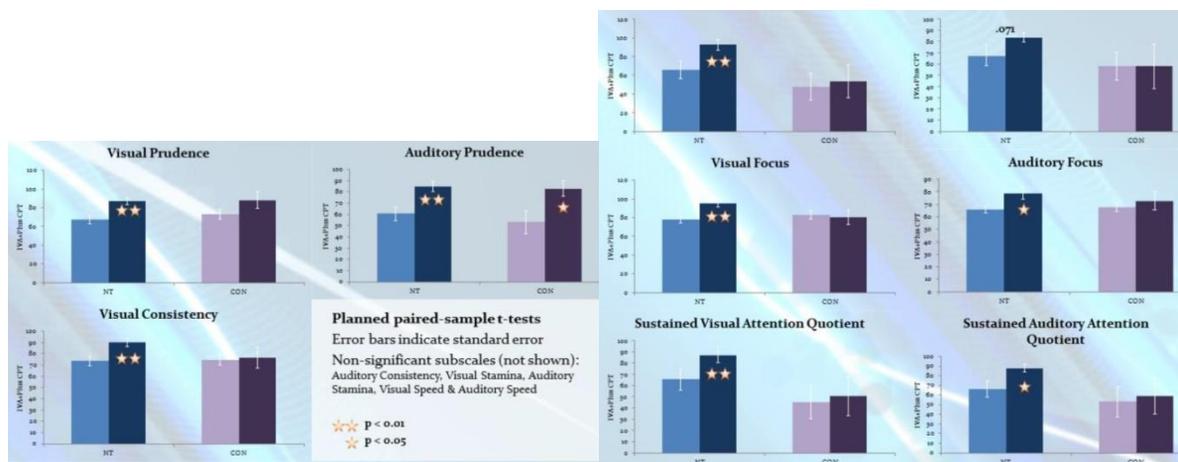
### Method

A test and control group of 5 Elementary school students each were included in the study, selected based on severely impaired rating on the IVA+Plus™ Continuous Performance Test. Both groups produced NeuroTracker initial baselines with statistically insignificant differences. The test group completed 21 five-minute NeuroTracker training sessions distributed over 3.5 weeks, the control group did no training. Both groups were then retested on the neuropsychological assessments.

### Findings

The Test Group improved NeuroTracker speed thresholds by an average of 61% over the course of the training. The control group showed negligible difference in pre-post neuropsychological assessments scores, whereas the trained group showed variable but significant improvements across a range of visual and auditory measures. Gains were most pronounced in Prudence, Consistency and Focus in both visual and auditory domains, matching previous findings, and suggesting cross-modal performance transfer.

In general the improvement ratios suggested that a short-term NeuroTracker training intervention can improve severe attention deficits towards moderate attention deficits in this population, with potential to positively impact learning outcomes at a young age.



## 18. NeuroTracker Case Study on Recovering Memory in Aging

'Memory training and benefits for quality of life in the elderly: A case report'

[Dementia and Neuropsychology](#)

### Aim

This case report sought to examine in detail the effects of a combined intervention program (NeuroTracker and Memory Training) for recovering memory and attentional functions in an older individual.

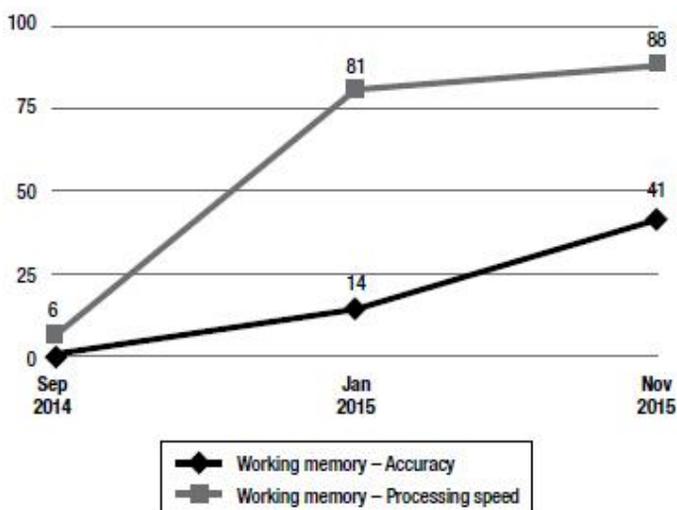
### Method

1 healthy 80 year old male with frequent memory complaints underwent 32 NeuroTracker sessions of Sustain mode over 12 months, alongside Memory Training based on consciously learned mnemonic strategies. The patient completed a robust pre-mid-post training battery of tests on memory, quality of life and stress.

### Findings

At the post-assessment stage, training proved effective for gains in sustained and alternating attention, with above-average cognitive flexibility. Assessments for memory accuracy and processing speeds showed a steadily rising curve. Improvements were evident in self-perceived attention, memory, quality of life and self-confidence. A reduction in stress symptoms was observed with measured improvements in physical, psychological and environmental domains. NeuroTracker scores showed a rising curve throughout the training program.

Based on the case report findings, the researchers suggested such cognitive training programs should be made available in private and public institutions for elderly care to improve quality of life and delay the signs of senility during the aging process.



## 19. NeuroTracker as an Athletic Performance Tool

'Visual Perception Training: Cutting Edge Psychophysics and 3D Technology'

[Semantic Scholar](#)

### Aim

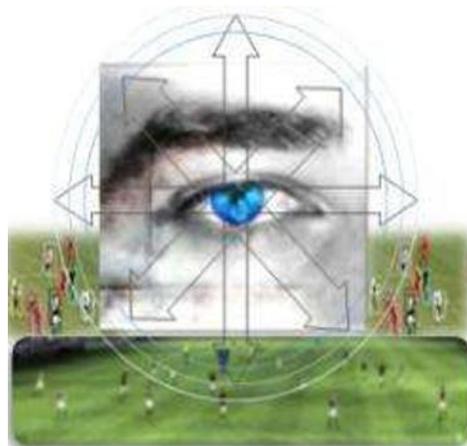
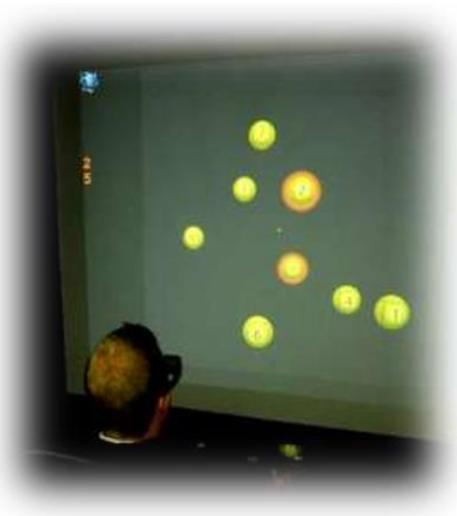
This discussion paper outlines how NeuroTracker and related technologies provide new training opportunities for assessing and enhancing the perceptual-cognitive skills of athletes.

### Method

NeuroTracker application in sports performance is discussed in three areas. Firstly, performance through increasing an athlete's ability to process complex motion and efficiently distribute attention. Secondly, through reduction of injury risk via improved peripheral vision awareness and collision avoidance. Thirdly, as a rehabilitation tool to prevent cognitive regression during prolonged injury periods.

### Findings

The authors conclude on the established relevance of vision training for peak sports performance and that the NeuroTracker technology has demonstrated successful performance training efficacy in elite sports (EPL, NHL, Top 14 Rugby), as well as applied value for other sports-related benefits such as injury reduction.



## 20. Athlete Training and Learning

‘Professional athletes have extraordinary skills for rapidly learning complex and neutral dynamic visual scenes’

[Nature Scientific Reports](#)

### Aim

To assess the learning capacities of elite athlete populations compared to amateur athletes and non-athlete university students on a neutral cognitive task (NeuroTracker).

