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Article

# Strategy and tactics in sports from an ecological-dynamical-perspective: What is in there for coaches and players?

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**Abstract** – In sports, strategy and tactics play a decisive role. This is certainly so in sport games like volleyball in which the players need to promptly adapt their actions to the continuously changing game situations. In this paper, we will take a closer look at how strategic and tactical decisions come about. Our goal is twofold. First, we want to tackle this discussion from the angle of the ecological-dynamical approach, in which concepts as perception-action coupling, affordances, and self-organization are put forward as vital elements to explain the control of actions/sport skills. In referring to animal behavior, we will push the idea that cognitive interventions are not a prerequisite for strategic and tactical interventions. Second, we want to translate these theoretical concepts into some general guidelines for coaches and practitioners. In doing so, we hope to increase the understanding that for practice the environmental constraints should be embraced in order to improve the strategic and tactical capacities of the players.

**Key words:** tactics, strategy, ecological approach, coaches, perception-action coupling

**Résumé – Stratégie et tactique en sport vus sous l'angle des approches écologique et dynamique : que peuvent en retirer les entraîneurs et les joueurs ?** En sport, stratégie et tactique jouent un rôle primordial. Ce constat est d'autant plus vrai dans les sports collectifs dans lesquels les joueurs doivent en permanence moduler leurs actions face à des situations en constante évolution. Dans cet article, nous nous intéressons à l'origine des décisions stratégiques et tactiques. Notre objectif est double. Tout d'abord, nous souhaitons aborder cette question sous l'angle des approches écologique et dynamique, au sein desquelles les concepts de couplage perception-action, d'affordance et d'auto-organisation occupent une place déterminante afin de rendre compte du contrôle d'une action. En nous référant au comportement des animaux, nous souhaitons promouvoir l'idée selon laquelle des interventions cognitives ne constituent en rien des prérequis à des prises de décision stratégique et/ou tactique. Deuxièmement, nous souhaitons traduire ces concepts généraux en un certain nombre de recommandations à destination des entraîneurs et des pratiquants. Nous espérons par la même occasion souligner l'enjeu lié à la prise en compte des contraintes liées à la tâche, dans une optique d'amélioration des capacités stratégiques et tactiques des joueurs.

**Mots clés :** tactique, stratégie, approche écologique, entraîneurs, couplage perception-action

## 1 Introduction

It is very pleasing to observe that research in sport sciences has been developing at a continuously increasing speed during the last decades. A simple but striking example is the number of hits for the topic Sport in the Web of Science during two distinct periods. While this search revealed 2014 hits for the 1980–1985 period, the number increased to 42 836 hits for the 2010–2015 period. Being aware of the relative nature of these figures – numbers do not necessarily refer to quality and/or impact – it is at least comforting to notice this impressive upsurge of scientific papers related to sports. While these numbers are reassuring, there is still plenty of room for papers that look at these findings from the viewpoint of the "experts" of the sport field, *i.e.*, the coaches. More precisely, we need some reflections on how the current findings and thoughts on high-level performance in sports

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can be put into an intelligible and convenient format for coaches and practitioners. Or, stated differently, the translation of high-quality research, theoretical or applied, into high-quality advice for practice needs more consideration and should also be high on the agenda of the "mixed community of scientists and coaches". Even though this latter pledge for an increased interaction between coaches and scientists is not new (see for example, Greenwood, Davids, & Renshaw, 2014; Memmert, 2010; Raab, Gula, & Gigerenzer, 2012), it remains a major concern.

The goal of this paper is to take up this challenge for a crucial aspect of elite performance in sport, namely the issues of strategy and tactics. Before entering into this debate, we want to further demarcate and prepare the playing field by choosing the ecological-dynamical approach as the theoretical framework that will nourish the essence of our discourse. The choice for the ecological-dynamical approach is not only the logical continuation of our extensive research into this framework, but also linked to our ambition to challenge the idea that tactics and strategy in sports are entirely based on cognitive interventions. Note that we do not dismiss inferential and indirect cognitive processes when talking about strategy and tactics in sports. Yet, the aim of this paper is to push the ecological-dynamical approach to its limits as an alternative explanation for the strategic and tactical behavior demonstrated by the players on the court. We are certainly aware that players can and will use cognitive interventions to cope with specific situations during the game. However, the question is whether these interventions are actually the best solution for every situation or can be substituted by what Ibáñez-Gijón *et al.* (2017) labeled as task-specific smart devices.

