INSTRUMENTS AND TECHNOLOGIES FOR THE MEASUREMENT OF THE EFFICIENCY OF VISUAL-SPATIAL PERCEPTION IN SOCCER

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1. Introduction

The present comprehensive chapter is based on our reading and analysis of the performance of experts and academics in the field of sports sciences (Wang et al., 2019), cognitive psychology (Antonenko et al., 2010), neuropsychology (Kalbfleisch & Gillmarten, 2013) and physiological physiology (Landers, 1985), though tens of works and according to the restrictions and mechanisms imposed by the specialization in various fields of sports sciences. We shed light on the role of experts and specialists, as well as tools And measurement technologies that have known an accelerated development in the field of elite sports training, cognitive learning (Chikha et al., 2021) and sports psychological measurement in particular. The chapter tackles also a set of theories adopted by researchers, and modern techniques related to other sciences such as neuroscience, computer science, photography, medicine and radiology science. A particular attention is given to the role of these methods, technologies and measurements in addressing the outstanding questions in this field. The impact of the absence of technological tools in these measurements has been demonstrated, conducting to asking new questions and reformulating old questions, and leading to the development of new methods to explore issues related to mental training, especially the cognitive aspect of the athlete's performance (Park et al., 2015).

The researchers used modern technologies aiming to carry out deep and specialized measurements for the mental performance (Lau-Zhu et al., 2019) of the athlete in various individual and collective disciplines. This chapter considers the instruments and technologies used in measuring the efficiency of visual-spatial perception in soccer, such as the electroencephalography of the brain (EEG) (Antonenko et al., 2010; Biasiucci et al., 2019; Kalbfleisch & Gillmarten, 2013; Park et al., 2015; Wang et al., 2015, 2019) and multimedia (Ben Mahfoudh & Zoudji, 2022; Chikha et al., 2021; Dehn et al., 2020; Khacharem et al., 2013). The definitions, methods, importance, and purposes related to these tools are discussed in the present chapter, based on the most important scientific studies that used these tools in the field of our research. The chapter highlights how these instruments and tools are employed by the researchers in their research designs as well as their contribution to the improvement of the quality and credibility of research in this field.

2. Main Instruments and Technologies Used in Measuring the Cognitive Aspects in Soccer

Affective and cognitive neuroscience, contrary to the levels of other mental process analysis (cellular and behavioral neuroscience), seeks to understand the mechanisms responsible for higher levels of activity, such as attention, executive functions, and language (BEAR et al., 2016), In this way, stimulating the brain or neurological imaging measurements makes it possible to see the brain in the event of work and understanding the evaluation of topical activation and metaphysical activity of brain structures. The cerebral cortex, the amygdala illustrated in Figure 1, is shown to perform a primary role in the processing of memory and decision making (Amunts et al., 2005). The visual-spatial perception is based on this type of mental processes.

