Visual Perception Training: Cutting Edge Psychophysics and 3D Technology Applied to Sport Science

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Visual Perception Training: Cutting Edge Psychophysics and 3D Technology Applied to Sport Science

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Abstract
This article will outline new training technology for enhancing perceptual-cognitive skills of athletes achieved through training with a 3D ‘cave’ environment. CogniSens Athletics (www.cognisensathletics.com) specializes in applying neurobiological science and technology for performance applications in the sports, medical and military environments. The science behind the technologies (Neurotracker, Neurominder and NeuroBalance) has been developed by Dr. Jocelyn Faubert and his team. Dr. Faubert is Director of the ‘Visual Psychophysics and Perception Laboratory’ based at the University of Montreal. These technologies are designed for both performance enhancement and concussion management. NeuroTracker can be used for a) performance enhancement, b) reduced risk of injury, and c) as a baseline reference for post-concussion return-to-play protocol:

a) Performance enhancement: NeuroTracker is a unique perceptual-cognitive training device to improve athletic performance. NeuroTracker trains an athlete to absorb and process complex movement and distribute his attentional resources throughout the visual field. The trained athlete will decrease his response time during play action and increase time available to make decisive decisions.

b) Reduction of risk of injury: with improved peripheral vision awareness, the athlete can anticipate avoidable collisions and thereby reduce risk of injury.

c) Baseline reference for post concussion Return-to-Play decision: NeuroTracker maps and stimulates high-level cognitive functions directly related to performance. The baseline reference of the healthy athlete provides the target Return-to-Play objective reference to ensure the athlete is fully recovered from his concussion injury, thereby reducing the risk of recurring concussions.

Keywords: Perceptual-Cognitive Training, Decision-making, 3D Virtual Reality

Introduction:
Athletes and coaches are always looking for an extra edge to help them perform in their sport. Most athletes and coaches spend 90 percent of their time working on technical, tactical and physical components of sport performance. But in sport where split-second timing can make all the difference, exceptional visual skills are a must. Many sport science studies have demonstrated that experts or athletes at the top of their game have much better dynamic visual skills than non-experts (Williams et al, 1994; Zwierko, 2007). Professional athletes and coaches know that because visual skills play such key roles in sport performance, they could be the key factor that prevents a good athlete from becoming an exceptional one or conversely, superior visual skills can propel a good athlete to higher levels of performance.
Vision is defined as the ability to process or interpret information that is seen, while vision perception training is the process of improvement of perceptual-cognitive abilities for interpreting images and/or dynamic scenes. Visual perception may be the most important and selective of all brain processes involved in sports; whereby attempting to observe movements in motion that occur in sport, places significant demands on an athlete’s visual perceptual skills. Essentially, the eyes send information to the brain where it is integrated and interpreted as a three-dimensional (3D) binocular image and then sends out appropriate motor signals to the muscles (Williams, Davids, & Williams, 1999). If the visual system is not receiving messages accurately or quickly enough, athletic performance may suffer. Consequently, it is important for coaches and athletes to understand the important role visual perception training plays in sport performance.

Efficient visual perception requires good brain function: Expert performers in sport such as Wayne Gretzky in hockey and Michael Jordan in basketball were also able to perform at their best when time was of the essence - like on the last shot of the final playoff game or the perfect cross-ice pass to an open teammate without looking to set-up a perfectly timed pass for the game winning goal. Sport science research has demonstrated that these expert performers are not only endowed with excellent peripheral vision, but are also expert decision makers at the same time (Starkes & Anderson, 2003). Decision-making, although less obvious than other sport skills, is an important skill set that can distinguish expert athletes from elite and novice performers. Decision skill is the ability of an athlete to quickly anticipate and accurately select the best option from a variety of options that may appear while in motion and often while an object – ball or puck is in motion simultaneously. In coaching terms, it’s the athlete’s ability to read and react to the situation. While Michael Jordan and Wayne Gretzky may not have been the fastest or strongest in their respective sports, their ability to accurately predict the game’s next open man/play means they appear to have all the time in the world.