Our approach seems particularly valid given the recent theoretical and experimental developments that try to explain tactical behavior from the viewpoint of the ecological-dynamical approach (*e.g.*, Araújo, Davids, & Hristovski, 2006). In contrast to the information processing theory, with its representational anchoring, this approach stresses the importance of both the intimate relationship between actor and environment and the self-organization capacity of the human movement system as crucial elements in the organization and control of human behavior. The viability of this theoretical concept has been acknowledged in a vast number of publications, both from a theoretical (Davids, Handford, & Williams, 1994; Van Gelder & Port, 1995) as from an experimental standpoint. These experiments were not limited to situations in which players had to perform technical skills (*e.g.*, Montagne, Laurent, Durey, & Bootsma, 1999; Temprado, Della-Grasta, Farrell, & Laurent, 1997; van der Kamp, Savelsbergh, & Smeets, 1997) but, especially in the last decade or so, also touched upon the issue of tactics (*e.g.*, Bourbousson, Sève, & McGarry, 2010a, b; Duarte, *et al.*, 2010).

To start our discussion, we will examine the concepts of strategy and tactics from the viewpoint of the coach. In this second section, we will explain both concepts and also provide a categorization of sports, as different types of sport (*e.g.*, individual *vs.* team sports) engender considerable effects on the strategic and tactical options available to the coaches, athletes, and players. In the third section, we will take a close look at strategic and tactical behavior in the animal kingdom, as animal behavior provides a great illustration of lawful tactical behavior. Given the resemblance of the impressive hunting behavior of spiders or packs of wolves with the attack patterns observed in sports, a short excursion into the world of the quadrupeds and arachnids will be more than informative. Where appropriate we will link this behavior to actual situations in sports. The fourth section focuses on the symbolic and lawful theories of action and elucidates the difference between the cognitivist and the ecological-dynamical approach. In focusing on the latter one we will explain in a concise way how skilled performance is the result of an intimate interplay between an actor (the player) and the environment (here amongst others: the dimensions of the field, the teammates, the ball, the crowd, and the referees) and how the self-organization capacity of the movement system shapes the actions of the players/athletes. In the fifth section, we elucidate how this ecological-dynamical framework can shape strategic and tactical behavior in sports. To do so, we will provide an overview of the most relevant experiments and studies that tried to explain decision making in sports from within this framework. We will also draw on the concept of affordances to explain how choices between tactical options emerge.

In the sixth section, the strategic and tactical behavior will be positioned into the perspective of the scale-based approach proposed by Ibáñez-Gijón *et al.* (2017). In developing a top down "task-related" logic, we will show how the overall strategy constrains the tactical engagements. To anticipate our argument, the crucial difference between the notions of strategy and tactics presented in this section is that the constraints for the control of tactical behavior are lawfully specified in the ambient energy arrays, whereas the constraints for the control of strategic behavior are not lawfully specified. Strategy requires additional knowledge about the structure of tactical engagements and their outcomes. In addition, strategy is also modulated by situational probabilities, that is, the contextual factors that may affect the outcome of a match. Therefore, strategic constraints cannot be directly perceived. They are, however, operationally efficient: they are useful to modulate the outcome of a match. In sum, we propose that, in addition to the available information, elements like statistical knowledge of the task, learning and inheritance are required to specify the environmental constraints for strategic behavior. The final section will be devoted to the perspective of the coach and touch upon a number of issues that could facilitate the implementation of the theoretical framework into a practical setting. As far as this later issue is concerned, we want to refer to the common knowledge among coaches and practitioners that a thorough knowledge of the specific sport is a prerequisite to make sound conclusions about the underlying processes (Thomas, French, & Humphries, 1986). One could contest this point of view as it appears to deny the value of more generic processes in controlling movements and hence sport skills (for a recent review on the organization and control of skilled movements see, Ibáñez-Gijón, *et al.*, 2017), a viewpoint we agree upon. Therefore, the best formula for success seems to be a combination of specialized knowledge of the sport discipline and an extensive knowledge of the scientific field of study. So, even though this framework is applicable to the different sport disciplines, we will try to bridge the gap between theory and practice by using some volleyball examples as one of the authors has been involved in elite volleyball coaching for more than 15 years.

