

ADVANCED MOTOR-SPORT PEDAGOGY: EMBODIED (ARTIFICIAL) AND PERIPHERAL VISION

Arianna Fogliata^{1*} & Antinea Ambretti²

¹ Pegaso University & University of Campania “Luigi Vanvitelli”; fogliataarianna@gmail.com

² Pegaso University; antinea.ambretti@unipegaso.it

* Correspondence: fogliataarianna@gmail.com;

Abstract: The Sincrony Method, introduced in Italy in 1991, represents an innovative pedagogical approach in the motor-sport sector. Connected with the theory of embodied cognition, this method highlights the complex synergy between body and cognition, considering them fundamental tools in learning. A key aspect of this approach is the interaction between peripheral visual capacity and body dynamics, particularly relevant in high-level sports education. This study, focusing on Embodied Artificial Intelligence in the sports field, used as a specialized device, aims at training peripheral vision in real contexts. In the past decade, in this field, the integration of advanced technologies such as video games or viewers has been tested with ambivalent results often related to a lack of transferability. Therefore, the application of new technologies directly in the real training environment could make motor learning more efficient. Although data are limited, the integration of Embodied A.I. for the improvement of peripheral vision, according to expert estimates, is potentially enriching. However, it must be acknowledged that, while this technology is estimated to be useful in the evolution of motor learning, it cannot replace traditional teaching. The real challenge will then consist of integrating body, mind, environment, and technology in a holistic approach to refine technical skills while respecting individual uniqueness.

Keywords: Motor-sport education; Peripheral vision; Embodied A.I.; Sports training; Motor skills



Copyright: © 202X by the authors.
Submitted for possible open access
publication under the terms and
conditions of the Creative Commons
Attribution (CC BY) license
(<https://creativecommons.org/licenses/by/4.0/>).

1. Introduction

The Sincrony method is a motor teaching methodology that was developed in Italy around 1991, although the first official text was not published until 2008. It relies on the biomechanical understanding of movement and offers a practical and integrated approach that encompasses both the motor and neurophysiological dimensions. In this method, among the various investigated aspects of movement, it highlights the importance of the interaction between peripheral vision and bodily movement. Furthermore, it emphasizes how vision training can be utilized to enhance both generic motor abilities and more complex sports skills. This methodology can be connected to the theory of embodied cognition, as it views motor practice not as a collection of isolated abilities but rather interprets it as a complex function influenced by the continuous interaction between internal perception, the external environment, and action. The implementation of the Sincrony Method within the context of embodied cognition serves to illustrate how biomechanical concepts can be effectively applied in praxeology, but only if viewed through an integrative lens. With peripheral vision placed at the heart of the interaction between the individual and their environment, the Sincrony method also aligns with various theoretical models of motor physiology, underscoring the perpetual need for both internal and external feedback (Betestein, 1967; Adams, 1987). The attention to biomechanical detail, in synergy with the acuteness of visual perception, creates a motor learning system that highlights the interdependence between cognition and physical action, promoting a physical education that reflects the complex and coordinated nature of human experience.

1.1. Introduction-Specific

In this perspective, sport represents a crucial vehicle for motor learning, social integration, and personal maturation (Rink, 2013). Movement, understood as the act of moving and interacting with the surrounding environment, is central to how individuals interpret, experience, and learn from the world (Gibbs, 2006). A key component of this interaction is vision, which represents the primary system of communication and perception for human beings (Marr, 1982). It allows not only for the perception of the surrounding environment but also for the interpretation and reaction to various stimuli, playing a crucial role in coordination and motor learning (Goodale & Milner, 1992). This concept of interaction and perception is closely linked to the "embodied" view of cognition. Specifically, the mind is not just an information processing device but is deeply integrated with and influenced by the body and the environment it inhabits (Varela, 1991). In this light, learning and perception can be

considered "embodied" processes in which the body, mind, and environment are interconnected and interdependent. With the advent of emerging technologies, particularly robotics, new perspectives have opened up to enhance these skills, offering tools that emphasize and exploit the nature of learning in a real-world environment (Clark, 1997).

2. The Role of Vision in Motor Learning

Eyes serve as the primary window to the world for humans, particularly for athletes. Through them, strategies are developed, decisions are made, and reactions to stimuli during sports activities are executed. There are two main types of vision: foveal, which focuses on details, and peripheral, which provides a global overview. These types work together to assist athletes in moving and interpreting the environment during technical execution (Wolfe, 1998; Posner, 1980). More specifically, foveal vision refers to direct and focused vision, primarily managed by the eye's macula, allowing for detailed perception (Goodale & Milner, 1992). This type of vision is closely related to selective attention, a neurological mechanism that enables individuals to concentrate on specific stimuli or tasks while ignoring irrelevant stimuli (Posner, 1980). In the sports context, selective attention allows, for example, a soccer player to follow the trajectory of the ball amid a crowd of players (Medina, 2014).

