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VISUAL STIMULI FOR IMPROVING PERCEPTUAL-COGNITIVE SKILLS IN SPORT ACTIVITIES: THE TECHNOLOGY SUPPORT

GLI STIMOLI VISIVI PER IL MIGLIORAMENTO DELLE ABILITÀ PERCETTIVO-COGNITIVE NELLO SPORT: IL SUPPORTO DELLA TECNOLOGIA

Sonja Čotar
Handball Federation of Slovenia
sonja.cotar@rokometna-zveza.si

Antonio Ascione
University of Bari “Aldo Moro”
antonio.ascione@uniba.it

Davide Di Palma
University of Napoli “Parthenope”
davide.dipalma@uniparthenope.it

Valeria Agosti
University of Salerno
valeria.agosti@gmail.com

Abstract

The purpose of this article is to analyze the possible contribution of visual training systems in learning perceptual-cognitive skills. Starting from a serious consideration on executive functions, a deep analysis of scientific literature guided us up to Transfer of Training concept, i.e. to understand that visual stimuli could create new learning fields so that what is learning during the training could be transferred to competition.

Lo scopo del presente lavoro è quello di analizzare quale possa essere il contributo dei visual training systems nell’apprendimento delle abilità percettivo-cognitive. Partendo da una attenta riflessione sulle Funzioni Esecutive una approfondita analisi della letteratura scientifica ci ha guidati fino ad arrivare concetto di Transfer of Training, vale a dire alla comprensione di quanto gli stimoli visivi possano proporre nuovi ambienti di apprendimento tali che quanto appreso in corso di esercizio possa essere naturalmente trasferito in ambiente di gara.

Keywords

Visual stimuli; Sports technology; Executive functions; Cognitive skills; Transfer of training.
Stimoli visivi, Tecnologia sportiva; Funzioni esecutive; Abilità cognitive; Transfer of training.
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Introduction

In recent years, a growing interest in the study of perceptive-cognitive skills is emerging in the sports world, that is in that skills useful in processing information and in adapting quickly to rapid changes of the context, both in terms of complexity than of situations. Sports sciences are therefore moving towards the study of so-called executive functions (EF), that Diamond (2013) defines as a "family of top-down mental processes needed when you have to concentrate and pay attention, when going on automatic or relying on instinct or intuition would be ill-advised, insufficient, or impossible". According to the theoretical model of Miyake et al. (2000), EF "cores" are three: *inhibition and interferences control*, that is the ability to eliminate, during the execution of a task, all the variables that could play the role of distractors in achieving the aim; *working memory,* that allows you to keep the memory of all new information useful for carrying out an activity; and *cognitive flexibility,* that is, the ability to modify one's action in line with changes of the environment and the task being performed. EF term therefore includes all the cognitive skills that allow us to inhibit automatic responses to stimulation, to keep information in the working memory and to move attentional focus on the related but distinct aspects of an assigned task or problem (Blair, 2017). Like many aspects of cognitive ability, EF are useful in many different situations. In complex sport situation, where reasoning, problem solving, and planning are essential skills, these cognitive abilities are essential. In fastball sport, like soccer, are crucial to "read the game" and make the player able to assess all the internal and external body variables and to select an adequate motor behavior in a short time and in conditions of emotional stress (Vestberg et al., 2017). In view of the above, cognitive skills become almost more important than physical ones, going to affect the organization and execution of the athlete's performance. The cognitive skills are been described as keys elements in determining Reaction Time (RT) in sport. RT, defines the time that elapses to detect, evaluate and respond in a complex action and it turns out to be crucial in a successful sport performance, where a high level of perceptual ability is required in order to show an efficient execution of motor behavior (Reigal et al., 2019).

Visual skills are key elements in perceptive-cognitive skills training, therefore the use of technological systems stimulating cognitive skills through the only administration of visual stimuli is currently spreading and consequently they train and test RT (Örs et al., 2019). These tools are nowadays considered a *gold standard* for improving athlete's performance, particularly for fastball sports, but there is no scientific evidence remarkable enough to validate this statement. This work would like to be a reflection and a theoretical inspiration in a field missing of a supporting scientific literature. Training and the consequent transfer of perceptual-cognitive skills into the specific sport gesture is a current topic and it is going to be structured. It therefore requires the utmost attention of both coaches and athletic trainers. This is even more true now that new technologies are offering tools for cognitive training but its effects are not well evaluated and clarified yet.