“Growing up, I was always the small guy,” Gretzky has said. “I couldn’t beat people with my strength. My eyes and my mind have to do most of the work.” One of the critical tasks for athletes during a game is to perceive and integrate complex moving patterns while allocating attentional resources to different players on his team, the opposing players, the boards and the constantly moving puck at variable speeds appropriately termed player movement dynamics (Faubert & Sidebottom, in press). As the developmental level increases in each sport, so will the rapidity and complexity of the play, such that the determining factor as to whether an athlete succeeds at the elite levels of sport, will be his perceptual-cognitive processing under pressure situations (Williams, Davids, & Williams,1999). Skilled athletes are proficient in the anticipation of opponent’s movements and superior to novices in peripheral awareness in team sports (Williams, 2000). Research has shown that playing experience is not a determining factor when testing for visual anticipatory skills between elite and sub-elite athletes (Vaeyaens, Lenoir, Williams, Mazyn & Philippaerts, 2007). As a result, elite athletes do not learn these perceptual-cognitive based skills through traditional sports training, yet these critical skills are trainable at all levels (Williams & Hodges, 2005; Williams et al, 2006).

How do we create effective simulations for training purposes? The answer may well lie within virtual reality. Historically, coaches have relied on 2D video replay for training purposes. However, one can ask, are 2D video images the most effective training medium for sport? In
virtual environments, athletes, can move their heads, eyes and limbs to explore multisensory 3-D integration where they can interact with objects (Psokta, 1995). These virtual reality environments or “caves” allow one or several athletes to interact utilizing controllers or “data gloves”. Few sport organizations and/or researchers have explored the potential of virtual reality environments with the exception of baseball batting caves (Anderson, 1993) and table tennis (Todorov, Shadmehr, & Bizzi, 1997), yet these systems have been used in training surgeons (Tendick, et al, 2000) and NASA pilots (Allerton, 2000) and military special forces teams. Consequently, the aim of this article focuses mainly on factors within the athlete’s control utilizing a 3D technology to improve perceptual cognitive skills such as peripheral vision and decision making for improved sport performance.

3D NeuroTracker Technology (CogniSens Athletics: [www.cognisensathletics.com](http://www.cognisensathletics.com))

The science behind the CogniSens NeuroTracker perceptual-cognitive training system is driven by world-leading neuro-physicist Dr. Jocelyn Faubert, who is Director of the Visual Psychophysics and Perception Laboratory based at the University of Montreal. The NeuroTracker technology has emerged from combining the fields of neurophysics, virtual reality technology, and sport science. Consequently, it represents a truly innovative, yet scientifically valid approach toward perceptual-cognitive training of athletes (Faubert, 2001).

At first glance, NeuroTracker is a new training technology for enhancing multiple object tracking achieved through neurophysical or perceptual-cognitive training. NeuroTracker trains an athlete to absorb and process complex movement and distribute his attentional resources throughout the visual field. As a result of this training, the athlete will be able to decrease his anticipatory response time in terms of reading the play, make quicker decisions during play action and increase the time available to choose the best play option (Faubert & Sidebottom, In press).

The Neurotracker training system was developed in collaboration with a leading team in the English Premier League (Football) and is currently utilized by teams in the English Premier League, the National Hockey League (Hockey), the Top 14 French Rugby League (Rugby) and US NCAA varsity teams. These professional teams have implemented this technology through their Directors of Sport Science and have developed monitoring and tracking systems for scientific research that is integrated within their yearly training plans. Preliminary research is very optimistic and will be published shortly (Faubert & Sidebottom, in press).
CogniSens NeuroTracker Core training itself is relatively simple, with most athletes fully engaged in the training within a minute’s instruction. Essentially four spheres are targeted for tracking and then blend with another four. These spheres then move randomly through true 3D space, deflecting and crossing over each other. Each Neurotracker play session is six seconds and knowledge of results (KR) with a correct score acts as feedback for the athlete. With correct identifications, the speed and difficulty increases for each athlete’s threshold over the 15 trials. Although simple to attempt, this is a complex perceptual cognitive process that activates significant mental resources. The main core program starts at a given speed and if the four spheres are not correctly identified the next trial will be slower and correspondingly if the four spheres are correctly identified the next trial is faster. Repeated trials following a staircase procedure allows athletes to both expand the amount of movement information they can absorb in the field and process that information more efficiently until a training speed threshold is established (Levitt, 1971).