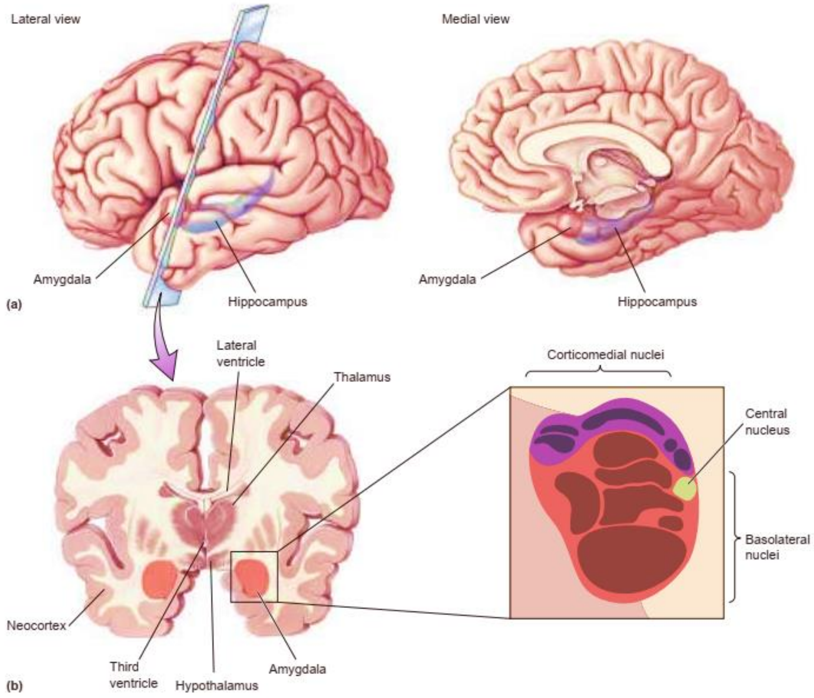

Figure 1. A cross section of the amygdala. (a) Lateral and medial views of the temporal lobe, showing the location of the amygdala in relation to the hippocampus. (b) The brain is sectioned coronally to show the amygdala in cross section. The basolateral nuclei (surrounded by red) receive visual, auditory, gustatory, and tactile afferents. The corticomedial nuclei (surrounded by purple) receive olfactory afferents (BEAR et al., 2016).

These measurements allow the researcher in the sports field to discover the changes in the cognitive and emotional functions, resulting from practicing sports activity or exposure to psychological pressure, as these changes are not visible and cannot appear through observation of behavior, or traditional tools (form, questionnaire, and simple observation). The brain processes involved in cognition and emotion can be detected with a high degree of accuracy using electrophysiological techniques and neuroimaging.

The accuracy of time indicates the sensitivity of the measurement to discover changes in brain activity as a time function and is very accurate in electroencephalography (EEG) and Magnetoencephalography (MEG). The spatial accuracy also indicates the ability to discover structures and processes in the brain, which is a feature of magnetic resonance imaging (MRI), functional magnetic resonance imaging (FMRI), positron emission tomography (PET) scanning, computed tomography (CT) scanning.

Although there are many tools that allow the brain to display during work, the EEG has an advantage over all other technologies where the researcher enables the measurement in the natural position to perform sports activity. For instance, and unlike the MRI where the device does not allow any movement to approach the targeted area and the considered position for the athlete undergoing the test, EEG allows the analysis while tasks are performed under the real-world conditions or virtual reality environments.

3. The Electroencephalography EEG

The electrical schemes of the brain represent a time series of electrical activity registered from the brain by placing electrical electrodes in certain locations on the scalp. Figure 2 shows the uniform EEG registration sites (A) and is monitored for EEG during the goal period that requires attention (B). The standard electronic mode system determines the locations of the poles based on the anatomical monuments on the head, which are indicated by the international system 10-20, as indicated on Figure 3, allowing the results to be compared for different individuals submitted to tests (H. Klem et al., 1999).