1. Visual–motor reaction training technologies

The visual processing follows a bidirectional system, where feedforward (bottom-up) and feedback (top-down) mechanisms support each other by transmitting information to and from the lower and upper cortical areas (Kafaligonul et al., 2015). The visual system is based on a high structural and organizational complexity and acts by involving numerous structures that allow us to capture and transform the light reflected by objects in the environment into clear images. The perception and processing of such information is necessary, especially in sport, because it acts as "sensory shortcut" that consistently organizes a motor action in its space-time variables (where and when to move) (Discombe & Cotterill, 2015). In athletes, in particular in elite athletes, having the ability to use this shortcut, that is, visually perceiving the relevant information in the shortest possible time, is essential to maximize the RT and movement time

(MT) of the motor performance (Hüttermann et al., 2018). We can define MT as the interval between the beginning and the end of the motor action and is considered an indicator of both the decision-making process and the consequent success of sports performance. Both RT and MT can be trained and both can be used as indicators of specific perceptual-motor tests (Loureiro & Freitas, 2012; Örs et al., 2019).

In the last years it has been spread the use of technological tools with emission of light and/or visual signals to train RT and test MT (Appelbaum & Erickson, 2018). Tools such as FitLight System®(Fitlight Sports Corp., Aurora, Ontario) or Blazepod® (Play Coyotta ltd, Tel Aviv, Israel) or Reaxlight®(Reaxing s.r.l., Milano, Italy) or also SMARTfit ®(SMARTfit, Inc., Camarillo, California) are currently on the market as a training proposal both for élite athletes and for children and the elderly; they are also proposed as useful tools in functional recovery and rehabilitation protocols and also in neuromotor and cognitive rehabilitations. Recently placed on the market, from an engineering point of view they are built with a simple, inexpensive and not particularly complex technology. These systems have some similarities to each other: they have pre-established programs to train speed and reactivity using sequences of lights of different colors, they have the possibility to record the motor performance data of each participant, they are equipped with wireless light systems that can interface with each other also if they are far from each other and / or two-dimensional panels, and they also have a control platform. Of the aforementioned systems, only SMARTfit® allows participants to pursue not only bright colored targets, but also shapes, numbers and letters; for this reason, its value is enhanced as a "visual-cognitive motor training system". There are no scientific articles on this latter, but, in order to demonstrate that the system thinks and organizes itself differently than the others, a recent clinical trial (ClinicalTrial.gov, 2018), whose results have not been published yet, has evaluated the use of this technology to train motor function, cognition and functional connectivity of the brain in patients affected of Parkinson's disease.

Due to their connectivity, recording and data retention characteristics, these systems are often used to reproduce motor tests and therefore evaluate motor and athletic performance over time. In particular, the FitLight System®, the first to be widely distributed on the market, it was also used to evaluate attentional processes in sports performance of professional handball athletes (Zwierko et al., 2014). The same system has recently been used to implement the protocol of the classic "single leg hop motor test" to measure and record RTs after an injury, in order to evaluate not only the athletic load of the performance, classically measured with the standard protocols, but also the neurocognitive one (Millikan et al., 2018; Simon et al. 2019). In order to find a new approach to dual-task tests, FitLight System® has also been used to implement a cognitive stimulation protocol; this has enabled to train and simultaneously test motor performance on postural control in elderly subjects (Laessoe et al., 2019).

Called visual-cognitive systems, these tools are therefore widely affirmed in subverting the classic strategies used over the years to assess perceptual-cognitive skills in training and in sport (Hernández-Mendo et al., 2019). Although their use is not well clarified yet, overall these new systems have allowed significant improvements in the assessment and cognitive preparation of athletes (Appelbaum & Erickson, 2018). The rapid development of new technical measuring and training tools constantly increases the ecological validity of the measures, bringing the athlete's training experience closer to an authentic game context. Therefore, the development of technology opens a very promising path for this line of research, offering possibilities previously unexplored. However, to increase the usefulness of cognitive assessments and training, it will be necessary to improve the transfer of laboratory knowledge to real-life contexts. Furthermore, to solve any doubts regarding the real involvement of cognitive processes in visual training tests and visual training protocols, it will be necessary to think about implementing these systems with specific tasks recalling EFs, which will therefore allow to inhibit rooted behaviors, focus attention in a strategic way and organize our thoughts in terms of complexity, as it happens during sports performances (Blair, 2017).

2. The Transfer of Training and the technological tools: from training setting to competition environment

The ability to update information of the working memory is a key element of the executive functioning of our brain (Miyake et al., 2000). In recent years, this topic has aroused considerable interest, particularly in the possibility to specifically train the update ability of working memory, and also if and how much the benefits of this training could be transferred to other cognitive sectors, what is called Transfer of Training (TT).