Multiple object tracking (MOT) research suggests that multifocal attention mechanisms are necessary to process such information (Cavanagh & Alvarez, 2005). The ability to track multiple objects in a dynamic sports environment has been identified as essential to anticipatory response and decision making in team sports (Williams, Hodges, North & Barton, 2006). These skills are not only relevant to team sports which constantly overwhelm athletes with scenes of complex and dynamic motion, but also relevant to individual sports such as fencing, karate, taekwondo, where athletes are required to discriminate and process cues from their opponents bodies simultaneously while carrying out an attack or counter attack (Mouton & Oberle, 2007). Finally, the 3D conditions within the cave environment contribute to what is known as binocular 3D visual stereoscopy, which allows for 50% greater gain in speed thresholds (Tinjust, Allard & Faubert, 2008) than you would in a 2D video environment.
Extending the Perceptual-Cognitive Limits of Elite Athletes

In team-sports cognitive skills are central to a whole range of performance demands. This has been well founded in sports science literature with the contrasts between elite and sub-elite athletes being minimal physiologically but large mentally (Ripoll, 1991; Man et al, 2007). Simultaneous demands (i.e., time pressure) across many mental skills easily overwhelm players, causing cognitive interference and limiting performance.

3D-multiple object tracking is a core perceptual skill and is highly trainable. Increased proficiency in this area can free up processing resources for other mental skills. Consequently, with training, athletes become more confident as they move through the various levels of the training staircase. For teams, the value added, is that with improved individual confidence, quicker decision-making skills, improved peripheral awareness, athletes are better able to respond to performance situations under pressure which ultimately will improve team toughness.

Neural Plasticity: Training your Mind

By far the greatest advantage of NeuroTracker is the pronounced effects of perceptual-cognitive training on the mind. In terms of actual time spent tracking spheres, 1 hour produces an average improvement of over 50%. This has been confirmed scientifically both with the general population and with elite athletes in the field. It is now well recognized in neuroscience that training the mind is possible and the brain is highly plastic (Mahncke, et al, 2006). Neuroplasticity is the reason these gains are attainable, as the brain is remarkably good at rewiring itself anatomically to adapt to intensive functional tasks (Draganski & May, 2008; Ma, et al, 2010). Brain imaging studies have demonstrated complete neural reorganization as a result of training (Kupers, Chebat, Madsen, Paulson, & Ptito, 2010).
Training Principles

A true sports science methodology can be applied perfectly with NeuroTracker training. Core perceptual-cognitive skills are targeted for training in a way that is similar to doing squats to build up leg power for generic gains in sprinting, plyometrics and box-jumping. Maximal stimulation is achieved by an intelligent staircase procedure that pushes an athlete above and below their NeuroTracker perceptual-cognitive threshold. The six minute Neurotracker training sessions are highly practical and can even be integrated into circuit training routines with physical exercises. The phenomenon of ‘distributed learning’ means that small amounts of training spread out over time increases these effects due to the role of rest and recovery.

CogniSens Cave

NeuroTracker perceptual-cognitive conditioning takes place in a CogniSens Cave, in which up to 5 five athletes can train at the same time. This light controlled structure can be setup in a gym.
with only a single power cable required outside of the cube. An 8ft wide true 3D environment is created with the latest technology in ultra-short range projection and wireless shutter glasses.

**Neurotracker Programs**

NeuroTracker training is provided through a spectrum of nine different programs: a) standard, b) advanced and c) team programs. Standard programs use scientific measurement procedures useful for the assessment of cognitive agility and improvement rates based on a core test. Subsequently, the athlete moves through the staircase of programs that increases cognitive processing or ‘brain speed’ in processing information encouraging automaticity. Peak speed is assessed after each session and is tracked and monitored for each athlete. Advanced programs layer additional perceptual tasks onto standard training, these relate generically to in-field tactical tracking skills, attentional focusing and defender training. Team programs bring psychological dimensions into NeuroTracker testing, conditioning athletes to work cooperatively or under pressure competitively in one-on-one and/or two-on-two situations. Future programs will highlight sport specific situations athletes find themselves. Examples include goaler training on penalty kicks in soccer, goaler training on penalty shots or shots from the point with men in front obstructing the view in ice hockey, etc. (Savelsbergh, Van der Kamp, Williams, & Ward, 2005).

**Meaningful Results**

Large amounts of NeuroTracker data is generated from the 15 mini trials comprised within each session. Knowledge of results (KR) is provided continuously to the athletes throughout the
sessions. Scores and progress rates are displayed automatically in graph form at the end of each test, and all the details of results go straight into a database. Any or all data is available instantly to coaches through simple yet powerful Motion Charts. These reports reveal significant trends quickly and intuitively in a range of displays (e.g., rates of improvements for all their players, and/or compare their players by position and/or recruits to existing players by position, etc.).