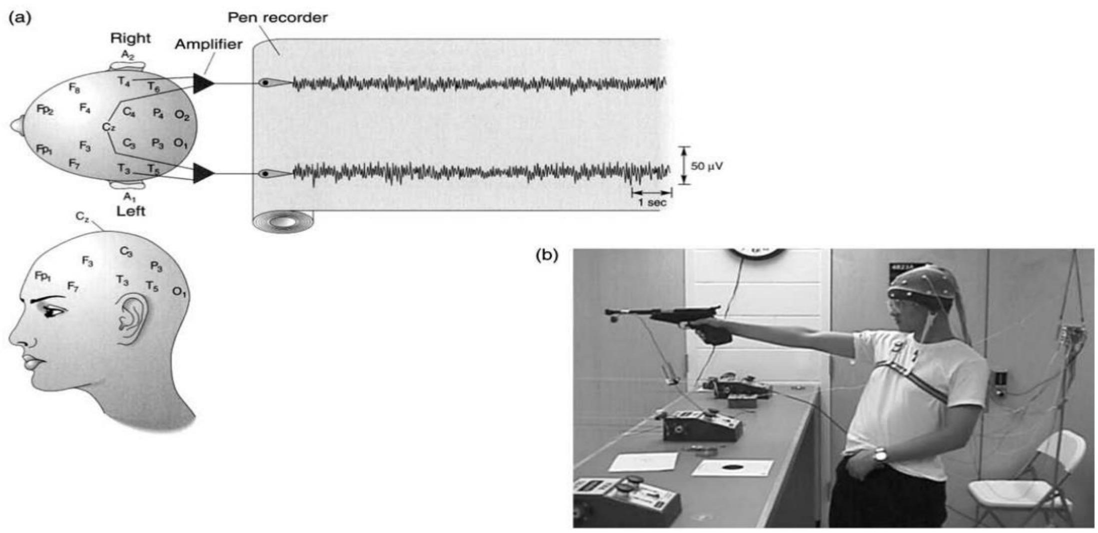

Figure 2. (a) Registration EEG, (b) The archer is monitored for EEG and eye movements during the fixed correction period.

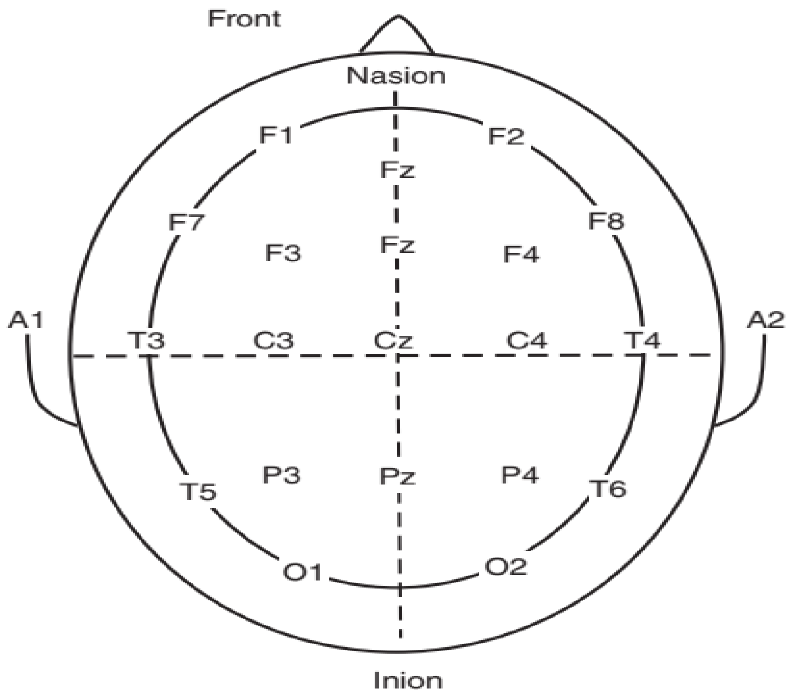

Figure 3. International System 10-20 to set the standard EEG sensor on the head, allowing to obtain differential amplification and the time chain caused by volatile voltage. The designation depends on the fact that the places of the electrode depend on fixed levels (10 % and 20 %) of the distance between the standard landmarks, such as nasion (nose bridge) and inion (occipital bone bone). The newest recording montage contains up to 256 sensors to localize the source or to solve the reverse problem.

EEG sensor uses wires fed from pairs of electrodes to loudspeakers, and reveals the transient or volatile assembly of the exciting and installed potential (currents) of tens of thousands of neurons, perhaps the glial cells located below the surface of the scalp inside the cortex, which generate electric charge or effort. The captured EEG sensors appears in the arrangement of part of a million voltage, or Micro Volt (μV).