### Method

308 participants were tested on 15 distributed NeuroTracker sessions, grouped as the following:

#### 102 elite level team-sport athletes

- 51 professional soccer players (English Premier League)
- 21 professional ice hockey players (National Hockey League)
- 30 professional rugby players (French Top 14 Rugby League)

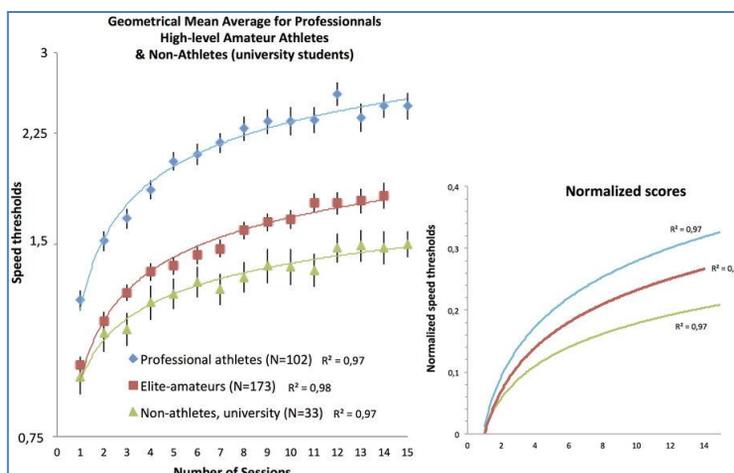
#### 173 elite amateurs

- 136 NCAA university sports program (USA)
- 37 European Olympic training centre

#### 33 non-athlete university students (Université de Montréal)

### Findings

The results showed a clear distinction between the level of athletic performance and corresponding fundamental mental capacities for learning an abstract and demanding dynamic scene task. Elite athletes showed significantly higher baselines than the other groups, along with substantially superior learning rates. The amateur athletes group similarly showed superior learning rates over the non-athletes’ student group. The findings with these large study populations demonstrate that NeuroTracker is a valuable tool for investigating the advanced cognitive learning characteristic of athletes, shown for the first time in this research domain.



## 21. NeuroTracker Study on NBA Performance Metrics

‘Visual tracking speed is related to basketball-specific measures of performance in NBA players’

[Journal Strength and Cond Research](#)

### Aim

The purpose of this study was to determine the relationship between visual tracking speed (NeuroTracker) and reaction time on basketball specific measures of performance.

### Method

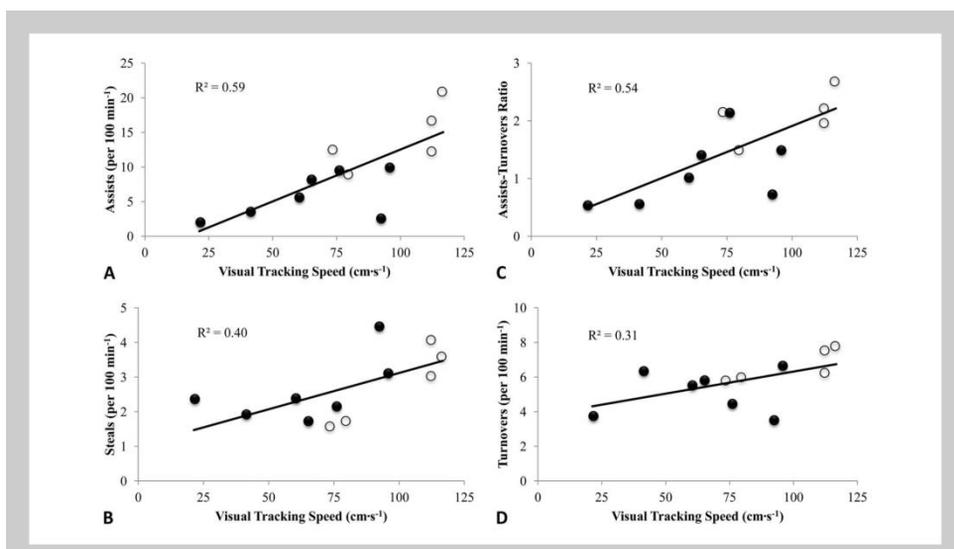
12 professional NBA basketball players were tested with 1 session NeuroTracker speed threshold baselines, and compared with the following basketball-specific measures of performance during the regular basketball season: Assists, Turnovers, Assist-to-turnover ratio, Steals.

All performance measures were reported per 100 minutes played. Performance differences between backcourt (guards) and frontcourt (forward/centers) positions were also examined.

### Findings

Relationships were most present between VTS and Assist-to-turnover ratio, and Turnovers. Backcourt players were most likely to outperform frontcourt players in AST and very likely to do so for higher NeuroTracker baselines. Reaction time was not related to any of the basketball-specific performance measures.

In conclusion, 1 session NeuroTracker baselines showed significant correlation to a basketball player’s ability to see and respond to various stimuli on the basketball court that results in more positive plays, as reflected by greater number of AST and STL and lower turnovers.



## 22. NeuroTracker Cognitive Load Assessment of Jet Pilot Performance

‘Perceptual-Cognitive & Physiological Assessment of Training Effectiveness’

[Research Gate, Conference Paper](#)

### Aim

Military and aviation industries have a strong need for measurable proof that training solutions meet or exceed requirements to deliver effective training, yet there are a lack of valid methods available. The goal of this multi-year research project is to develop methods for assessing the efficacy of training (including live and simulated platforms) by validating measures of cognitive workload that characterize skill acquisition.

### Method

10 evaluation pilots (100-300 flight hours of experience) were selected to perform low, medium and high difficulty flight manoeuvres in both a jet flight simulator and live jet flight (Aero Vodochody L-29 jet trainer) using experimental conditions. During flight ECG data (NeXus-4) and eye-tracking data (Dikablis) was collected. Flight performance was analysed for altitude, roll, and vertical speed errors, and cognitive workload was subjectively assessed (10-point Bedford Workload Scale).

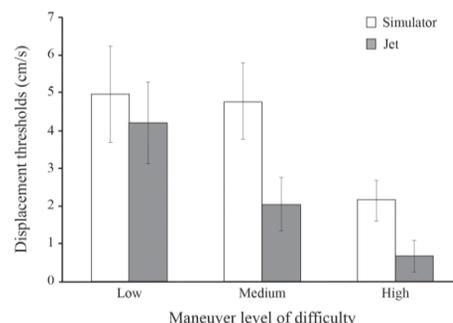
As a validated tool for evaluating perceptual-cognitive skills, NeuroTracker was selected as to measure spare cognitive capacity via extraneous load (Cognitive Load Theory). All pilots first completed home-based NeuroTracker consolidation training (15 Core sessions). NeuroTracker was integrated into the flight testbed. Low, medium and high difficulty flight manoeuvre tests were performed by all pilots, both without NeuroTracker, and while simultaneously performing NeuroTracker Core sessions.



### Findings

Compared to performing NeuroTracker alone, live and simulated flight across all manoeuvres, caused a drastic decrease in NeuroTracker speed thresholds (average of ~97%). This, perhaps for the first time, objectively demonstrated that jet flight involves very high intrinsic cognitive loads.

Live flight resulted in lower NeuroTracker speed thresholds and physiological performance than simulated flight, with greater differences for higher difficulty manoeuvres. This evidence suggests that physiological and cognitive loads are significantly heavier in live flight, supporting the theory that that brain dynamics differ in real-world environments compared to those of a laboratory.



## 23. NeuroTracker Correlation to Driving Simulator Performance

'Driving simulator scenarios and measures to faithfully evaluate risky driving behavior: A comparative study of different driver age groups'

[PLOS ONE](#)

### Aim

To investigate correlations between mental workload, age, and NeuroTracker measures, with driving performance in 3 simulated scenarios, to see if these factors could be predictive of driving risks.

### Method

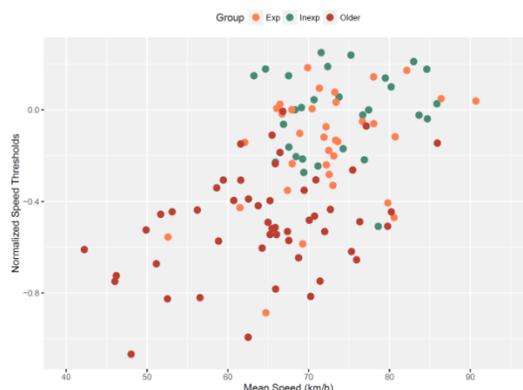
115 drivers were divided into three age and experience groups: young inexperienced (18-21 years old), adult experienced (25-55 years old) and older adult (70-86 years old). Participants were tested for 2 hours across three different driving scenarios varying in mental workload (low, medium, high), which each involved dangerous events that the participants needed to react to. A sophisticated VS500M simulator was used which provided 18 different metrics on driving performance. To evaluate the participants' ability to capture and integrate relevant information in a highly complex visual environment, they were also evaluated with NeuroTracker (3D-MOT) initial baselines. The overall data was analysed in detail for correlations.