## 2 Strategy and tactics from the perspective of the coach

When asked about the importance of strategy and tactics for team sports, the answers of trainers and coaches appear to be univocal and clear. Strategy and tactics are crucial to the game as they define the intentions of the players and set the boundaries that define the defensive and offensive actions of the player. So, given the huge impact of strategy and tactics on the game we want to take a closer look at these concepts.

Strategy and tactics both relate to the different options players have at their disposal to be successful in the offensive and/or defensive aspects of the game. The actual decisions that emerge from these options become visible in the specific performance of the players and teams on the court. As both tactics and strategy refer to the same underlying process, *i.e.*, choosing among options, the difference between both concepts need to be located elsewhere. Lopes & Casey (1994) provided an elegant verification of this divergence in a study entitled "Tactical and strategic responsiveness in a risk-taking task". The authors concluded that the difference between strategy and tactics is merely a matter of "time". While strategy appears to be linked to a long-term perspective, tactics represent the short-term adaptation required by the developing situation. This fits well with the claim of Gréhaigne, Godbout, & Bouthier (1999) who state that "*tactics operate under strong time constraints, while strategy is associated with decisions based on reflections without time constraints*" (p. 166). These observations fit well with the idea that strategy is a broader concept and provides the framework that modulates the actual tactical behavior. We will come back to this issue more extensively in Sections 3 and 6.

It is interesting to examine how tactics appear in different sports, as the nature of the specific sport disciplines confines the type of decisions players or athletes can make during a game. This is obvious when we compare for example sports like golf and soccer. While the latter is characterized by specific spatial (the size of the court is clearly stipulated) and temporal ($2 \times 45$ minutes) dimensions imposed on two teams of 11 players engaged in a contact game, the former is in essence an individual activity played on golf courses that vary significantly as far as the layout of its 18 holes is concerned. So, even though tactical decisions may touch upon the same processes, they color very differently, as the constraints the players are confronted with (*e.g.*, time pressure, nature of the playing field, and physical interaction of the competitors) demand very specific tactical moves.

For this reason, it is worthwhile to take a closer look at these constraints and try to classify the different sports accordingly. Even though only very few studies tackled this problem, there have been some attempts to label different sports disciplines based on one or another principle. One of the best-known classifications is certainly the distinction between open and closed skills (Poulton, 1957), in which the absence or presence of environmental stability during the execution of the skill is the decisive criterion. In this line of thinking, volleyball would be an open skill (the environmental information – *i.e.*, teammates, adversaries, and the ball – changes continuously), while gymnastics would be classified as a closed skill (specific movements are executed in a stable environment). Even though tactical behavior plays a role in both types of sport skills, it is obvious that the high environmental variability broadens tactical options of players and coaches involved in open sport skills. This open *vs.* closed sport skills classification has proven to be valuable as it provided a sound basis to analyze specific characteristics of players for different sport disciplines (*e.g.*, Wang, *et al.*, 2013) but even more so as a study by Farrow, Pyne, & Gabbett (2008, p. 489) showed that "there was a significantly larger volume of game-like decisions required of the participants in all open drills". This adds to our claim that tactical and strategic elements have a higher impact in sport skills that thrive in open skills.