Samples are taken from the continuous transnational capabilities or analog signals, changing in size over time, converting them into digital values by analog to digital transformer (AD), and amplifying them from 20 to 50 thousand times, although amplification can be much lower using high accuracy AD transformers, due to their ability to distinguish between very small increases in the voltage. The current is then subject to differential amplification. Differential amplification is a process through which the electrical scheme of the brain is actually produced by creating a score of the difference in the voltage between the registration sites and the reference site that is usually placed in a non-brain area, such as earlobe measuring or tip of the nose. The differential amplification process allows the rejection of any common signals between the two sites, which is believed to be not brain in the first place, so that the amplified temporal chain reflects the electrical activity of the brain. EEG record is a two-dimensional time series of voltage fluctuations (see Pan A, Figure 2) characterized by capacity and frequency. The frequency or spectrum range extends from 1 to about 50 rpm (Hz), with higher frequencies indicating greater activation. In essence, the raw EEG signal consists of a mixture of frequencies in the spectrum. It can decompose its basic components or pocket-frequency components to determine the activity degree. The complex record decomposition or EEG wave is called a period of time or a specific era of spectral analysis and is accomplished sporty by the fast Fourier transform (FFT). In this regard, low frequencies, as high-capacity Delta (i.e., from 1 to 3 Hz), Witta (i.e., 4 to 7 Hz), and alpha domains (i.e. from 8 to 13 Hz), indicate the relaxation of the situation, while the higher frequencies, such as low-capacity beta ranges (I.e. from 13 to 30 Hz) and Gama ranges (i.e. from 36 to 44 Hz) indicates topical activation (Figure 4).

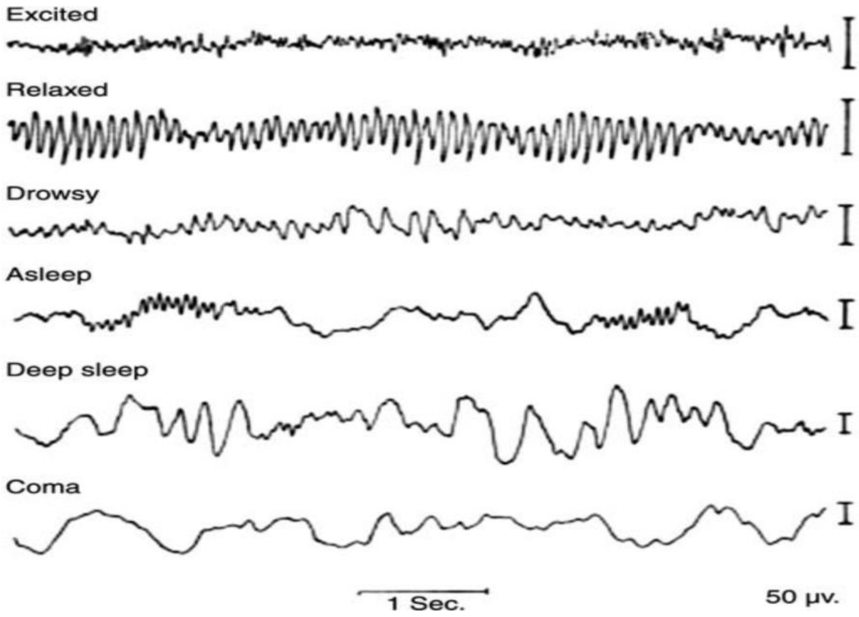

Figure 4. The electrical scheme of the brain and associated arguments. The temporal series raised mainly consists of beta and gamma frequencies; The comfortable time series consists mainly of alpha frequencies; While the nasal time chain consists greatly from the frequencies of the Delta and Theta.

Topical activation results from simultaneous activity top capacity and is likely to be the consequence of similar neurological states in the brain's interest in the ROI. Regarding alpha strength, a similar case of nerve gatherings is likely to occur during the relaxation state, which leads to the collection of post-suspicious capabilities (and alpha coincides with the similarity of neurological conditions (for example, similar to members of the choir singing in complete harmony). On the contrary, a non-similar condition of nerve gatherings is likely to occur during the active participation in the task, which leads to differential customization of neurons, lack of synchronization or reduction of the strength of alpha or its capacity. The advantage of the electrical scheme is that it does not only capture rapidly changed events, but also can be used to discover the timing of communication between the different cortical areas by analyzing the cohesion. It is assumed that the similarity in the EEG spectral content registered in different locations (i.e., high cohesion) indicates the cortical contact. EEG and Magnetoencephalography (MEG) can only be used to evaluate the timing or sequence of the alum's permanent network models. However, one of the main restrictions on the electrical plan is the problem of volumetric connection, or the spread of the electrical charge throughout the fluid of the brain so that stimulation, emotion and psychological physiology (albeit with low effect are captured by sensors. Beyond or at the top of tissue. For this reason, it is said that the brain electrolyte diagram is relatively weak in spatial accuracy compared to nervous imaging techniques such as functional magnetic resonance imaging and PET. However, both EEG and MEG are more performant than all the other nervous imaging techniques in terms of time accuracy.