### Findings

Older participants generally drove more slowly, and after perceiving potential threats, older drivers took defensive action earlier than younger drivers. However, older drivers were also less likely to identify these threats in sufficient time to react appropriately. Younger participants were more likely to be involved in near crashes than older drivers. For responding to dangerous events, younger drivers tended to favor steering movements to avoid crashes, while older drivers were more likely to brake abruptly.

Statistical analysis of NeuroTracker results demonstrated that they effectively predicted elevated risks of crashes. More specifically, NeuroTracker data predicted steering rate and the distance at which large steering reactions were made in order to evade accidents. Lower NeuroTracker scores also correlated significantly with slower average driving speed for older adults, providing evidence towards the theory that driving more slowly is related to the cognitive effects of aging.

Correlations between NeuroTracker baselines and average voluntary driving speed.



## 24. NeuroTracker Associated to Older Driver Performance

'Three-Dimensional Multiple Object Tracking Speed Thresholds are Associated with Measures of Simulated Driving Performance in Older Drivers'

[Proceedings of the Human Factors and Ergonomics Society Annual Meeting](#)

### Aim

To test the theory that driving performance is strongly associated with dynamic processing of multiple objects, by evaluating if NeuroTracker measures correlate with older driving performance in simulated scenarios.

### Method

30 experienced drivers with ages ranging from 65-85 years old were tested on one session of NeuroTracker (3D-MOT), and completed up to 3 driving scenarios on the STISIM 3.0 driving simulator. 5 unexpected events were included in the scenarios to test crash risk. The correlations between NeuroTracker speed thresholds and simulator measures (crash rate, lane deviation) were then calculated.

### Findings

Highly significant correlations were found between NeuroTracker thresholds and both crash rate and lane deviation in the highway driving scenarios. Lower NeuroTracker scores were strongly associated with lane deviation during highway merging, and higher NeuroTracker scores related to participants being less likely to crash across different scenarios, and to have better overall lane maintenance skills.

This study adds plausibility to the idea that a multiple object tracking test such as NeuroTracker could be a candidate for inclusion in an assessment battery for older drivers.



STISIM 3.0 driving simulator city and highway scenarios

## 25. NeuroTracker Study on Athlete Training and Learning

'Perceptual-Cognitive Training of Athletes'

[Journal of Clinical Sport Psychology](#)

### Aim

This paper covers foundational concepts of NeuroTracker's relevance to training of cognitive capacities deemed critical in sports performance, particularly in dynamic team-sports. It also contains a study investigating the effects of attentional loads in learning paradigms, with the aim of understanding optimal load conditions for training perceptual-cognitive ability.

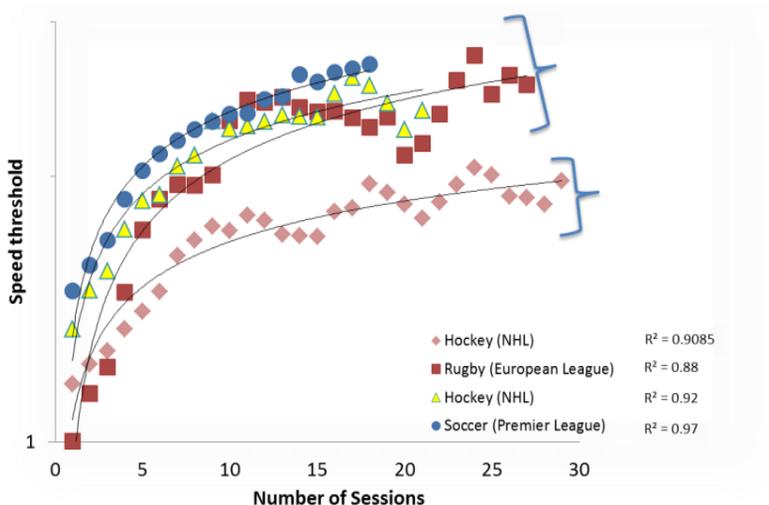
### Method

4 elite professional sports teams trained their athletes on NeuroTracker (15-30 sessions) during their competition seasons. An English Premier Team club, a National Hockey League team, and a European Rugby team were all trained in the standard sitting down position to isolate any influence from attentional mechanisms involved in posture control. Another NHL team performed the training in standing position, involving basic balance demands on attention.

### Findings

Taking the statistical average for learning progression on NeuroTracker, the three professional sports teams training in sitting position showed near identical progression, with rapid early learning slowing down towards longer term but continued learning. The standing sports team showed much lower NeuroTracker scores, but more importantly slower overall learning progression, with a large magnitude of difference to the other teams.

The findings clearly demonstrate the link between balance control mechanisms and perceptual-cognitive demands solicited by NeuroTracker training. This demonstrates that cognitive training loads need to be sensitively optimised to attentional thresholds in order to generate effective short and longer term learning adaptations.



## 26. NeuroTracker Study on Surgery Skills

'Can Multiple Object Tracking Predict Laparoscopic Surgical Skills?'

[Journal of Surgical Education](#)

### Aim

To examine the relationship between NeuroTracker and simulated laparoscopic surgery skills, in order to investigate the role of high-level cognitive skills in this performance domain.

### Method

29 surgeons in training completed a baseline of 3 sessions of NeuroTracker, and age, hours of sleep, caffeine, and video game use) were measured via questionnaires. Simulated surgery tests were used to measure time to completion and average surgical arm movement behaviour.

### Findings

NeuroTracker baselines revealed a significant prediction of surgery skills, explaining, 29% of the variance of time to completion and 28% of the average surgical arm movement. Compared to the questionnaire measures, NeuroTracker baselines were the only significant predictor of performance.

The research team concluded,

'NeuroTracker software provides a cost-effective and easily administrable approach to enhance cognitive skills necessary for laparoscopic surgery. Furthermore, the software is dedicated to enhance specific attentional skills rather than training unspecific skills...we view the training of specific attentional skills as an important addition to surgical training.'



## 27. NeuroTracker as an Indicator of Driving Safety

'Above and beyond driving abilities: toward a single index'

[Points de Vue – International Review of Ophthalmic Optics](#)

### Aim

To combine several tests known to assess driving fitness and propose a methodology to bring these together under a single index termed the 'Driver's Safety Index'.

### Method

115 licensed drivers between the ages of 18 and 86 were separated into two groups: 64 young participants (average age of 29 years), and 51 older participants (average age of 77 years). Each participant was assessed on three different experimental phases.

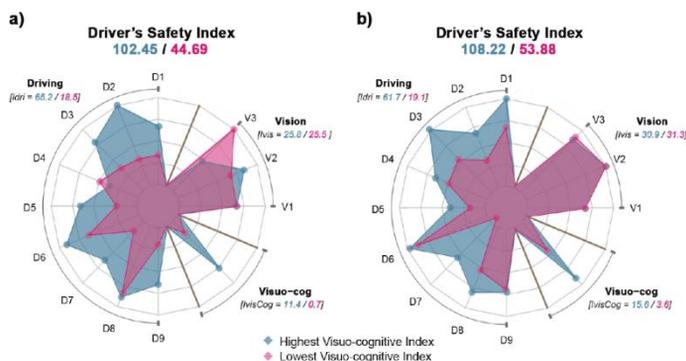
1. Visual tests: visual acuity test (V1), stereoscopic vision test (V2), and a binocular visual field test (V3)
2. Simulator driving tests across 3 difficulty based scenarios: highway (low), rural (medium) and city (high)
3. NeuroTracker as a visuo-cognitive test

A wide range of driving performance metrics from the simulator test were analyzed for correlations with the visual tests, age, and NeuroTracker scores.