In addition to the open *vs.* closed distinction, other classification criteria were also used. For example, Thomas, French, & Humphries (1986, p. 267) made a distinction between *discrete* and *continuous* sports. While they defined the former as "*sports that have a pause between the subsequent game actions (e.g., golf or baseball) continuous sports (e.g., soccer or basketball) are less prone to breaks during the game*". According to the authors, this difference affects the decision making process as preplanning each action is possible in the discrete sports, but not so in continuous sports. Other classifications were inspired by cardiac adaptation to the specific category of sports (*e.g.*, Luijkx, *et al.*, 2012; Mitchell, Haskell, & Raven, 1994; Mitchell, Haskell, Snell, & Van Camp 2005) or by their individual *vs.* team format, invasive *vs.* non-invasive character, and time-limited *vs.* point-limited nature.

Being as it may, defining concepts or classifying sports is one thing, explaining how decision-making takes place is more complicated. In the next paragraphs, we will take a closer look at the tactical behavior of animals. Looking into animal behavior to explain decision-making in the context of sports might seem a little awkward. However, animal behavior provides a great illustration of how tactical behavior can emerge from the lawful interplay between operating constraints.

## 3 Strategy and tactics in animals

Apparent or not, tactical behavior is omnipresent in the animal world, as the following examples will highlight. Take for example the *Portia*, a genus of jumping spiders, and a predator that hunts for other spiders. The hunting behavior of these miniscule creatures with even smaller brains is quite amazing as it is characterized by the deployment of an impressive repertoire of hunting tactics (Jackson & Wilcox, 1998). These spiders invade the webs of other spiders using mimicry, deception, and even detours to capture their prey. For example, when confronted with a species for which *Portia* has no preprogrammed tactic, it produces a variety of web signals to simulate a small insect trapped in the web. If one of these signals makes the other spider approach, *Portia* continues producing only this latter signal to lure in its prey. According to these authors, these spiders show an astonishing illustration of "*how a brain so small orchestrates such complex and flexible behavior*" (p. 357).

Given the tactical competence of spiders, it is predictable that a similar flexibility and adaptability must be present in animals with more complex nervous systems. These actions range from selection of vulnerable prey (Cresswell & Quinn, 2004), adaptations of herd size in the vicinity of wolves (Creel & Winnie, 2005), to the use of perfect synchrony and communication observed when killer whales attack seals (Nøttestad, Ferno, & Axelsen, 2002). These and a score of other examples from the animal kingdom (for some intriguing examples see also, Ford, *et al.*, 2005; Harland & Jackson, 2006) illustrate the tactical ingenuity of animals. The previous observations suggest that tactical decisions in sports might be much more driven by environmental constraints, and not defined by cognitive interventions, as some coaches might like to believe.

With respect to strategic behavior, examples in the natural world also abound both in individual and collective behavior. A significant part of ethology is concerned with the study of evolutionary stable strategies (Smith & Price, 1973) in mating, parental care, space occupation, foraging, etc. In this perspective, search behavior is a very active area of research within the discipline of movement ecology that focuses on the tradeoffs that constrain the behavioral strategies found in nature (Bartumeus, *et al.*, 2016). All these situations can be described as strategic behavior because there is not enough current information available to fully specify the environmental constrains that should guide the actions, and therefore additional means to specify them are required, be it by means of learning or inheritance.

For example, Penteriani *et al.* (2013) compared the patterns and rhythms of activity of two predators (the lynx and the red fox) and their shared prey (the rabbit) during the different moon cycles. As expected, the hunting behavior followed the moon phases, since the prey reduced their night activity near the full moon (high visibility) as the risk of predators being on route increased. In contrast, foxes appeared to prefer darker nights to avoid the top predator who are less active during these periods. So, foxes time their hunting excursions in such a way that the risk of a lynx encounter was reduced.

In spite of these fascinating examples, the question still remains how tactical and strategic behavior emerges. In the case of tactical behavior Bell, Bell, Schank, & Pellis (2015) took up the challenge as they examined the defensive moves of pairs of rats that competed for a piece of food. Actually, one of the rats was in possession of the food while the other tried to rob it. The spatial trajectories of the rats were monitored as well as the dodging moves produced by the rat that was in possession of the food. The results show that the defensive moves in reaction to the attack of the robbing animal were not the result of the activation of stereotypic motor programs. In contrast, the "tactical" solution was just a simple sensorimotor rule of gaining and maintaining a particular inter-animal distance, by matching its movements to that of the robber (Bell, *et al.*, 2015, p. 277). So the defensive maneuver does not need to be specified as a motor pattern with determined properties. Similar observations were made for other species (Bell, Johnson, Judge, Cade, & Pellis, 2012), even though different sensory rules appeared to be used to shape the defensive movement.