Peripheral vision, on the other hand, refers to the ability to perceive and recognize stimuli outside the center of the visual field (Wolfe, 1998). This vision is associated with diffused attention, a cognitive mechanism that allows for monitoring the surrounding environment without focusing on a specific point (Green & Bavelier, 2007). Although fundamental in many sports, diffused attention and peripheral vision are often more challenging to train. Moreover, in an increasingly digital world, with growing exposure to screens and focal demands, peripheral vision may be less stimulated than in the past, making its development even more challenging for coaches and teachers (Shumway-Cook & Woollacott, 2012). It is noteworthy that some studies suggest that high-level athletes often possess superior peripheral vision compared to non-athletes or amateurs (Green & Bavelier, 2007). Thus, peripheral vision is essentially responsible for detecting stimuli at the edges of the visual field and is inextricably connected to diffused attention, a cognitive mechanism allowing for the simultaneous awareness of numerous stimuli without intense focus on a specific one (Chun MM, 2008).

This interrelationship assumes critical importance in motor learning, a process through which individuals acquire or refine motor skills. In sports contexts, peripheral vision is crucial for anticipating and reacting to opponents' movements, facilitating quick decisions and motor actions, especially for perfecting technical gestures (Cornelissen et al., 2002). Therefore, it plays a fundamental role in optimizing advanced motor learning and effectively adapting to dynamic environments. Neurosciences suggest that while foveal vision and selective attention can be improved through specific exercises and targeted training, peripheral vision and diffused attention rep-

resent a more arduous task for sports coaches and teachers (Brooks, 1991; Green & Bavelier, 2007). With the introduction of video games and digital technology, it has been possible to make significant improvements in training specific capabilities, integrating them into training programs for high-level athletes (initially especially for pilots). Traditional exercises, however, often focused on techniques such as tracking moving objects with the eyes and focusing on fixed points while noticing objects in the periphery (Abernethy, 1990), unfortunately, often did not yield satisfactory results, especially for those moving at high speeds. Research has indicated potential benefits of the same for visual function (Spence & Feng, 2010). However, these benefits investigated in a natural environment were often limited and not applicable in the specific context of the game-competition (Boot et al., 2008; Murphy & Spencer, 2009; van Ravenzwaaij et al., 2014; Kristjánsson, 2013; Ferguson, 2007). It was thus hypothesized that early video games, being simple and not specifically designed for sports training or for the development of specific skills, offered limited applications in this field (Wolf, 2007; Powers, 2013).

In recent decades, the rise of virtual reality (VR) (Biocca, 1992) has therefore catalysed the interest of the scientific community, particularly regarding the potential in training peripheral vision. The depth and immersion offered by modern viewers indeed promise to create a training environment emulative of real situations. Studies have, however, emphasized the importance of questioning the effectiveness of such technology when translated into real scenarios, as there have been issues related to the transferability of skills (Stojić, 2015; Hays, 1992; Mantovani 2003; Dalgarno, 2010).

One of the main reference tools in sports today in VR is eye-tracking technology, which allows monitoring and/or accurately recording where a user is directing their gaze, this is very useful for possible training. This allows for a detailed visual mapping, but in light of the concept of transferability, does not meet the criteria for verifiability of the existence of a direct correlation between focus-perception-processing of information from the segment of the visual field (Cunningham, 2001).

Some studies have explored this aspect in sports like soccer, basketball, and running, attempting to verify possible effects on the players' anticipation abilities of the opponents' moves (Smith & Ericsson, 2019; William, 2002). The results found that, despite there being improvements in the virtual environment for the variables investigated, there was not always a direct transfer of these skills to the real game field. Furthermore, the divergence between the virtual experience and the real game situation can also be amplified by another important factor: emotional responses. For example, while an athlete might be able to react quickly to a stimulus in a virtual environment, and use peripheral vision to do so, the emotions that arise in a real game context could differently influence their responses (Parsons & Rizzo, 2008).

This thus pushes research towards a reflection on the importance of interaction with the real environment in learning, making particularly interesting another emerging technological field: embodied artificial intelligence and its intersection with robotics in motor learning. Embodied AI could indeed use body-environment in-

teractions with the athlete moving from virtual to physical. Today there are robots for sports training, but their use is still limited. In the International and National plan of advanced-level sports training, there are: RXT-1 used in boxing and/or martial arts; the Muratore robot employed (almost exclusively) by the Japanese men's volleyball national team.

There are also recently conceptualized soccer goalkeeper robots. These devices challenge athletes to respond in real-time to an external stimulus, indirectly emphasizing the refinement of peripheral vision that must be activated to perform the task. This, deductively, could allow contextualizing the training in a natural and real environment, emphasizing the importance of adaptation and rapid motor response to unpredictable situations similar to the technical request (Shumway-Cook & Woolacott, 2012) and indirectly allowing an improvement of peripheral vision. To there are still no available data from studies of movement with the aid of Embodied A.I.