**Performance Profiles: Invaluable Intelligence**

The results of NeuroTracker perceptual-cognitive training represents a vanguard for cognitive assessment of athletes, as the data provides a direct indicator of perceptual performance capabilities which include complex motion integration, distributed attentional control, fluid-rapid processing and visual working memory. This new form of intelligence for athletes can complement other assessments (e.g., technical skills, physical conditioning, psychological profiles, rest & recovery tests, performance statistics, etc) for a fuller understanding of each player’s overall skill-set termed a performance profile. As an emerging sports technology, NeuroTracker is particularly valuable for recruitment testing as it provides an untapped area for performance assessment.
Applied Results

NeuroTracker trains an athlete to absorb and process complex movement and distribute his attentional resources throughout the visual field. The trained athlete will decrease his anticipatory response time during play action and increase time available to make decisive decisions (Haywood, 1984; Hodges et al, 2005; Mori, Ohtani & Immanaka, 2002). A range of other benefits exist outside of the principle gains of performance enhancement. NeuroTracker provides a medical role for supporting assessment of concussions. Typically, NeuroTracker perceptual-cognitive ability will be drastically reduced under the effects of mTBIs (mild traumatic brain injuries), which compromise critical high-level visual resources (e.g., visual search, visual perceptual processing, visual scanning, peripheral vision etc.). Such tests present quantitative and unbiased objective evidence for when a player is back in game shape (Rogers & Landers, 2005).

NeuroTracker can also be performed on an exercise bike in the CogniSens Cave, where results correlated with biofeedback data can then reveal the extent of physiological fatigue on each athlete’s concentration, and may well provide a method for conditioning resistance (Alvarez & Franconeri, 2007).

Finally, injured athletes can get a great deal out of NeuroTracker, as the training is non-physical and can be carried out intensively. It allows a player to return to competition with significantly increased abilities, boosting confidence at a critical period during the rehabilitation process. Athletes injured long term can be identified for cognitive and peripheral regression brought about through a sustained lack of game stimulation (Brosseau-Lachaine, Gagnon, Forget & Faubert, 2008). In these cases NeuroTracker conditioning can then be applied to accelerate perceptual-cognitive regeneration.
Conclusion:
In conclusion, we have proposed a new perceptual-cognitive training tool for sports vision training. We have demonstrated the relevance of vision training for peak sports performance. Specifically, we have introduced the Neurotracker system functioning in a 3D virtual reality cave. Initial results for CogniSens NeuroTracker 3D perceptual-cognitive vision training with professional teams in English Premier League (Football), National Hockey League (Hockey), Top 14 (Rugby) and NCAA Varsity has proven to be very successful. Finally, we have also demonstrated the perception-cognitive training may have other sports related benefits such as injury reduction, concussion return-to-play management, and reduction of fatigue-related decision errors so critical in elite sport performance.

CogniSens Athletics Neurotracker Cave integrated in the Strength and Conditioning facilities of a leading NHL team
References:


Founder – Peak Sport Performance Mindroom

Dr. Pierre ‘Red’ Beauchamp is an internationally renowned sport performance coach and Founder of Peak Sport Performance Mindroom. Dr. Beauchamp holds a doctorate in Sports Psychology (University of Montreal) and Masters/Bachelors’ degrees from McGill University. Dr. Beauchamp’s groundbreaking sport science Mindroom has achieved world-wide recognition through the utilization of cutting edge technology to enhance sport performance and to prepare elite athletes to perform on demand and under pressure.

Dr. Beauchamp has worked with hundreds of world-class performers from: National Karate & Take Won Do Teams, Players Forsyth Racing Team, P.G.A Tour, and CPGA Tour professionals, OHL Belleville Bulls, Canadian Olympic Aerial Ski Team, Canadian Olympic Mogul Ski Team, Canadian Olympic Short Track Speedskating Team, Canadian Olympic Ski Cross Team, Para-Cycling, etc.
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Jocelyn Faubert - Director of the Visual Perception and Psychophysics Laboratory & NSERC/Essilor Industrial Research Chair-Visual Function

Dr. Faubert’s facility is recognized as one of the world’s leading research centers in human perceptual-cognitive performance. Dr. Faubert has built a multi-disciplinary team of more than 30 researchers and PhD students currently exploring complex motion-perception, neural stimulation, neural-training, and neural rehabilitation. The lab uses state-of-the-art fully immersive 3D cave technology to support the natural 3D training environment needed for effective performance research, and also uses state-of-the-art immersive driver training & testing equipment to research perceptual capacity in older population groups.