Modern developments in EEG technology improved spatial accuracy using dense electrodes recordings that include up to 250 registration sites. The poles or dense sensors preserves allow the reversal of the reverse solution, i.e. estimating the site of the responsible or possible brain sources that are likely to be a candidate to determine the electrocardiogram registered on the surface. Records of these dense matrices can also be obtained with structural magnetic resonance of the electrical planning of the brain registered on the surface. In this way, the dense electrodes of the EEG registration allow the spatial survey of the cortical sources while taking advantage, at the same time, of the high time accuracy. In addition, EEG is the only method that allows the test of the studied participants in unrestricted settings and even in natural environments through the use of mobile registration systems or larger systems used along with virtual reality settings. All other nervous imaging techniques require the participant's reservation in the study so that the movement should be reduced while lying in a closed environment. Movement should also be reduced to record the electrical scheme of the brain free of confusion, but restrictions are dramatically reduced for all other technologies. In terms of cost, EEG is the most efficient technique in terms of saving time, effort and money as compared to other technologies.

Several studies in sports training have relied on EEG as a measurement tool. One of the most early studies in this field is a study of Landers (Landers, 1985), which valued the registration of EEG activity in four regions (T3, T4, O1, and O2, All Referenced to CZ) in the targeted period of time. The sample consisted of 15 high level shooters, in which the researcher relied on the comparison between the registration of EEG in the case of relaxation and the registration of EEG in the event of competition. The study concluded that the superior performance of the athlete is linked to mental relaxation, this study considered one of the most important problems presented in sports psychology, relying on the theoretical background of nervous cognitive psychology, aiming to avoid the athlete’s exaggerated critical thinking and its impact on the high performance.

The study of (Konttinen & Lyytinen, 1993) is also one of the most important studies in this field, as slow electrical brain waves transformations were recorded before operating the front and side areas (C3, C4) and occipital, in addition to the heart rate (HR) and breathing, during the shootings of three archers. The study concerned the national elite team and 3 inexperienced adults. The average data from the pre-operation period reached 7.5 seconds 300 accounts per second separately for three different test sessions. The heart rate slows down before starting with a peak at the launch point. The typical breathing pattern consists of self-confinement with a slow exhalation that precedes the pressure of the trigger. An increasingly erect negative displacement is found between the active electric electrodes and the reference of the masts before pressing the trigger. In the sniper's collection, the slow negative displacement was significantly greater on the front for less successful shots compared to the highest bullets.

One of the recent reviews (Wang et al., 2019) presented an interesting overview about the potential applications of dry EEG systems to understand the brain-behavior relationship in sports, invoking dry electrodes (Mullen et al., 2015) , neural dynamics (Moreau & Chou, 2019), sports expertise (Wang & Tu, 2017), sports neuroscience (Thompson et al., 2008), and mobile EEG system (Lau-Zhu et al., 2019). The study hastaken these behavioral findings to highlight the relationship between context-general cognition and sports.

4. The Multimedia

Keeping pace with technological developments and the huge amount of information imposed on sports training in general and football in particular, information revolution has been integrated. This integration is carried out by adapting and applying various sciences such as computer science (kraibaa & Mansor, 2017), physiological psychology with science in sports and methods of measurement and evaluation. This prompted many specialists and researchers in the field of football to use advanced and modern technological devices to carry out tasks that contribute to increasing the effectiveness of sports training, particularly through accurate measurement.