### Findings

There were limited correlations between driving performance and the visual tests. High NeuroTracker scores correlated strongly with high driving performance, and low scores with low driving performance, along with a strong relationship for crash risk. NeuroTracker scores were also a better predictor of driving performance than age.

Driving abilities are strongly associated with NeuroTracker scores. These findings highlight the importance of visuo-cognitive abilities in the assessment of driving abilities. This study paves the way toward a single, common indicator of driving behaviour. The study authors recommend that NeuroTracker should be a component in the battery of tests for obtaining or renewing a driving license.



## 28. NeuroTracker Study on Cognitive Load Biomechanics

'The combined impact of a perceptual–cognitive task and neuromuscular fatigue on knee biomechanics during landing'

[The Knee Journal](#)

### Aim

This study investigated the effects of a simulated game-situation cognitive load (NeuroTracker) on lower limb biomechanics, using a landing task relevant to straining of the Anterior cruciate ligament (ACL). ACL injuries are known to be one of the most sports common injuries, and occurrence has been linked to cognitive factors.

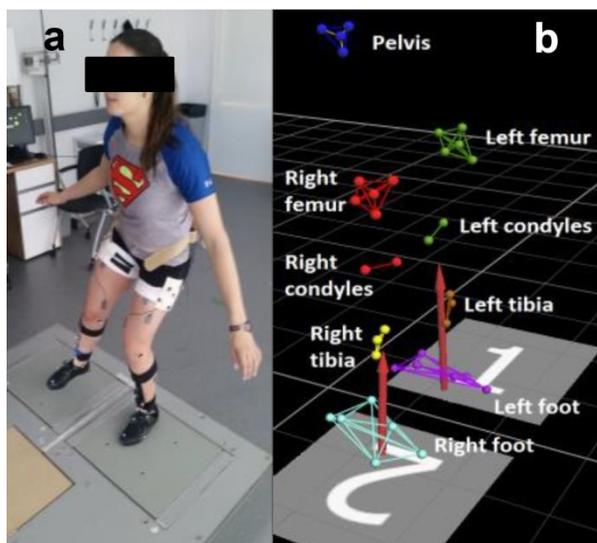
### Method

7 college level healthy athletes (soccer, volleyball, football) performed 16 single-leg landing trials involving a jump forward and a lateral jump to the opposing leg. These movements were measured via force plates and motion capture of the legs and pelvis using 36 markers. The NeuroTracker task was assigned randomly to half of the trials (dual-task procedure), with jumps performed during the tracking phase.

### Findings

While NeuroTracking hip and/or knee kinematics measurements were significantly different for all participants. The largest change was found with knee abduction angle, known to be most associated to ACL injury. Of the 7 participants, 4 showed biomechanical changes from the added NeuroTracker task that revealed increased ACL strain associated with ACL injury.

Based on the preliminary findings, the researchers hypothesize that a NeuroTracker training intervention may reduce risk on of non-contact ACL injury, and will perform a larger study with more detailed biomechanical analysis.



## 29. NeuroTracker on Fluid Intelligence

'The characterization of attention resource capacity and its relationship with fluid reasoning intelligence: A multiple object tracking study'

[Intelligence](#)

### Aim

The objective of the study was to examine MOT capability at different levels of cognitive load (tracking 1,2,3, or 4 objects) and its association to higher level processes, particularly fluid reasoning intelligence.

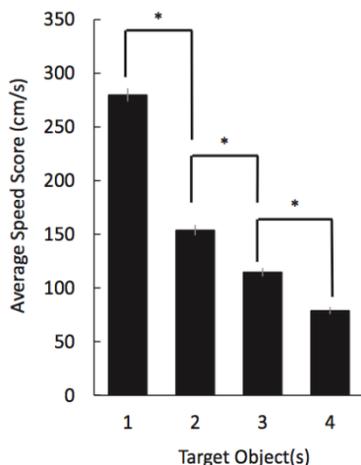
### Method

70 adult participants (mean= 23 years of age) completed NeuroTracker and were then assessed on the Weschler Abbreviated Scale of Intelligence 2 test. Participants were asked to track one, two, three and four targets out of a total of 8 spheres for eight seconds.

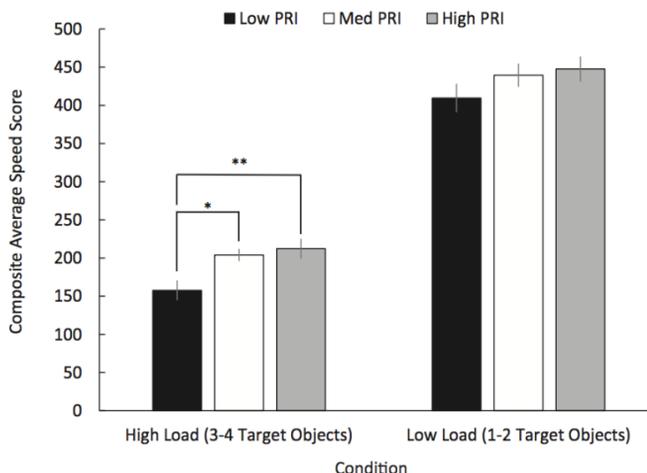
### Findings

The results showed that as the number of targets increased, the average speed the participants successfully tracked all the objects decreased. This finding allowed the researchers to confirm that average speed score can be used as a suitable metric for MOT and in turn, attention resource capacity. As a result, the outcomes indicate that visual tracking capability is positively associated with fluid reasoning intelligence. Consequently, this finding demonstrates that there is a link between fluid reasoning intelligence and MOT capability, especially in conditions of high load (tracking 4 out of 8 targets).

D- MOT average speed scores by load condition



Fluid Reasoning intelligence by High and Low Conditions of Load



### 30. NeuroTracker’s Safety of Use in Children Delayed mTBI

NeuroTracker as a potential means of active rehabilitation in children with atypical mild traumatic brain injury recovery: A pilot safety study

[Wiley Online Library](#)

#### Aim

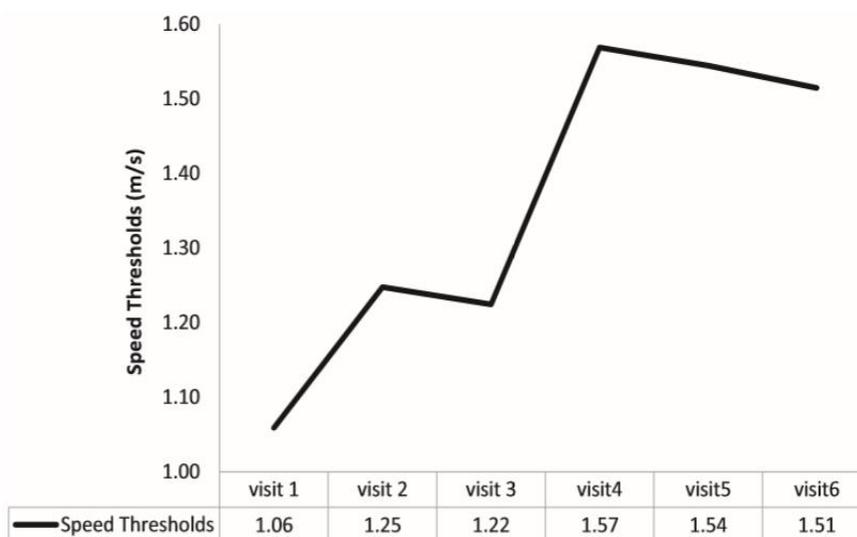
To determine if children with delayed post-concussion recovery can use NeuroTracker training safely.

#### Method

9 youths aged 12 to 17 years old being treated with delayed mTBI symptoms were trained on 16 NeuroTracker sessions over 6 visits. The status of mTBI was assessed pre and post training on each visit. Safety was measured through the reporting of adverse effects and tolerability.

#### Findings

91% of all training sessions were completed with significant learning effects. Clinical measures of mTBI symptoms revealed no worsening of mTBI symptoms. No participants experienced adverse effects, and one participant recovered from mTBI effects during the study. The results demonstrate that children who are still symptomatic after an mTBI can tolerate and safely undergo a NeuroTracker training intervention.