The inter-personal distance has been also shown to mediate the tactical moves of opposing players in sports. This is the case in soccer, in which the players very often operate as dyads representing an offensive player in possession of the ball and a defensive player trying to recover the ball. For example, Duarte *et al.* (2010) revealed that relative velocity became a critical factor at specific values of interpersonal distances, implying that attackers need to accelerate their movements when they are close enough to the defender. Even though coaches would reckon this observation to their common knowledge, the results of this and studies on dyads in for example rugby (Passos, *et al.*, 2008) and basketball (*e.g.*, Bourbousson, *et al.*, 2010a, b) illustrate that tactical moves are better pictured as the perception-action couplings studied by the ecological-dynamical approach. In the next section, we will explain the essentials of this framework starting from the concepts of local and global constraints.

A striking example of the emergence of *strategic behavior* in animals can be found in social termites (see Kugler & Turvey, 1988, for details). Some species periodically construct nests of up to 6 meters of height that weigh more than 10 tons. The construction of such structures involve the active participation of millions of insects in a seemingly coordinated activity. This architectural feat does not require an explicit plan or a central director that blends together their actions. Quite on the contrary, this is an example of emergence of strategy as a distributed process in which the individual insects follow two simple implicit principles: move in the direction of the strongest pheromone gradient and deposit building materials at the point with the highest concentration. Therefore, as the authors put it: "*the constraints that organize the building activity arise in an informational* *pheromone field that is linked to the behavior of the insects through a chemical affinity*" (Kugler & Turvey, 1988, p. 115).

The nest-building process is based in a closed cycle of organizational modes, in which each successive mode is induced at the end of the previous phase (see Figure 13 from Kugler & Turvey, 1988, for details). In the first phase, the insects fly in a random pattern, then it is followed by a pillar construction phase, an arch construction phase, and the cycle finishes with a dome construction phase. Each morphological state of the nest is associated with a qualitatively distinct mode of behavioral organization in the colony. These global morphologies provide a low-dimensional informational description (the pheromone fields) that can be used to constrain a high-dimensional actuator system (*i.e.*, the ants that constitute the colony).

These examples from the animal world provide an essential insight: dealing with symbols and representations is not a necessary condition for tactical and strategic behavior to exist. For natural adaptive systems, an exquisitely fine-tuned interaction with the environment is enough. We turn now to a more theoretical examination of how is it possible to organize complex individual and collective behavior without reliance on symbol systems.

## 4 Symbolic and lawful theories of action

Common sense on the topic of tactic and strategy dictates that decisions is all they are about. Research on decision making is typically related with representational approaches to cognition (see for example, McPherson, 1994; Morgan, Williams, & Barnes, 2013), although some exceptions exist (*e.g.*, Araújo, *et al.*, 2006). The long-standing debate between the adherents of the ecological-dynamical perspective and the cognitivists to explain how movements in general and sport skills in particular are organized has been intense and by times even fierce. While the cognitive interpretation puts the existence of representations and memory structures in the midst of the control process, their opponents regard the human movement system as a self-organizing system that operates in an intimate relationship with the ever-changing environment.

The cognitivist framework positions the brain in the role of a command center that, after gathering information and analyzing the different elements, forwards a specific decision to the muscular system that executes the transmitted movement patterns (for an interesting review on this topic see Williams, Ford, Eccles, & Ward, 2011). This approach had a number of positive effects on coaching and training, as it provided the coaches with a theoretical backbone that could be used to structure and develop specific training programs. A perfect example of how this information processing theory became operational in the field can be found in the variability of practice hypothesis (*e.g.*, Boyce, Coker, & Bunker, 2006; Shea & Kohl, 1990; Hall & Magill, 1995). The rationale is that variation in the parameters of the actions (*e.g.*, speed, distance) will result in a stronger motor schema. As a result, the player will be able to better cope with the variability required by the different game situations.