Multimedia is one of the latest and most prominent technological means for learning and measuring in field of mental training. It is considered a form of communication, used in almost all fields, especially educational and mental training. It uses a combination of various content forms such as text, audio, images, animations, or 2D & 3D videos into a single interactive presentation. Multimedia can be recorded for playback on computers, laptops, smartphones, and other digital devices.

Multimedia is an easy-to-use method used to present a huge and complex amount of written, audio and visual information in a simplified and synchronized manner, as this was not possible several years ago. This would facilitate the educational process for both the teachers and learners, and facilitate the work in various fields of research, such as in the field of mental training in soccer, by giving them the ability to control all variables easily and smoothly.

Many studies concerned with mental training in football have relied on multimedia as an effective teaching and measurement method at the same time (Ben Mahfoudh & Zoudji, 2020, 2022; Chikha et al., 2021), and this made it an indispensable tool in the various stages of the soccer training process. In this section, we will discuss multimedia, its components, importance, and the most important studies that used multimedia as a measurement method.

One of the most recent studies is that of Ben Mahfoudh and Zoudji (Ben Mahfoudh & Zoudji, 2022). This study investigates the effect of visual-spatial abilities (VSA) and the level of expertise on memorizing an animated soccer scene by using computer programs based on multimedia as a learning and measuring tool. Two computerized tests were created and displayed on a TOSHIBA L755-1GL laptop with a 15.6-inch screen. The control test contained six tasks to measure subjects' VSA, and the main test consisted in memorizing an animated soccer scene and reproducing it on a printed paper. The tasks were created using the Unreal Engine® software of the American Epic Games studio written in C++. For static VSA, three tasks were designed based on the taxonomy of (Linn & Petersen, 1985). The participants (N = 96) first performed a control test to assess their level of VSA, followed by the main test which consisted of recalling and reconstructing a displayed scene (figure 5). Results indicated a main effect of the level of expertise and the level of VSA on memorization performance. A significant interaction between these two factors was also found. Findings suggest that both VSA and the level of expertise must be considered to optimize the memorization of dynamic visualizations in team sports.

Besides, in the study of Chikha et al. (Chikha et al., 2021), the researchers investigated the mixed effects regarding the relation between spatial ability and visual instructions in primary young children, they particularly explored how young children with varying levels of spatial abilities integrate information from both static and dynamic visualizations. Children (M = 6.5 years) were instructed to rate their invested mental effort and reproduce the motor actions presented from static and dynamic 3D (figure 6) visualizations. They used for the learning and outputs a stimuli presented on a 17-inch LCD computer screen with a 1,280 × 1,024-pixel display. A 3-D game sequence titled "the passing game" was designed and developed using Macromedia Flash MX Professional 2004. For the measurements, they used MFTC test (Harrison et al., 2013), and CMTT test (Ceballos & Ehrlich, 2006). The results indicated an interaction of spatial ability and type of visualization. Children with high spatial ability benefited particularly from the animation, while low spatial ability learners did not, confirming therefore the ability-as-enhancer hypothesis. The study suggests that an understanding of children spatial ability is essential to enhance learning from external visualizations.

The study of Glavaš (Glavaš, 2020) examined the roles of basic concentration and visuospatial ability in adolescent soccer performance. The researcher measured participant's basic cognitive abilities with the Corsi block and the concentration grid tasks, soccer performance was measured in this study through five soccer skills. Concentration had no predictive role in elements of soccer performance, but visuospatial ability was significantly related to tactical abilities, technical skills, mental toughness, and situational awareness and thus, to overall soccer performance. These findings provided support for the importance of visuospatial ability but not concentration (as measured by the concentration grid) in young males' soccer performance.

In the study of Bhargava & Cuzzolin (Bhargava & Cuzzolin, 2020), the researchers explored some of the applications of computer vision to sports analytics. Sport analytics deals with understanding and discovering patterns from a corpus of sports data. Analyzing such data provides important performance metrics for the players, for instance in soccer matches, that could be useful for estimating their fitness and strengths. Team level statistics can also be estimated from such analysis. This paper mainly focused on some of the challenges and opportunities presented by sport video analysis in computer vision. Specifically, they used their multi-camera setup as a framework to discuss some of the real-life challenges for machine learning algorithms.