NeuroTracker scores

## 31. Effect of Age and 3D Stereo on NeuroTracker Performance

'Effect of age and stereopsis on a multiple-object tracking task'

[PLOS ONE](#)

### Aim

3D vision (binocular stereo) develops during childhood and tends to reduce after 65 years of age. This study aimed to investigate whether these effects are significant when processing complex and dynamic motion.

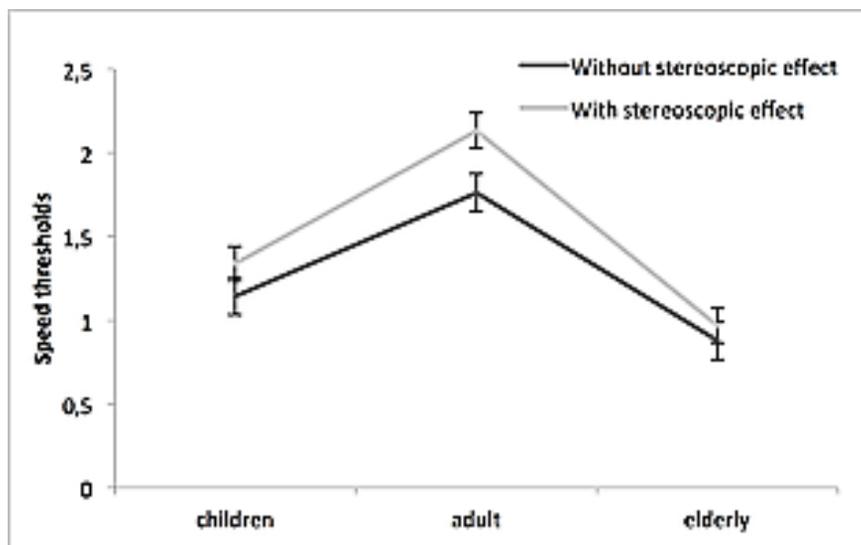
### Method

Three groups of 20 subjects were recruited: children (7–12 years old), adults (18–40 years old) and older adults (≥65 years old). Each person completed 4 NeuroTracker sessions, 2 in 2D (no binocular stereo) and 2 in 3D (with binocular stereo).

### Findings

As typical, adults achieved significantly higher NeuroTracker scores than children or elderly. They also gained a significantly larger advantage when performing NeuroTracker in 3D. In turn, children showed more advantage with 3D than elderly. This suggests that older populations have reduced ability to process complex and dynamic motion using stereoscopic processing.

This study reveals that comparison between scores with and without stereoscopic effect, allows direct evaluation of the stereopsis advantage when performing NeuroTracker.



## 32. NeuroTracker Study on Measurement of the Cognitive Effects of Exercise

'Resistance exercise may improve spatial awareness and visual reaction in older adults'

[Journal of Strength and Conditioning Research](#)

### Aim

Cognitive function has been shown to decline as a person ages with increased risk of falling or the development of dementia. Several studies have shown that aerobic exercise can slow this decline, and in some cases, improve cognitive function in the older population. The purpose of this study was to investigate for the first time, the effects of resistance training on cognitive function, as measured by changes in NeuroTracker measures.

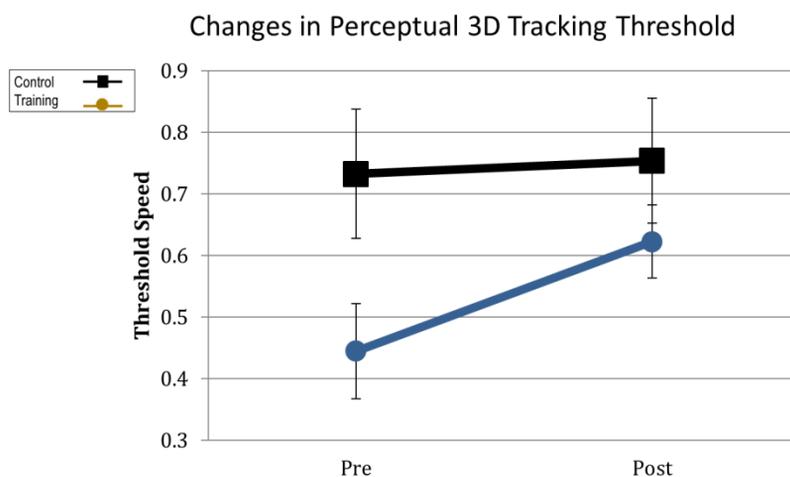
### Method

25 older adults with a mean age of 70yrs were split into a trained group (6 weeks of resistance exercises), and an untrained group. Perceptual-cognitive ability was measured pre and post training using NeuroTracker baselines.



### Findings

The older adults who performed six weeks of resistance training experienced significant improvements in perceptual-cognitive function as measured by NeuroTracker. Resistance training may therefore be an effective means to slow age related cognitive decline.



### 33. Cognitive Profiling of College Athletes

‘Evaluation of cognitive-perceptive abilities in university athletes’

[Journal of Physical Activity Sciences](#)

#### Aim

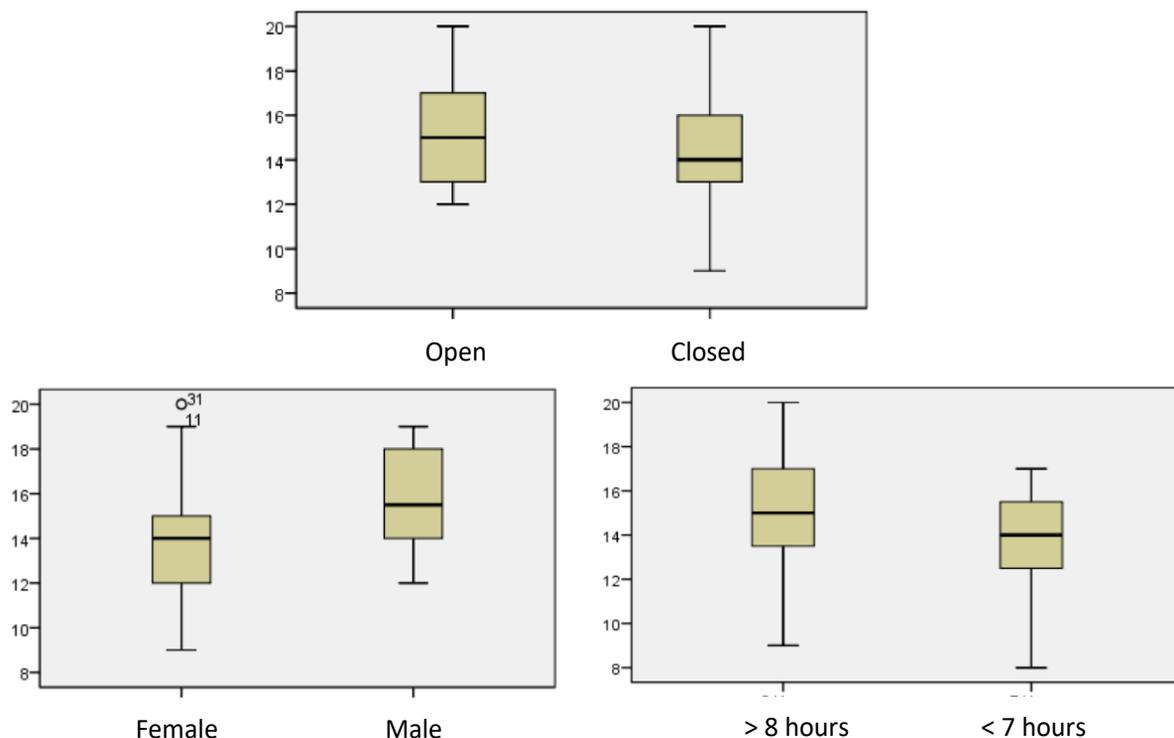
To investigate if NeuroTracker baselines can be used to differentiate athletic experience and class of sport.

#### Method

101 female (36) and male (67) athletes at Universidad Playa Ancha (Spain) in soccer, basketball, volleyball, rugby, handball, swimming, athletics, table tennis and rowing, completed NeuroTracker baselines. These were all completed at noon, following intense workouts the day before. The sports were classified into open structure (e.g. soccer) and closed structure (e.g. swimming) groups, due to expected differences their cognitive demands.