The TT concerns the processes by which the improvement of performance in terms of exercises or tasks (training) can influence the performance in exercises or alternative (trained) motor tasks (Zhao et al, 2018). On the topic, scientific research contains conflicting results but it is clear how important this transfer ability is not only in sports performances but also in motor function in general. Furthermore, it must be considered that, in sport field, this transfer must be considered differently if we refer to motor technical skills, i.e. to the skills related to the specific sport component of the performance, or to motor abilities, i.e. to the skills related to the athletic component of the performance. It has been widely described that the TT of motor technical skills is much more limited than the TT of motor abilities and how both are directly dependent on the level of expertise of the athletes: low and medium level athletes are more sensitive to any type of stimulus, including those not related to specific sports, while high level athletes need from the specificity of the exercise (Issurin, 2016).

It is so worth noting that the problem of TT is directly connected to motor learning, in particular to the Transfer of Learning, that is, to the impact that learning one motor skill can have on learning the other ones (Willingham, 1998; Seidler, 2010), and this must be clear both in the proposal of technical exercises (sport specific) and conditioning exercises (athletic motor abilities). Visual cognitive systems are proposed on the market as an opportunity to create “movement models” by stimulating the athlete’s reaction and perception with visual stimuli, and this possibility is expanded by the fact that they can be adapted and configured for any sport, for the hand-eye coordination, foot-eye coordination training, athletic conditioning and/or controlled rehabilitation of injuries, thus facilitating the role of the coach. So, the problem that each coach must solve has not be faced in proposing the simple use of these systems, but in how and how much these can be useful in creating new exercises, in proposing learning fields matching the specific needs that determine the competitive performance (Issurin, 2013): motor learning will be all the more efficient if the activities proposed are closer to the transfer criteria required in cortical processing. This growing diffusion of new technologies designed to train perceptual-cognitive abilities of athletes and support TTs must therefore be carefully analyzed. Not all the relevant factors involved in facilitating TT can be proposed or adapted by modern technology to serve sport and training. Biofeedback and neurotracking systems, virtual reality, artificial environments, visual training systems, are all proposed as “effective” in improving motor and sport performance; but none of these has been scientifically validated or supported by rigorous scientific studies which have verified their real (and non-commercial) effectiveness in promoting the learning of perceptual-cognitive skills and the subsequent and necessary TT (Issurin, 2013; Hodges & Williams, 2019).

Conclusion

This article has been oriented in determining whether and how much visual stimuli and visual training systems can be useful and decisive in promoting an improvement of sports and motor performances. The topic requires a lot of attention as these systems are currently widely offered on the market and widely used by coaches and athletic trainers. Attention must be particularly paid to the link between these systems, the EF and the TT, that is to say to understand and evaluate how much these tools are really useful in proposing new learning and motor stimulation fields, particularly in élite athletes. Motor performance is strictly connected to the development of EF and motor activity is itself an excellent way to solicit and implement them: it is clear how structuring exercises aimed at achieving specific objectives inherent in the development of executive skills can be important for the development of new motor skills and skills both in athletes and non-athletes. Like many aspects of cognitive ability, EF tend to improve the more we train them. The big questions are: how much and what kind of practice it has to be used? How to train in order to have long-lasting and widely applicable benefits? The answers are complex and, for the most part, still unknown. There are, however, some good indicators of how visual stimuli and visual cognitive systems, economic and user-friendly training systems, can play a role in formulating the answers to these questions. However, it must be kept in mind that training must not only look at the ability *di per se* but at how these skills become motor skills, in order to be effectively expressed in the specific sport gesture and even more in the race. Up to now, the answers provided by the manufacturers and users of these systems are still not satisfactory, lacking scientific and neurophysiological bases. Concrete evidence is still lacking and this remains a fruitful area for future investigation.

References

Diamond A. (2013). Executive Functions. Annu Rev Psychol. 64:135–168. doi:10.1146/annurev-psych-113011-143750

Miyake A, Friedman NP, Emerson MJ, Witzki AH, Howerter A, Wager TD. (2000). The unity and diversity of executive functions and their contributions to complex “frontal lobe” tasks: a latent variable analysis. Cogn. Psychol. 41:49–100. doi:10.1006/cogp.1999.0734

Blair C. (2017). Educating executive function. Wiley Interdiscip Rev Cogn Sci. 8(1-2). doi: 10.1002/wcs.1403.