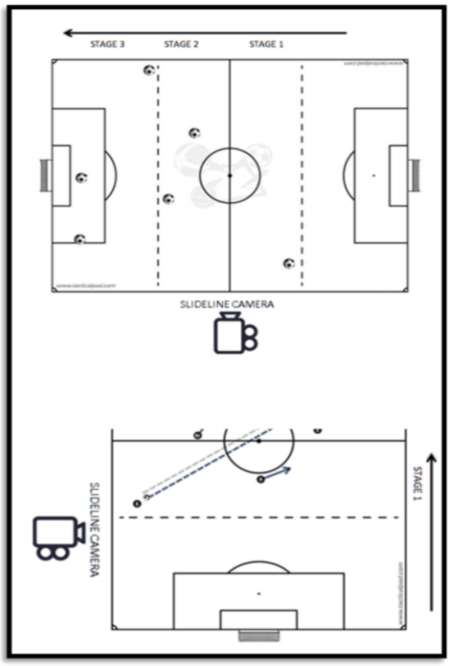

Figure 5. Schematic presentation of the empty soccer play, position of camera side-line and the direction of the play, position of passes and the stages on the soccer paly.

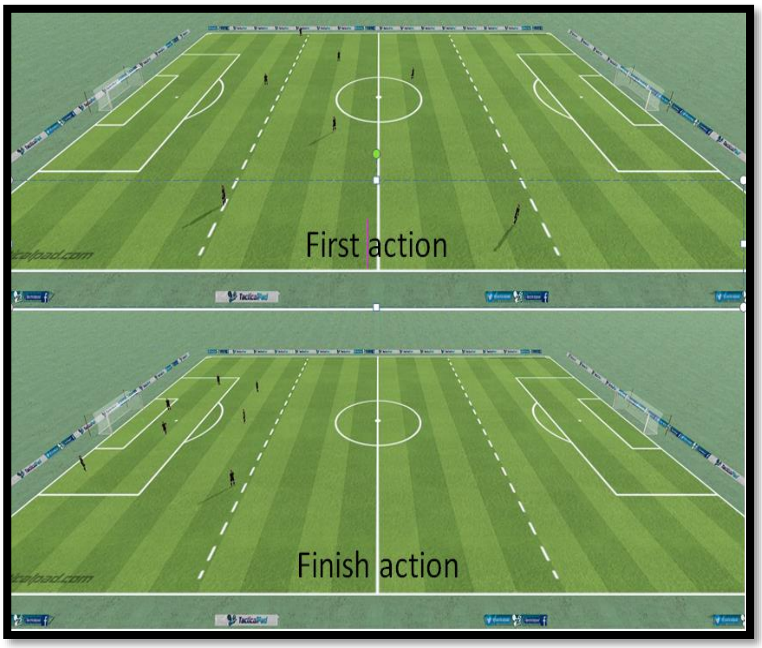

Figure 6. Schematic Representative diagram of a 3D animation dynamic scene to memorise.

5. Conclusion

The various recent studies in the field of mental training and visual-spatial perception relied on many measurement tools, the most important laboratory measurements have been treated in the present chapter, namely, EEG and multimedia.

The EEG allow the researcher in the sports field to discover the changes in the VSA capacities, resulting from practicing mental and cognitive exercises or exposure to psychological pressure. Its values are very accurate, and help to identify the influencing factors during the experiments, which the researcher can control and isolate.

However, the EEG methodology in the visual spatial perception of soccer player would be incomplete without some discussion of neurofeedback.

Through our review, it has been also noticed that many researchers used multimedia as a measurement tool, while it is considered an educational tool and a means of delivery and communication, rather than a means of measurement, Objectively, multimedia can be used as an aid to measurement in the field of visual-spatial perception, provided that the conclusions are not made exclusively based on laboratory studies, but also with tests on the field and evaluation of their impact on the football player during the competition, and the results the player may achieve through these experiments.

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