#### Findings

Overall, statistical analysis showed that NeuroTracker baselines correlated significantly with sex, amount of athletic training, and class of sport. The researchers conclude that these results show that NeuroTracker provides an accessible measure of perceptual-cognitive function that relates significantly to athletic performance variables in university athletes.



## 34. The Effects of a Soccer Season on Cognitive and Physical Status

'Performance and Muscle Architecture Comparisons Between Starters and Nonstarters in National Collegiate Athletic Association Division I Women's Soccer'

[Journal of Strength and Conditioning Research](#)

### Aim

To examine physiological and cognitive differences between starters and non-starters in women's soccer over the course of a season.

### Method

28 NCAA Division I female soccer players were tested at preseason and postseason on battery of assessments. This battery included a one session baseline NeuroTracker, vertical jump power, repeated line drills, reaction time, cognitive questionnaires, and finally, muscle architecture changes using ultrasonography.

### Findings

Over the season, both groups had very similar NeuroTracker baselines, and both group's speed thresholds improved significantly from pre-season to post-season. As there was no training intervention, the researchers concluded that this improvement effect revealed the positive influence of daily soccer practice on cognitive functions. This suggests NeuroTracker is a sensitive measure of the cumulative effects of sports training over time. These measured contrasted the cognitive questionnaire results, where the soccer player self-reported decreases in energy, focus and alertness, in line with increased fatigue, over the season.

The other assessments showed overall that performance measures are maintained, or can be improved, during a competitive soccer season.

	Pre	Starters mid	Post	Pre	Nonstarters mid	Post
Visual analog scales						
Energy (cm)	10.5 ± 1.3	7.3 ± 2.4	6.6 ± 2.3	10.7 ± 2.0	8.4 ± 2.6	7.4 ± 3.0
Focus (cm)	10.4 ± 3.1	9.1 ± 2.8	6.3 ± 1.6	11.3 ± 2.3	10.0 ± 3.2	9.1 ± 3.2
Fatigue (cm)	6.9 ± 2.4	10.6 ± 2.0	10.2 ± 2.8	6.5 ± 2.8	9.0 ± 3.3	9.6 ± 3.4
Alertness (cm)	10.4 ± 2.1	8.6 ± 3.3	7.1 ± 1.7	10.6 ± 2.5	9.7 ± 2.6	8.2 ± 3.5
Multiple object tracking (AU)	1.13 ± 0.37	1.40 ± 0.42	1.57 ± 0.41	1.16 ± 0.45	1.44 ± 0.34	1.53 ± 0.47
Upper-body reaction						
Visual reaction (s)	0.38 ± 0.06	0.35 ± 0.03	0.35 ± 0.04	0.35 ± 0.04	0.35 ± 0.03	0.33 ± 0.04
Motor reaction (s)	0.27 ± 0.04	0.25 ± 0.03	0.23 ± 0.05	0.25 ± 0.07	0.26 ± 0.08	0.23 ± 0.04
Lower-body reaction						
Correct hits	26.3 ± 2.8	29.0 ± 3.0	27.8 ± 3.0	27.1 ± 2.5	28.7 ± 3.0	28.4 ± 2.3

\*Pre = preseason; Mid = midseason; Post = postseason; AU = arbitrary units. All data are reported as mean ± SD.

## 35. Assessment of Hydration Strategies for Athletes

'Individualized hydration plans improve performance outcomes for collegiate athletes engaging in in-season training'

[Journal of the International Society of Sports Nutrition](#)

### Aim

To to determine whether a hydration plan based off of an athlete's sweat rate and sodium loss, improves anaerobic and neurocognitive performance during a moderate to hard training session, as well as heart rate recovery from the session.

### Method

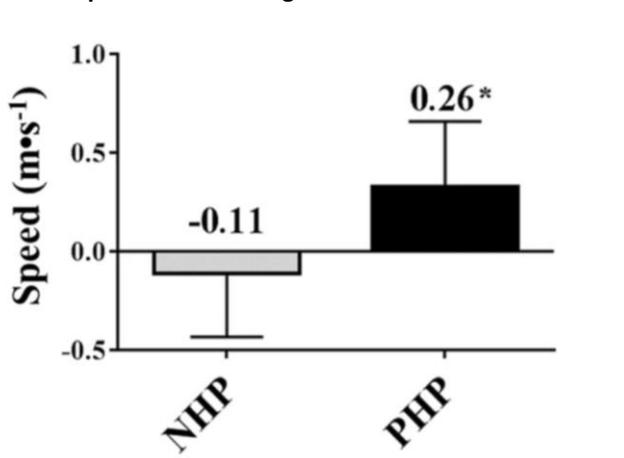
15 NCAA collegiate athletes from Merrimack College from multiple sports first underwent a qualitative assessment for hydration habits and knowledge, then were assessed for sweat loss, and randomly assigned to either a prescription hydration plan (PHP) or asked to continue with their normal hydration habits (NHP). All participants completed underwent performance assessments prior, during, and immediately after a moderate to hard sports-specific training session. Assessments included NeuroTracker baselines, standing long jump, heart rate and Vo2 Max monitoring, as well as sodium and sweat loss monitoring.

### Findings

NeuroTracker baselines provided a clear indication that a prescription hydration plan has a significantly better influence on perceptual-cognitive functions, both pre and post physical training, compared to a normal hydration plan.

Overall, the researchers conclude that this is the first investigation to show that an individually tailored hydration plan improves athletic performance for collegiate athletes engaged in a variety of sports.

Pre and post-session changes in NeuroTracker baselines



Change in performance following a 45–120 min bout of moderate to hard training. \* =  $P < 0.05$ , \*\* =  $P < 0.01$

## 36. Effects of Noise Stimulus on NeuroTracker Performance

'Exploring the Effect of Simulated Crowd Noise on Multiple Object Tracking Performance in USPORT Football Athletes'

[SCAPPS](#)

### Aim

To investigate how attentionally based performance and learning is affected when audio stimuli is present in athletic populations.

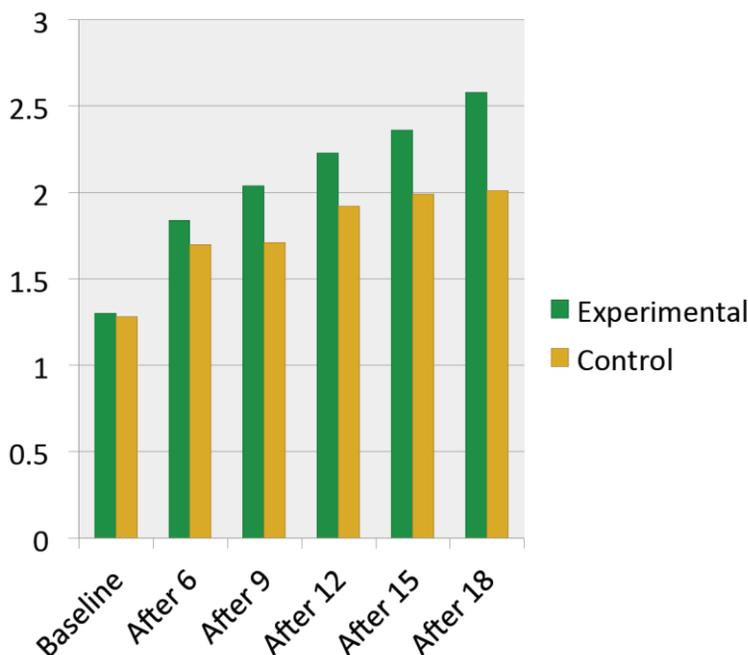
### Method

Twenty USPORT level football athletes (mean age = 20.5yrs) completed in 18 sessions of NeuroTracker Training. Ten athletes completed the training in a dark room with no external noise (had noise cancelling headphones). The other ten athletes completed the training in the same room but were exposed to a consistent simulated crowd noise.

### Findings

No significant differences in NeuroTracker initial baselines were found between the two groups were found. However, after the 18 training sessions, the mean NeuroTracker score for the noise group was 2.07 (SD = 0.24). In contrast the no noise group averaged significantly slower at 1.77 (SD = 0.32).