Vestberg T, Reinebo G, Maurex L, Ingvar M, Petrovic P. (2017). Core executive functions are associated with success in young elite soccer players. PLoS One. 12(2):e0170845. doi: 10.1371/journal.pone.0170845

Reigal RE, Barrero S, Martín I, Morales-Sánchez V, Juárez-Ruiz de Mier R and Hernández-Mendo A. (2019). Relationships Between Reaction Time, Selective Attention, Physical Activity, and Physical Fitness in Children. Front. Psychol. 10:2278.doi: 10.3389/fpsyg.2019.02278

Kafaligonul H, Breitmeyer BG and Ögmen H. (2015). Feedforward and feedback processes in vision. Front. Psychol. 6:279. doi: 10.3389/fpsyg.2015.00279

Loureiro Jr LDFB, Freitas PBD. (2012). Influence of the performance level in badminton players in neuromotor aspects during a target-pointing task. Rev Bras Med Esporte. 18(3): 203-207. doi:10.1590/S1517-86922012000300014

Örs BS, Cantaş F, Onarici Güngör E, Şimşek D. (2019). Assessment and comparison of visual skills among athletes. Journal of Sports and Performance Researches. 10(3):231-24. doi: 10.17155/omuspd.522342

Discombe RM, Cotterill ST (2015). Eye tracking in sport: A guide for new and aspiring researchers. Sport & Exercise Psychology Review. 11:627–658

Hüttermann S, Noël B, Memmert D. (2018). Eye tracking in high-performance sports: Evaluation of its application in expert athletes. Int J Comp Sci Sport. 17(2):182-203. doi: 10.2478/ijcss-2018-0011

Appelbaum LG, Erickson G. (2018). Sports vision training: A review of the state-of-the-art in digital training techniques. Int. Rev. Sport Exerc. Psychol. 11:160–189. doi: 10.1080/1750984X.2016.1266376

ClinicalTrials.gov. (2018). [Internet]. Bethesda (MD): National Library of Medicine (US). 2000 Feb 29. Identifier Protocol NumberHS-17-00928, Effect of SMARTfit training on motor, cognitive functions and brain connectivity inindividuals with Parkinson’s disease: a pilot study. Version 1. Principal Investigator: Liu C; Co-Investigators: Fisher B, Pa J; Available from:https://clinicaltrials.gov/ProvidedDocs/59/NCT03921359/Prot_SAP_000.pdf

Millikan N, Grooms DR, Hoffman B, Simon JE. (2018). The development and reliability of four clinical neurocognitive single-leg hop tests: Implications for return to activity decision making. Journal of Sport Rehabilitation, 1e26. https:// doi.org/10.1123/jsr.2018-0037

Simon JE, Millikan N, Yom J, Grooms DR. (2019). Neurocognitive challenged hops reduced functional performance relative to traditional hop testing. Phys Ther Sport. 41:97-102. doi: 10.1016/j.ptsp.2019.12.002

Laessoe U, Larsen CB, Schunck LN, Lehmann LJ, Iversen H. (2019). Age related differences in balance approached by a novel dualtask test of anticipatory postural control strategies. PLoS ONE 14(6): e0218371. doi:10.1371/journal.pone.0218371

Hernández-Mendo A, Reigal RE, López-Walle JM, Serpa S, Samdal O, Morales-Sánchez V, Juárez-Ruiz de Mier R, Tristán-Rodríguez JL, Rosado AF and Falco C. (2019). Physical Activity, Sports Practice, and Cognitive Functioning: The Current Research Status. Front. Psychol. 10:2658. doi: 10.3389/fpsyg.2019.02658

Zwierko T, Florkiewicz B, Fogtman S, Kszak-Krzyżanowska A. (2014). The ability to maintain attentionduring visuomotor task performancein handball players and non-athletes. Central European Journal of Sport Sciences and Medicine. 7(3): 99–106

Zhao X, Xu Y, Fu J, Maes JHR. (2018). Are training and transfer effects of working memory updating training modulated by achievement motivation? Mem Cognit. 46(3):398-409. doi: 10.3758/s13421-017-0773-5

Issurin VB. (2016). Benefits and Limitations of Block Periodized Training Approaches to Athletes' Preparation: A Review. Sports Med. 46(3):329-38. doi: 10.1007/s40279-015-0425-5

Willingham DB. (1998). A Neuropsychological Theory of Motor Skill Learning. Psychological Review. 105(3):558-584

Seidler RD. (2010). Neural Correlates of Motor Learning, Transfer of Learning, and Learning to Learn. Exerc Sport Sci Rev. 38(1):3–9. doi: 10.1097/JES.0b013e3181c5cce7

Issurin VB. (2013). Training transfer: scientific background and insights for practical application. Sports Med. 43(8):675-94. doi: 10.1007/s40279-013-0049-6.

Hodges NJ &Williams AM. (2019). Skill Acquisition in Sport: Research, Theory and Practice, Edition 3. Routledge, ISBN 9781351189736