Exergame-Design and Motor Activities Teaching: An Overview of Scientific Paradigms on Motor Control

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Abstract: *This study is part of a larger project designed to assess the effectiveness of the use of exergames in the teaching of motor activities. The project starts with an overview of the state of the art of exergames and the influence of psychological models of the movement in software design. The experimental section of the project involves the creation of 3 exergames educational, of which:an exergame related to visuomotor integration, on the basis of tests as Bender Gestalt and VMI, an exergame dedicated to test, in augmented / virtual environments, some commonly accepted principles in motor control (speed-accuracy trade-off, Hick's law, stimulus – response compatibility, Fitts' law), and an exergame related to the acquisition of cognitive skills through the involvement of the whole body (reading – writing skills). In this general framework, this study locates itself as the scientific starting basis, providing an overview of the literature on exergames (from which does not seem to be present exergames specifically designed for use in teaching of motor activity) and a summary of the psychological models of movement*

Keywords: *exergames; motor control; cognitive approach; motor learning;*

1. Introduction

The term "exergame" is used to define the combination of gaming with exercise. In particular, with exergame we refer to a category of video games in which the interaction is not based only on the hand-eye coordination, but on the whole body. The interaction based on the whole body is made possible by a series of non-standard controller, such as, for example, the Wiimote and Balance Board, connected to the Nintendo Wii console, and the Microsoft Kinect sensor, popular as an accessory for the Xbox.

The exergames were immediately hailed as a welcome development, for the contribution they offer as a weapon against a sedentary lifestyle (Chamberlin & Gallagher) and the level of user involvement, which adds to the traditional value of videogames (Baranowski, Buday, Thompson, & Baranowski, 2008) the attractiveness of natural interfaces (Wigdor & Wixon).

Attention was initially focused on promoting healthy lifestyles and on the struggle against physical inactivity, therefore the focus was on energy expenditure. (SIEGEL, HADDOCK, DUBOIS, & WILKIN)

The aspect that is frequently emphasized in the studies that have dealt with the energy expenditure is the attraction exerted by exergames on individuals normally reluctant to physical activity. The exergames, in other words, are mainly a way to promote wellness and encourage the movement of persons engaged in sedentary lifestyles.

“Exergaming is a term used to describe video games that provide encouragement to exercise, particularly for an audience that may be reluctant to engage in the more traditional forms of exercise. Exergames are a commonly accepted method of encouraging more physical activity to promote better health for those with high levels of sedentary screen time”(Whitehead, Johnston, Nixon, & Welch).

The results are encouraging, considering that energy expenditure doubled in subjects involved in exergames as compared to individuals that use "traditional" videogames. (Lanningham-Foster et al.)

On the basis of positive results, research has explored other fields, showing how the videogaming based on the whole body can bring benefits at cognitive level in autism or enhance brain activity in the elderly.

“Exergaming may be useful for the management of behavioral disturbance and for increasing cognitive control in children on the autism spectrum” (Anderson-Hanley, Tureck, & Schneiderman, 2011); “Exergames' boost brain function among seniors” (Anderson-Hanley et al.)

The results of cited studies cited had the effect of subverting the traditional skepticism with which gaming activities have often been considered within physical education and health education.

The current trend is to consider how video games present many potential advantages in the field of motor activities and promotion of wellness. The features which can positively influence skills, attitudes and behaviors regarding health and exercise, are:

- the fascination of these games (and therefore the increased motivation),
- opportunities that videogames offer for active and experiential learning of concepts and skills,
- personalized feedback and instruction,
- opportunity for learning through social interaction.

"Exergame present many potential benefits for HE and PE. […] Pulling together those benefits, it derives that major common strengths for both disciplines, which may positively influence young people' knowledge, skills, attitudes and behaviors in relation to health and physical exercise, are the unique motivational appeal that those games possess as well as the opportunities that they offer for active, exploratory and experiential learning of concepts and skills, for rehearsal of skills within a safe environment, for individualized feedback and differentiated instruction, and for learning through social interactions. In addition, the new generation of physically interactive electronic games seems to be particularly valued in the overviewed literature as it can provide opportunities for actual physical exercise and motor skill learning within PE contexts." (Papastergiou).

However, other studies have led to less exciting results and revealed the limits of exergames

A study by Hsu (Hsu et al.) on effects of Wii Bowling in an exercise regimen for patients with long-term dysfunction of the upper limbs showed that the only significant finding was a greater enjoyment of 'activity compared to a control group subjected to a standard regimen.

A study on "effects of adding Nintendo Wii® Bowling to a standard exercise regimen for residents of long-term care with upper extremity dysfunction" showed as"the only significant finding was a measure of enjoyment of activity when compared to a standard exercise group." (Tanaka et al.)

This leads to consider how the current generation of exergames is not designed specifically to support teaching of motor activities or rehabilitation. There are general purpose products, intended for large groups of users, but software products based on a robust theoretical framework, oriented to the acquisition of specific motor skills, for use in teaching of physical education and rehabilitation, are still prerogative of the experimental research and have not enough spread to allow an overall estimate of the cognitive and educational impact of exergames.