3. Embodied AI in Sports Training

Various sports are currently seeking to integrate specialized robots as tools for advanced training:

Boxing: The RXT-1 robot as mechanical sparring partners. They can replicate various combinations of punches at different speeds and intensities, adjusting to the boxer's responses. The athlete, therefore, must not only predict and react to incoming punches but also maintain awareness of the surrounding environment, which, according to the authors, could indirectly develop peripheral vision.

Volleyball: The Japanese men's national team has adopted, as the first in the world, robots capable of blocking (a defensive technique). This forces players to quickly read the field, anticipate the trajectory of the ball, and react accordingly to overcome the obstacle, thereby stimulating, according to the authors, the indirect development of peripheral vision.

Soccer: Goalkeeper robots. This should help athletes develop tactical shooting skills, and challenge them to perceive even minor movements of the goalkeeper in the act of shooting, when vision must be peripheral. Fundamentally, by using robotics in training, athletes could be pushed to react to ad hoc stimuli in an interactive real environment. The capacity of a robot, unlike a human opponent, requires the trainee to pay greater attention. This, in turn, indirectly encourages athletes to use their peripheral vision as a tool for anticipation and reaction. For example, as a boxer trains with a robot like the RXT-1, due to the robot's calculated variability, they are forced to use peripheral vision to anticipate punches and avoid being hit, as well as to find opportunities to counterattack.

4. Application Hypothesis

In light of the reflections and studies presented, a preliminary pilot study is envisioned to verify the effectiveness of Embodied Artificial Intelligence (Embodied AI) in training martial artists through the aid of RXT-1. The main goal is to assess whether the use of training protocols integrated with Embodied AI can lead to an improvement in peripheral vision compared to traditional methods using pre-post training evaluative test batteries.

Given the still not easy availability of RXT-1 and the high costs, the authors have made a prospective estimate of the expected results based on the Delphi method. Despite the scarcity of data currently in the literature, and having a still limited number of "experts" in the field, a qualitative estimate was nevertheless obtained. It would suggest that both workgroups should show improvements in peripheral vision, with a more marked increase for the method integrated with Embodied A.I. up to a maximum of 20%. They would also suggest an increase in the learning speed of finer techniques. It's important to note that these estimates must be interpreted with caution but open the possibility of conducting a detailed study in this regard.

5. Conclusions

The convergence of embodied artificial intelligence and robotics is emerging as an intriguing element for the future of motor and sports pedagogy (Andriacchi & Alexander, 2000). These advanced technologies could not only provide innovative methods for training peripheral vision, but their integration could represent an additional tool for technical learning. However, it's essential to approach these technologies with balance and critical reasoning.

The data available to us today are limited, and the debate on the transferability of skills is more alive than ever. Moreover, the conscious and rational use of the body, as emphasized by the Sincrony methodology and numerous theories in the field of motor psychology and neuroscience (Bernstein, 1967, Gibson, 1979), is fundamental for learning and cannot be replaced. Therefore, while the importance of peripheral vision in the context of motor-sport learning is undeniable, and the use of Embodied A.I. could support it, it might be less functional if not placed in a broader context. The introduction of specialized robots for motor learning represents an interesting perspective in the view that these technologies support the refinement and are not substitutes for traditional training. We believe it is useful to maintain a balance between technological development and individual responsibility, in order to grow in the study of motor praxeology in an integrated perspective.

Acknowledgments

The Authors would like to thank Daniele Mazzilli and Chiara Gamberini for their support in the Delphi information collection.

