## Unveiling the Mental Game: Cognitive Abilities in Sports Performance and the Role of Virtual Reality Training

In the high-stakes world of competitive sport, physical prowess is just one piece of the puzzle. Behind every incredible goal, every game-winning pass, and every last-minute save, lies a complex web of psychological factors that can make or break a player's performance.

One important psychological factor is cognition: The mental processes we use for anything related to thinking, learning, and understanding. Alongside training the physiological systems, there is emerging interest in training an athlete's cognitive ability. Virtual Reality (VR) is claimed to be one option offering elite performers such as football players immersive and realistic scenarios to enhance their cognitive abilities and game-time decision-making skills.

Join us as we uncover the science behind the cutting-edge cognitive training methods that are shaping the future of football.

### The role of cognitive abilities in sport performance

Football is a faced-paced game and players must be able to gather important information and accurately process it at speed. To make split-second decisions under pressure throughout a match and tournament requires mental fortitude. During the 2022 World Cup, Argentina captain Lionel Messi lifted the winner's trophy and received the adidas Golden Ball. He was also proportionally the player who ran the least, knowing exactly when to accelerate and when to make a pass. His playing efficiency and therefore cognition is exceptional.

Research shows that elite footballers are highly skilled cognitively. In 2012, Vestberg and colleagues showed that elite football players demonstrated enhanced executive functions (various cognitive processes that are needed for the cognitive control of behaviour); specifically, greater creativity, response inhibition, and cognitive flexibility. The researchers also found that the players' cognitive test scores predicted their football success measured as the number of goals and assists.

### Cognitive skills in football: Scanning

Quote:

"*I have lost many top players because their head was on the ball, and they were not seeing what was around them. Great players isolate from the ball; their head is like a radar.*" (Arsène Wenger, 2019)

One way to explain how football players take in information from all around them is called "scanning". Scanning is any movement of the head, body, or eyes prior to receiving the ball, to perceive information away from the ball and to act appropriately when the ball arrives. Scanning is a dynamic cognitive process that requires visual attention and perception, working memory, processing speed, strategic decision-making, and football tactics. Using scanning, players such as Messi can take a mental picture of the pitch just before they get the ball. This helps them know where they are on the pitch, where their teammates and opponents are, and thus select the best action to take next. We can easily link this to the expression used by Wenger when he described a player's head as a "radar." If you are familiar with football games, you might also hear: "keep your head up" or "stop looking at your feet". So, is enhanced scanning ability one of the reasons for Messi's success? If yes, has he trained this ability? The real question is: Is it possible to train

cognitive and perceptive abilities and to transfer these skills to performance improvement on the pitch?

Nowadays, many cognitive training and mental preparation methods have been developed, such as visualization, or ecological imagery training. However, the pursuit of performance has no limits, and in recent years, a more realistic and immersive way to train athletes' cognitive processes has emerged: virtual reality (VR).

**What is virtual reality?**

When we delve into the field of virtual reality, it is common to immediately think of VR headsets used for video games, where the player can see animated sequences and sometimes interact with them. However, there are multiple facets to what is more generally referred to as extended reality (XR). The term extended reality encompasses three different types of computer-generated simulations: virtual reality (VR), augmented reality (AR), and mixed reality (MR). Each of these modalities has its own characteristics and can be placed on a spectrum of extended reality (Fig…).

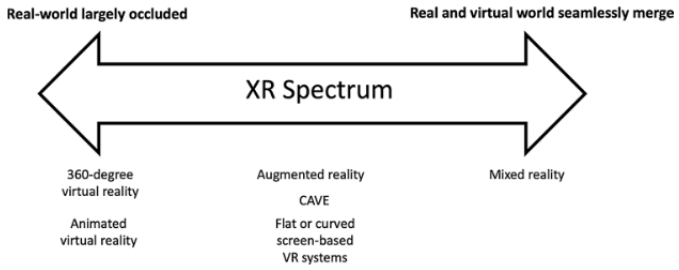


*Figure … : Extended reality continua*

Augmented reality combines the real-world with computer generated content, whereby virtual elements are added to the real-world environment, usually through technology like a phone, tablet, or even glasses. Pokémon Go is a good example of a game using AR. However, for training in football it might not be the best option as it doesn't allow individuals to physically interact with virtual objects, like a virtual ball for example.