The research on the actual effectiveness of exergames in the acquisition of specific motor skills still seems lacking. (Di Tore & Raiola, 2012)

"Because many exergames such as DDR or Wii Sports tennis require rapid hand–eye or foot–eye coordination, they may improve general coordination skills. However, the majority of research on coordination benefits involves elderly people playing sedentary video games, not exergames. Video game play increased perceptual-motor skills including hand–eye coordination, dexterity, and fine motor ability (Drew & Waters). At present, there is no exergame research on this topic." (Staiano & Calvert)

2. Exergame-design and motor activities teaching

In this context, below is presented a brief summary of currents of thinking in the context of motor control and its learning, to assess their methodological and didactic consequences and evaluate the didactic implications to be considered in exergame design and development process.

In the context of PE teaching, the main approaches to motor control and motor learning are:

- the cognitive approach
- the ecological approach

The different approaches are distinguished by the position and the role attributed to prescriptive mental structures: representations, knowledge, motor plans, plans in the production of motor skills.

The motor control theories developed in cognitive psychology have generated a substantial amount of educational applications. According to these theories, the human being has, at the cerebral level, a series of motor programs, or sequences of commands that at the level of the central nervous system, coordinate the execution of the movements. According to a first draft, the information processing by sense organs and associated analyzers, including those defined proprioceptors, allows the system to correct the movements during the performance through the closed loop model of motor control (Adams).

The closed loop model assumes that the movements are performed slowly, in the order of 200 milliseconds, such as to allow the correction of the error registered during the action, on the basis of feedback. The longer the time of execution, the larger the possibility of using the motor control circuits based on feedback, peripheral control, and on the on line error correction (Schmidt & Wrisberg, 2008).

In lower execution times, ie when the movement is more rapid, due to the high speed of conduction of nerve impulses, the movement is not susceptible of correction in progress and is fully programmed at the level of central nervous system , with the open loop motor control model (Schmidt). Errors can be recorded for possible use in the next run.

The cognitive theory of motor learning is derived directly from the integration of open loop model and closed loop model in a synthesis commonly accepted known as generalized motor program.

Learning movements is to develop cognitive structures, by information processing, definitions of motor programs, selection of programs with monitoring actions. These processes allow to compare in real time (closed loop) or later (open loop) results and expected results, triggering a process of continuous adjustment and refinement of movement and, ultimately, of the motor program itself.

The generalized motor program "is a motor program that defines a model (pattern) motion, this flexibility allows you to adapt it so as to produce variations of the motor pattern adapted to the changed demands of the environment" (Schmidt & Wrisberg, 2008). Its structure is such that allows the performer to adjust the movement in order to deal with the changing needs of the environment.

The teaching model that follows cognitive approach is, therefore, a prescriptive model , that is to give precise rules to student athlete with practice mode to stabilize and improve the motor program to achieve the highest possible performance: breaking down the variability of execution up to cancel to achieve technical perfection. Obviously, in order to acquire the learning motor according to the vision of cognitive psychology have been tried a huge amount of educational practices that have produced results on the strategies and techniques for structuring exercises to achieve optimal learning.

The ecological approach, instead, does not consider it necessary to use prescriptive mental structures: the action is directly available for those who act in their own environment. In other words, the system sensorimotor possesses properties of self-organization which does not necessitate the use of a motor program. In the ecological approach, the central nervous system is not regulated by specific laws, but it developed from the environmental influences on the neuronal groups that specialize on specific tasks. (Edelman, Tononi, & Ferraresi, 1995).

In this approach, learning is defined as an education of attention (Gibson, 1986) to make the body in close relation with the environment. The perception assumes a particular importance and gives meaning to the implementation of the action, acting on the mechanisms of motor learning. Learning involves optimizing the processes of perception and develop the ability to select appropriate stimuli for an immediate effect on motor behavior.

In the two approaches presented, the perception of the context is different and different is the definition of the learning process. In the first case of stabilizing a motor program effective in function of information processing. In the other, is a question of the adaptability of the motion by coupling the diversity of the environment and the specificity of the individual (Carnus).

The direct consequence of cognitive theory to learning applications is a prescriptive approach. If learning movements means structuring motor programs increasingly articulated and optimizing parameters, the result is a prescriptive teaching of motor activities, which consists in prescribing exercise to the student how to stabilize motor programs and minimize execution variability. On this basis, was developed huge amount of results on the strategies and techniques for structuring exercise to achieve optimal learning outcomes.

By contrast, in ecological approach, practice does not mean repeating the same solution to a given task, but stimulate the emergence of spontaneous solutions (heuristics) to motor problems, then leverage the execution variability, that is to implement a process of finding solutions motor that passes through the continuous variation of motor gestures.

According to the ecological approach, learning means being able to gradually find the best solution to a given motor task in a given context. A prime example is the expression coined by Bernstein (Bernshteĭn, 1967), "repetition without repetition": practice does not mean repeating the same solution to a given task, but repeating over and over again the process of solution of the task. If learning movements means optimizing the process of solving motor tasks, educational implications are different from those prescriptive of the cognitive approach:

The teacher should assist the student in finding autonomous solutions. If the learning task is too complex, teacher does not have to impose constraints to learner to simplify the motor execution, but he must apply constraints to the environment. The precondition for any effective strategy for facilitating learning is that the unitary perception / action structure, postulated in the ecological approach, is not altered.

3. Conclusion

On the basis of the above, knowledge of psychological models of movement is a necessary basis for the design and development of exergames intended for teaching of motor activities.
The next challenge for designers is the development of exergames oriented to the learning of motor skills, developed with reference to a scientific tradition, in order to achieving effective and efficient tools for teachers and trainers.

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