The ecological-dynamical perspective integrates both the dynamical approach (Bernstein, 1967) and the ecological approach (Gibson, 1986), and intends to unravel how complexity can be simplified by dimensional reduction (Buekers, *et al.*, 2017). Put into plain words, these latter authors state that: "*A limited number of crucial dimensions would suffice (1) to organize the movement itself and (2) to integrate and blend these movements into their environmental context*" (p. 69). In linking this idea of dimensional reduction to the concept of scales, Ibáñez-Gijón *et al.* (2017) took this notion a step further. By distinguishing between a so-called functional scale, operating at the ecological or task level, and an execution scale, comprising the organic elements that participate in the production of functional behavior, the authors suggest that the task itself should be the starting point to study movements and to understand how sport skills are organized.

Synergies and affordances are the two central concepts of the ecological-dynamical approach that cover the abovementioned movement organization and integration. Synergy can be defined as the unitary outcome from the coordinated action of a multitude of elements. Synergies embody the multi-scale dimensional reduction explained above: the multiple elements at the smaller scale behave coherently and bring about a unit of action at the emergent scale in which the collective system operates. In the context of the discussion about tactics and strategy developed here, the nest-building example provides a great illustration of these concepts. The plurality of termites of the nest are the elements at the micro scale, whereas the colony itself is the emergent system at the macro scale that is produced by the coordinated action of the termites. Both the macro and the micro scales constraint each other in a loop of circular causality that defines the synergy itself. The micro scale can be analyzed as the mechanistic level of operation of the system, whereas the macro scale is better understood as the functional level of operation of the system.

Affordances are the objects of perception in the ecological approach proposed by Gibson (1977) in his theory of direct perception. They are functional descriptions of the environment from the perspective of the agent, that is, the opportunities for action in the environment. Therefore, the actions of an agent are not the mere physical displacements of the body or parts of it. Actions must be understood with respect to the layout of affordances, because action systems are organized so as to yield specific environmental effects that are functionally relevant for the agent (Ibáñez-Gijón, *et al.*, 2017, p. 291). In this sense, the functional scale in which affordances operate (the so-called ecological scale) constitute the macroscopic emergent scale of goal-directed behavior that constrains the degrees of freedom of the elements that interact at microscopic scales.

In the study of intentional behavior, the microscopic scale can be composed of multiple kinds of elements in interaction (limbs, joints, muscles, nerves, termites, etc.) depending on the system under study and the focus of interest of the researchers. To simplify the choice of functional and mechanistic scales, we proposed a generalized notion of task as the set of goals relevant to account for the behavior of the system under study (Ibáñez-Gijón, *et al.*, 2017). The goals that define a task (together with the action capabilities of the agents) would in turn specify the layout of affordances of the environment relevant for the intentional agent. The agent can detect and act upon these affordances due to the very intimate coupling of perception and action proposed in the ecological approach, as we illustrate below through examples from the domain of sports.

Studies on ball catching provide an elegant example of how perception-action loops actually work. In a nutshell, the idea is that specific higher order variables, also called invariants, exist in the dynamic environmental information (the perceptual flow) that can be directly linked to the control of actions (information-based control, Ibáñez-Gijón, Díaz, Lobo, & Jacobs, 2013). By tuning into these invariants through smart perceptual devices (Ibáñez-Gijón, *et al.*, 2017), the player or athlete can change his/her actions and make the necessary adaptations to be successful in the task. In the case of ball catching the invariant appeared to be the optical vertical acceleration of the ball, in such a way that the continuous cancellation of this acceleration would eventually position the player in the exact location to capture the ball (McBeath, Shaffer, & Kaiser, 1995; McLeod, Reed, & Dienes, 2006). Actually, this process is circular in nature as the dynamic information of the ball trajectory provides the regulatory power to rightly adjust the movements, while the actions of the player have an effect on the dynamics of the information as perceived by the player.