Alternatively, VR is a computer-simulated environment that aims to give the impression of being physically and psychologically present in another place, completely occluding the real world. Currently, there are two approaches to immersing the user in an animated virtual reality environment: head-mounted displays (such as HTC Vive or Oculus Rift) or through 3D projection viewed with 3D glasses in what we called a CAVE (Cave Automatic Virtual Environment).

**Does using VR enhance sport performance?**

The idea is that virtual reality can re-create a relatively representative environment which can induce the same behaviour as in reality and might help to train athlete's cognitive functions in a short time without inducing a huge physical workload on players.

**The evidence for performance transfer effects of VR:**

Performance transfer refers to whether potential training effects in VR can be translated to performance increases in the real-world. Specially, can training cognitive skills such as scanning using VR lead to improvements in scanning behaviour in real-life game situations?

Maybe! The research on whether training cognitive abilities in VR transfers to real-life sporting improvements is limited, so we don't know if it definitely works. But there are some promising signs. For example, in one research study conducted by Fortes and colleagues in 2021, an 8-week VR training intervention, compared with a non-immersive video intervention, led to increased improvements in decision-making and visual search behaviour in football players. We can also consider the effects of VR training in other sports. Researchers like Michalski and colleagues in 2019 and Richlan and colleagues in 2023 conducted reviews in which they looked at the results from a range of studies on the use of VR in sport Both reviews highlighted the positive effects of virtual reality training and the opportunities for transfer to the real-world. Notably, the researchers found that some previous studies reveal improvements in baseball in the ability to perceive the ball's trajectory, in table tennis performance, and in dart throwing. However, these conclusive results were only noted in certain studies. Therefore, the authors of both reviews concluded that additional research is necessary to confirm the transferability of skills developed in VR to real-world practice and to define the conditions under which this transfer could effectively occur.

**Other exciting opportunities for application of VR in sport**

Importantly in VR we can control every parameter of the training environment, such as speed of the football, number of players, the pressure opponents put on the user. Because of this detail, VR exists as an opportunity for injured athletes to maintain their cognitive abilities, and for healthy athletes to train more, without risk of injuries, just as mental preparation was introduced few years ago.

In the world of elite football, VR software is already in use and might help players to develop some of their cognitive abilities. For example, some Premier League teams are using VR environments to practice heading the ball without really touching a ball. In fact, the football association (FA) guidance recommends no more than 10 "higher force headers" per week of training for adult players, and even less for children under 18. So, in using VR, the goal is to practice the capacity to read the ball trajectory in different conditions through a lot of repetitions without any risk of repetitive head impact for players. In addition, the players can receive visual feedback on their behaviour to correct it. However, virtual reality is still far from being an easy-to-use tool, as creating environments require many hours of coding and programming. Moreover, continued use of VR may lead to cyber sickness or visual disturbances which could be detrimental prior to sporting performances (Harris and coll, 2020).

**What about in other sports?**

Even if we do not hear a lot about it, VR is used in different sports to prepare for the Olympic Games 2024 in Paris. For example, some French boxers train their dodging abilities against a virtual opponent to avoid any risk of concussion due to repeated hits. Some relay runners also train to pass and receive the baton alone thanks to virtual training partners with the same abilities as their future partners, something that they were only able to practice more or less 4 times per year before.

**Conclusion**

Overall, the ability of VR training to transfer to the field is still under investigation and to make the most of a VR tool in the sports world, it is important to consider its limitations and challenges.

| Pros | Cons |
| --- | --- |

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|---|---|
| - Low physical workload<br>- Low risk of injury<br>- Possibility to control every conditions<br>- High level of repetitions<br>- Adaptable to the level | - Detrimental effects on visual abilities before competition<br>- No verified transfer<br>- Low capacity to reproduce movement<br>- Low haptic feedback |