Journal of Experimental Child Psychology 167 (2018) 128–145

Contents lists available at ScienceDirect

Journal of Experimental Child Psychology

journal homepage: www.elsevier.com/locate/jecp

How do we learn to "kill" in volleyball?: The role of working memory capacity and expertise in volleyball motor learning

Elisa Bisagno [a,b,*], Sergio Morra [a]

[a] Department of Education, University of Genoa, 16128 Genova, Italy
[b] PGS Virtus Don Bosco Volley Club, 15067 Novi Ligure, Italy

ARTICLE INFO

Article history:
Received 19 July 2017
Revised 18 October 2017

Keywords:
Motor learning
Volleyball
Expertise
Working memory capacity
Neo-Piagetian theories
Task analysis

ABSTRACT

This study examines young volleyball players' learning of increasingly complex attack gestures. The main purpose of the study was to examine the predictive role of a cognitive variable, working memory capacity (or "M capacity"), in the acquisition and development of motor skills in a structured sport. Pascual-Leone's theory of constructive operators (TCO) was used as a framework; it defines working memory capacity as the maximum number of schemes that can be simultaneously activated by attentional resources. The role of expertise in motor learning was also considered. The expertise of each athlete was assessed in terms of years of practice and number of training sessions per week. The participants were 120 volleyball players, aged between 6 and 26 years, who performed both working memory tests and practical tests of volleyball involving the execution of the "third touch" by means of technical gestures of varying difficulty. We proposed a task analysis of these different gestures framed within the TCO. The results pointed to a very clear dissociation. On the one hand, M capacity was the best predictor of correct motor performance, and a specific capacity threshold was found for learning each attack gesture. On the other hand, experience was the key for the precision of the athletic gestures. This evidence could underline the existence of two different cognitive mechanisms in motor learning. The first one,

* Corresponding author at: Department of Education, University of Genoa, 16128 Genova, Italy.
E-mail address: elisa.bisagno@libero.it (E. Bisagno).

https://doi.org/10.1016/j.jecp.2017.10.008

relying on attentional resources, is required to learn a gesture. The second one, based on repeated experience, leads to its automatization.

Introduction

It is, by now, well established that sport and cognitive activity are highly interconnected: Diamond (2000) underlined the link between cognitive and motor development because when the first is affected (e.g., due to a neurodegenerative disorder), the second is also affected. Ellemberg and St-Louis-Deschênes (2010) compared the effect on cognitive performance of 30 min of aerobic exercise with the same time spent watching television, finding that even a single session of aerobic exercise is able to produce a significant, although not permanent, improvement in cognitive performance. Similar results were reported by Pesce, Crova, Cereatti, Casella, and Bellucci (2009) and by Davranche, Hall, and McMorris (2009). These and many other studies point to a strong connection between sport and cognitive development, but they study how physical activity affects our cognitive processes, whereas the influence in the opposite direction is still under-researched. Among the studies that examined this relation, those based on Baddeley and Hitch's (1974; see also Baddeley, 2000) model of working memory were mainly interested in identifying a specific subsystem for movement configuration (separate from the visuospatial sketchpad) by using a dual task paradigm (Quinn & Ralston, 1986; Smyth, Pearson, & Pendleton, 1988; Smyth & Pendleton, 1989); however, these first studies used very simple motor tasks and made no hypothesis on the relation between working memory and motor learning. More recently, Seidler, Bo, and Anguera (2012) showed that individual differences in spatial working memory are predictive of the rate of motor learning in both explicit and implicit sequence learning.

From a different perspective, thinking about working memory as a domain-general measure, reflecting an individual's ability to control attention, Engle (2002) suggested that working memory can be important during challenging activities in contexts that are "rich in distractors" such as sports. Behmer and Fournier (2014) suggested that neural efficiency during a new motor task is influenced by individual differences in working memory capacity, or "M capacity," assessed with the operation span. Pertaining to focusing attention and avoiding distraction, Furley and Memmert (2012) observed that basketball players with higher working memory are better at decision making, inhibiting irrelevant auditory information, and adapting their tactical decisions in a task involving videos of complex game situations.

All of these studies suggest that working memory plays an important role in facilitating motor learning and improving tactical decision making. In this study, we examined how children's and adolescents' ability in a structured sport, volleyball, is affected by working memory.

However, it is also clear that expertise—that is, the experience and amount of time that an athlete has spent practicing his or her sport—is involved in the cognitive processes related to sport ability. The role of expertise and automatization has long been recognized in cognitive development (Chi, 1978; Chi, Glaser, & Rees, 1982) and in particular seems to be very important in motor learning. In fact, whereas at the beginning performing a motor task still requires attentional resources, with practice it becomes more and more automated. A classical distinction in physical education and sport science was offered by Fitts (1964; see also Fitts & Posner, 1967), who proposed three phases of motor learning: the cognitive, associative, and autonomous stages. The first phase is characterized by a considerable cognitive load because movements are mainly controlled for in a conscious manner and learners need to use attentional resources in order to perform the correct sequence of movements: in this phase, movements are usually slow and hesitant. The associative phase begins once the athlete has acquired the basic movement pattern and is characterized by more fluent movement adjustments. Because certain motor patterns tend to co-occur, it becomes less effortful to perform them together;