References

- Adams, J. A. (1987). Historical Review and Appraisal of Research on the Learning, Retention, and Transfer of Human Motor Skills. *Psychological Bulletin*, 101(1), 41-74.
- Andriacchi, T. P., & Alexander, E. J. (2000). Studies of human locomotion: past, present and future. *Journal of biomechanics*, 33(10), 1217-1224.
- Bernstein, N. (1967). *The coordination and regulation of movements*. Pergamon Press.
- Biocca, F. (1992). Will simulation sickness slow down the diffusion of virtual environment technology? *Presence*, 1(3), 334-343.
- Boot, W. R., Kramer, A. F., Simons, D. J., Fabiani, M., & Gratton, G. (2008). The effects of video game playing on attention, memory, and executive control. *Acta Psychologica*, 129(3), 387-398.
- Brooks, R. A. (1991). Intelligence without representation. *Artificial Intelligence*, 47(1-3), 139-159.
- Chun MM, Turk-Browne NB. (2008). The Influence of Attentional, Emotional, and Motivational Factors on Visual Working Memory. *Current Directions in Psychological Science*.
- Clark, A. (1997). *Being there: Putting brain, body, and world together again*. MIT press.
- Cornelissen FW, Kimmig H, Schira M, Rutschmann RM, Maguire RP, Broerse A, et al. (2002). The role of peripheral vision in saccade planning: learning from people with tunnel vision. *Journal of Neuroscience*.
- Cunningham, D., Billock, V. A., & Tsou, B. H. (2001). Sensorimotor adaptation to violations of temporal contiguity. *Psychological Science*, 12(6), 532-535.
- Dalgarno, B., & Lee, M. J. W. (2010). What are the learning affordances of 3-D virtual environments? *British Journal of Educational Technology*, 41(1), 10-32.
- De Bernardi, F. (2008) *Educare al movimento*. Red Edizioni.
- Ferguson, C. J. (2007). Evidence for publication bias in video game violence effects literature: A meta-analytic review. *Aggression and Violent Behavior*, 12(4), 470-482.
- Gibbs, R. W. (2006). *Embodiment and cognitive science*. Cambridge: Cambridge University Press.
- Gibson, J. J. (1979). *The ecological approach to visual perception*. Houghton Mifflin.

- Goodale, M. A., & Milner, A. D. (1992). Separate visual pathways for perception and action. *Trends in Neurosciences*, 15(1), 20-25.
- Green, C. S., & Bavelier, D. (2007). Action-video-game experience alters the spatial resolution of vision. *Psychological Science*, 18(1), 88-94.
- Hays, R. T., Jacobs, J. W., Prince, C., & Salas, E. (1992). Flight simulator training effectiveness: A meta-analysis. *Military Psychology*, 4(2), 63-74.
- Kristjánsson, Á. (2013). The case for causal influences of action videogame play upon vision and attention. *Attention, Perception, & Psychophysics*, 75(4), 667-672.
- Mantovani, F., & Castelnuovo, G. (2003). The sense of presence in virtual training: Enhancing skills acquisition and transfer of knowledge through learning experience in virtual environments. *In Being There: Concepts, effects and measurement of user presence in synthetic environments* (pp. 167-181). IOS Press.
- Marr, D. (1982). *Vision: A computational investigation into the human representation and processing of visual information*. Henry Holt and Co. Inc.
- Medina, J. (2014). *Brain Rules: 12 Principles for Surviving and Thriving at Work, Home, and School*. Pear Press.
- Murphy, K., & Spencer, A. (2009). Playing video games does not make for better visual attention skills. *Journal of Articles in Support of the Null Hypothesis*, 6(1), 1-20.
- Parsons, T. D., & Rizzo, A. A. (2008). Affective outcomes of virtual reality exposure therapy for anxiety and specific phobias: A meta-analysis. *Journal of Behavior Therapy and Experimental Psychiatry*, 39(3), 250-261.
- Powers, K. L., Brooks, P. J., Aldrich, N. J., Palladino, M. A., & Alfieri, L. (2013). Effects of video-game play on information processing: A meta-analytic investigation. *Journal of Experimental Psychology: General*, 142(4), 1043-1059.
- Posner, M. I. (1980). Orienting of attention. *Quarterly Journal of Experimental Psychology*, 32(1), 3-25.
- Rink, J. E. (2013). *Teaching physical education for learning*. New York: McGraw-Hill Higher Education.
- Stojić, I., Savić, G., & Milovanović, M. (2015). The effectiveness of virtual reality based training on military skills development. *Vojnotehnički glasnik*, 63(1), 182-199.

- Shumway-Cook, A., & Woollacott, M. H. (2012). *Motor control: Translating research into clinical practice*. Lippincott Williams & Wilkins.
- Smith, D., & Ericsson, A. (2019). Use of virtual reality in sport psychology: Cognitive rehabilitation and motor learning. *Frontiers in Psychology*, 10, 2058.
- Van Ravenzwaaij, D., Boekel, W., Forstmann, B. U., Ratcliff, R., & Wagenmakers, E. J. (2014). Action video games do not improve the speed of information processing in simple perceptual tasks. *Journal of Experimental Psychology: General*, 143(5), 1794.
- Varela, F. J., Thompson, E., & Rosch, E. (1991). *The embodied mind: Cognitive science and human experience*. MIT press.
- Williams, A. M., Ward, P., Knowles, J. M., & Smeeton, N. J. (2002). Anticipation skill in a real-world task: Measurement, training, and transfer in tennis. *Journal of Experimental Psychology: Applied*, 8(4), 259.
- Wolfe, J. M. (1998). *Visual search*. In H. Pashler (Ed.), *Attention* (pp. 13-73). Hove: Psychology Press.
- Wolf, M. J. P. (2007). *The Video Game Explosion: A History from PONG to PlayStation and Beyond*. Greenwood Press.