Although studies show that noise can inhibit attentional processing, this study indicates that presence of the simulated crowd noise may enhance the ecological validity of NeuroTracker training for athlete populations.



## 37. Assessment of the Interrelationship Between Cognitive and Physical loads

‘A duel between cognitive and physical performance: who wins- the brain or body?’

[University of Regina Our Space](#)

### Aim

To investigate the ‘selfish brain hypothesis’, which suggests the brain prioritizes its own glucose needs over those of the peripheral organs such as skeletal muscle, using individual and dual-task assessments with NeuroTracker and exercise on a cycle ergometer.

### Method

32 participants were randomly assigned to a no priority, cognitive priority (focus on NeuroTracker task), or physical priority (focus on physical task) group. NeuroTracker and a cycle ergometer were used to measure cognition and physical performance, respectively. Participants completed 5 assessments: 2 cognitive, 1 predicted VO2 max, and 1 dual task. During the dual task participants completed 3 NeuroTracker sessions, while cycling on a cycle ergometer. The cycle ergometer was modified to remove demands on balance, isolating aerobic demands.

### Findings

Results revealed that the physical priority group had significantly higher cycle ergometer performance compared to the cognitive priority group. However, overall physical performance remained relatively stable throughout the physical and dual task assessments.

All groups experienced improvements in their visual tracking speed scores as they progressed through the study. No evidence was found to support the selfish brain hypothesis during dual task performance, in contrast results may indicate an arousal effect from physical exercise, heightening NeuroTracker performance compared to single task performance.

**Comparison of NeuroTracker scores  
across single and dual-task assessments**

Average VTS Differences			
	Group 1	Group 2	Group 3
NT- SNGL Assessment 1	1.28	1.47	1.37
NT- SNGL Assessment 2	1.39	1.63	1.41
NT- DT Assessment 3	1.46	1.70	1.52

## 38. The Effects of Soccer Fatigue and VO<sub>2</sub>max on NeuroTracker Performance

'Changes in Running and Multiple Object Tracking Performance During a 90-minute Intermittent Soccer Performance Test (iSPT): A Pilot Study'

[University of Central Florida STARS](#)

### Aim

To investigate how multiple object tracking abilities (NeuroTracker) may enhance strategies for maintaining spatial awareness and optimal player performance in soccer. Additionally, to examine the relationship between aerobic capacity and multiple object tracking capacity.

### Method

7 competitive female soccer players completed a 90-minute intermittent soccer performance test (iSPT) on a Curve™ non-motorized treadmill (cNMT) with monitoring of VO<sub>2</sub>max. This involved six individualized running, jogging or walking speeds, and a half-time period, to simulate demands in soccer competition. NeuroTracker baselines were completed three times during each half of the iSPT.

### Findings

The fatigue associated with 90 minutes of soccer specific running negatively influenced running performance during the second half. However, increased aerobic capacity appears to be associated with an attenuation of cognitive decline during 90-minutes of soccer specific running. Results of this study indicate the importance of aerobic capacity on maintaining spatial awareness during a match.

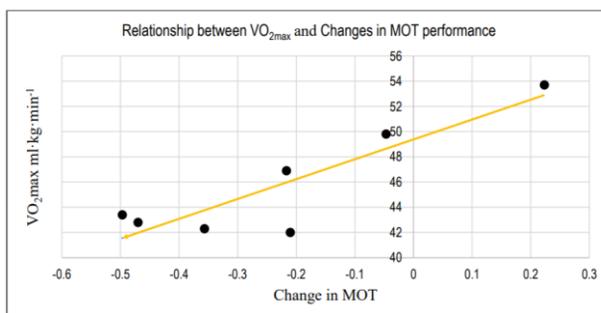
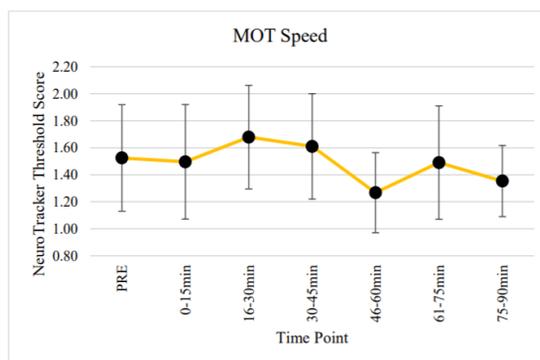


Figure 5: Correlation between VO<sub>2</sub>max and changes in MOT speed

## 39. NeuroTracker Study on Measuring Hydration Effects

'Effect of acute L-Alanyl-L-Glutamine and electrolyte ingestion on cognitive function and reaction time following endurance exercise.'

[Physiology and Nutrition](#)

### Aim

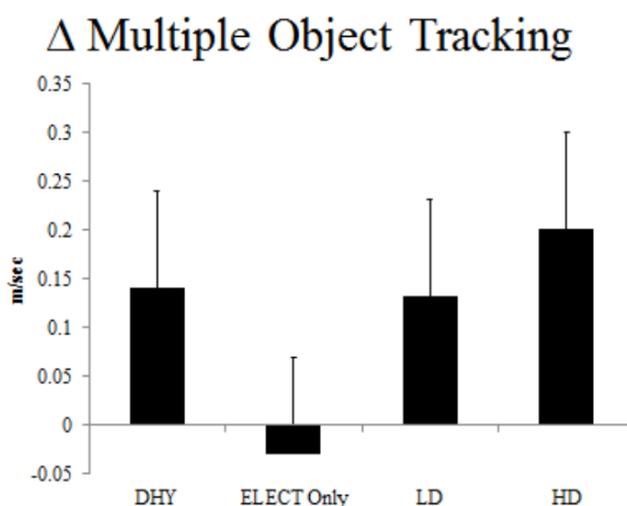
The purpose of this study was to examine the effect of the L-Alanyl-L-Glutamine dipeptide (AG) and electrolyte drink (ED) on cognitive function (NeuroTracker) following endurance exercise, in order to measure the effects of rehydration effectiveness.

### Method

12 male endurance athletes performed four trials, each consisting of running on a treadmill at 70% of VO<sub>2</sub>max for 1h, then at 90% of VO<sub>2</sub>max until exhaustion. One trial consisted of no hydration, another required ingestion of only a sports electrolyte drink (ED) and two trials required ingestion of a low dose (LD) and high dose of AG (HD) added to the ED. Cognitive function was measured through NeuroTracker baselines pre and post-exercise.

### Findings

Before rehydration, subjects lost on average 2.4% of their body mass. Pre-post rehydration changes showed HD to be the most effective in aiding cognitive function, and electrolyte only having questionable benefit.



## 40. NeuroTracker Measurement of the Effects of Pharmacological Intervention

'Cholinergic Potentiation Improves Perceptual-Cognitive Training of Healthy Young Adults in Three Dimensional Multiple Object Tracking'

[Cognitive Neuroscience](#)

### Aim

To examine the short and long term effects of Donepezil (DPZ) pharmacological enhancement (trade mark 'Aricept') on cognitive functions and learning related neuroplasticity.

### Method

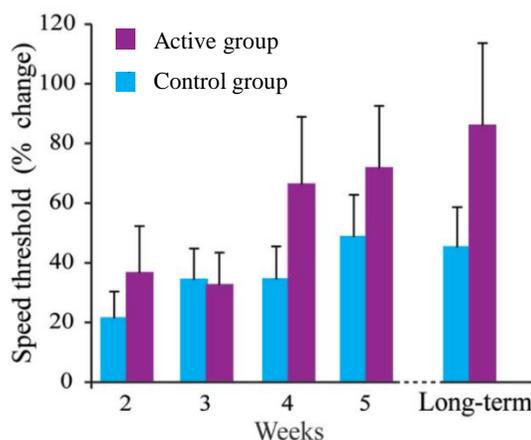
17 healthy young adults were randomly assigned to an active group (n = 9) and a control group (n = 8). In a double-blind placebo controlled intervention, both groups were initially tested on NeuroTracker one per week for 5 consecutive weeks. 3 hours before training the active group was administered 5mg of DPZ and the control group was given a lactose placebo. Additional NeuroTracker testing was undertaken 4-14 months after the 5 week training phase, and without any pharmacological intervention.

### Findings

All participants significantly improved at the NeuroTracker task during the 5 weeks training. However, the active group improved more quickly, with improvements in baseline 20%-50% higher than the control group by week 3. During the 4-14 months follow-up testing, the control group improved on their baselines by 45%, while the active group had a much more significant increase of 86% (double the effect).

In conclusion DPZ administration during perceptual-cognitive training led to an earlier improvement of NeuroTracking ability, and had potential long-lasting effects. This small study suggests that NeuroTracker testing was useful in revealing cognitive influences of DPZ intervention, which appears to increase learning capacities with both short and long term effects.

Measures of relative improvements in NeuroTracker scores over 5 weeks and long term, compared to baseline.



# 41. NeuroTracker Study Correlating Reaction Times in Soccer

Perceptual cognitive function correlates with reaction time in female collegiate soccer players

[Institute of Exercise Physiology and Wellness](#)

## Aim

This study sought to investigate how perceptual-cognitive function relates to reaction time in collegiate female soccer players, as measured on several reaction tests.

## Method

30 NCAA division I soccer players participated in a preseason performance assessment in the UCF Human Performance Lab, obtaining baseline measurements for:

- Cognitive Function (NeuroTracker)
- Visual Reaction (Dynavision D2)
- Upper Body Motor Reaction Time (Dynavision D2)
- Lower Body Motor Reaction Time (Quick Board)

## Findings

Overall, higher NeuroTracker baselines equated with better reactions, with a significant correlation on all three reaction assessments. In terms of practical applications the researchers suggested ‘cognitive function training could give a soccer player a competitive advantage. If a player were to train regularly on the NeuroTracker...this could lead to an advantage on the field.’

Figure 1: Correlation Between NeuroTracker Threshold and Fastest Visual Reaction Time

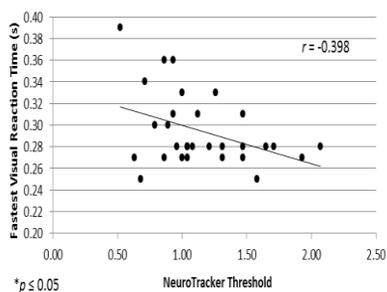


Figure 2: Correlation Between NeuroTracker Threshold and Fastest Motor Reaction Time

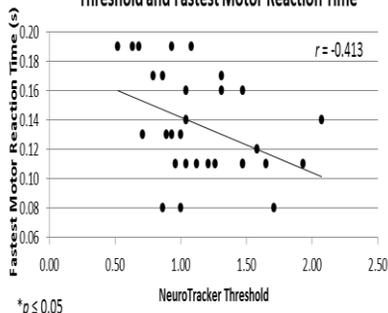
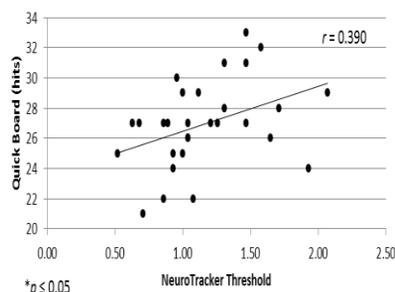


Figure 3: Correlation Between NeuroTracker Threshold and Quick Board Hits



## 42. NeuroTracker Study on Running Distance in Rugby

'Spatial Awareness is Related to Moderate Intensity Running during a Collegiate Rugby Match'

[Institute of Exercise Physiology and Wellness](#)

### Aim

This exploratory study sought to evaluate the relationship between spatial awareness, agility, and distance covered as measured by GPS.

### Method

12 American collegiate athletes were assessed on spatial awareness (NeuroTracker: 1 Core session), agility (Pro-agility and T Drill), and then measured for running distance in a competitive Rugby match at low, moderate and high intensity running speeds.

### Findings

Agility measures did not correlate with any of the running speeds, and the spatial awareness measure did not correlate with low or high intensity running. However spatial awareness did correlate significantly with moderate intensity running (cruising/striding).

Spatial awareness, as measured by NeuroTracker, appears to be related to the moderate intensity movement patterns of rugby union athletes. The researchers hypothesize that the ability to track teammates and opponents while at striding speed may be result of the processing of external and internal stimuli, while generally attempting to navigate open space on the pitch.

Table 2

Different running intensity zones and distance covered at each zone. Mean  $\pm$  SD

Intensity	Activity	Speed (m/s)	Distance Travelled (m/min)
Low	Walking/Jogging	< 2.7	39.5 $\pm$ 4.5
Medium	Cruising/Striding	2.7–5.0	20.9 $\pm$ 6.5
High	Running/Sprinting	> 5.0	4.9 $\pm$ 3.5

### 43. NeuroTracker Study on Effects of Feedback

‘The effect of feedback on 3D multiple object tracking performance and its transferability to other attentional tasks’

[Journal of Vision](#)

#### Aim

Attention and feedback are known to play critical roles in learning. This preliminary study sought to assess the benefits of instant feedback within NeuroTracker task performance.

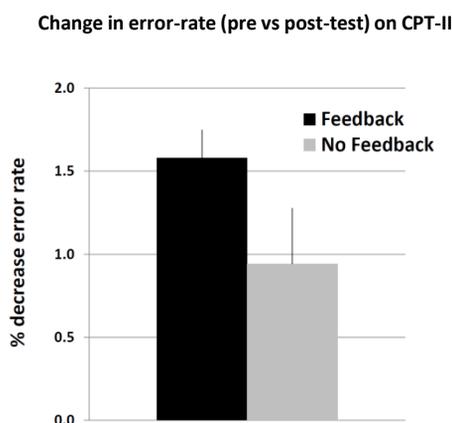
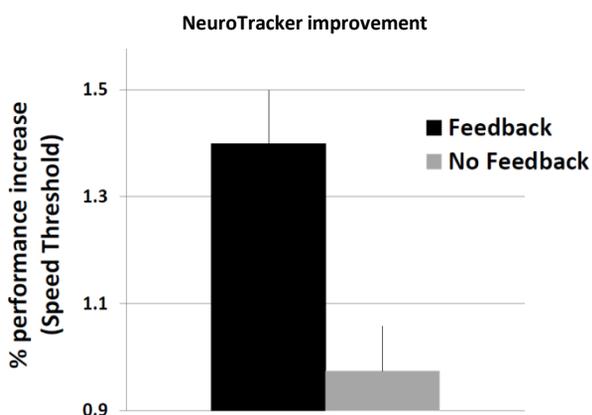
#### Method

38 young adults (mean 23yrs old) completed 4 NeuroTracker sessions over two days. 19 participants were assisted with feedback on test performance throughout the sessions, and 19 were given no feedback. Pre and post training assessments were completed using the Continuous Performance Test II to measure cognitive function.

#### Findings

The participants assisted with feedback demonstrated greater improvement in NeuroTracker scores over the 4 sessions. The feedback group also demonstrated better transferability effects to the CPT-II task, reflected by a significantly decreased pre/post mean error rate.

The results indicate that feedback has a positive effect on performance and may be an important aspect of transfer to cognitive functions.



## 44. NeuroTracker Study on Developmental Attentional Resources

'The limitations of attentional resources across developmental groups: A three-dimensional multiple object tracking study'

[Journal of Vision](#)

### Aim

This study sought to investigate the resource limits for dynamic visual attention across age development using NeuroTracker speed thresholds as a measure of attentional capacity.

### Method

21 participants were grouped by age.

School-aged (6-12 years)

Adolescent (13-18 years)

Adult (19-30 years)

Each group completed NeuroTracker baselines using speed threshold measurements at progressively increasing number of targets.

### Findings

For all groups, speed thresholds changed in logarithmic way consistent with the relative increase in multiple object tracking demands. Attentional capacities for NeuroTracker were determined by age, with significantly lower multiple object tracking limits for school-aged individuals.

The findings also suggested that the 3D stereo component of NeuroTracker is a critical enabling factor for processing greater attentional loads: school-aged individuals could track numbers of targets beyond the limits of 2D non-stereo (as established in previous studies).

These findings suggest that NeuroTracker can be used for characterizing the development of resource allocation in attentional processes through the use of a measure that best approximates real-world conditions.