After this summary of the two main theoretical frameworks that focus on the explanation of human action in general, we will explore in the next section to what extent the ecological-dynamical approach has been used to investigate and explain the organization of tactical behavior.

## 5 Tactics from an ecological-dynamical perspective

As mentioned before, the purpose of this review is to primarily focus on the tactical and strategic domain to explore to what degree this important aspect of elite sports can be unraveled and explained using the ecological-dynamical approach as a starting point. More specifically, we aim to extend previous work by Ibáñez-Gijón *et al.* (2017) and Buekers *et al.* (2017) and investigate to what extent the processes commonly referred to as decision-making can be understood without having to rely on the symbolic conventions and the information-processing metaphors proposed by the cognitivist approach. Rather, we aim to explain behavior as the interplay of a multitude of constraints that operate and interact at different levels (*e.g.*, the task, the movement of the limbs, the position of team members and the opposing players), or, as put forward by Duchon, Kaelbling, & Warren (1998): "The strategy [of the ecological approach] is to push natural law as far as possible into cognition, thus placing more constraints on the cognitive system".

Therefore, an ecological-dynamical approach to tactics in sports rejects the representational notions of internal models and motor commands explained in Section 4. In contrast, it defines tactics as behavioral settings characterized by the set of prevailing affordances or action possibilities to achieve the tactical goals. These tactical behavioral settings are specific engagements between the opponents and teammates, in which there is information here and now to specify the dynamic layout of affordances prevailing in each tactical setting.

Even though the ecological-dynamical approach already has a long tradition in explaining how complex movements and sport skills are organized and executed, it took a considerable longer time before the approach took up the challenge to try and demonstrate its relevance for explaining the emergence of tactical skills. Perhaps, the savor of cognition that entrenched itself into this "field of decision-making" deferred the attention for this topic. In spite of, or maybe just because of this challenge, a number of research groups started to look into this tactics issue. In the following paragraphs, we will discuss this literature and investigate to what extent these studies provide a more profound insight into how tactical behavior emerges.

As far as the practicality of the approach for coaches and trainers is concerned, Buekers, Montagne, & Laurent (1999) already touched upon this valuable issue at the end of the previous century in their paper entitled "Is the player in control, or is the control somewhere out of the player". A crucial step forward to orient the focus of attention on the issue of tactics was made almost 10 years later by Araújo *et al.* (2006, 2009) as they entered into a strong theoretical debate on "The ecological approaches to cognition and action in sport and exercise" arguing that "One should not only ask what to do, but also where to do it". The underlying message expressed by the titles of both papers reveals the crucial role of the environment in structuring the specific motor actions or sport skills. This latter paper resulted in a number of studies, primarily from Araújo, Davids *et al.* (*e.g.*, Araújo, *et al.*, 2015; Duarte, *et al.*, 2010, 2012; Passos, *et al.*, 2008). As we will describe in the next paragraphs, these studies covered different disciplines both from individual (sailing) and team sports (*e.g.*, rugby, soccer).

In the Duarte *et al.* (2010) paper, the authors investigated the ecological dynamics of one *versus* one phases in association football. Youngsters executed different condition of 1-vs-1 situations in which the offense player had to try to pass the defense player. From the position and velocity data of both players (obtained *via* video analysis), the interpersonal distance of the players and their relative velocity were calculated that served as the control parameters of this offense-defense interaction. The data showed an increase in relative velocity (attack player outrunning the defense player) when the interpersonal distance was lowering. So getting closer to the defense player followed by a swift acceleration appears to be characteristic for successful passing. Even though this finding is far from breathtaking, since most coaches and players will argue that this tactical behavior is already in place for many years, it is interesting to notice that the interaction of players can be correctly described as the operation of the interdependent dynamics of two players.

In a follow-up study, Duarte *et al.* (2012) took this issue a step further arguing that taking a closer look at the interpersonal coordination patterns could uncover the tactical preferences of players involved in 1-vs-1 situations. More specifically, they examined to what extent the outcome of the interaction, *i.e.*, success in offense or success in defense was characterized by specific dynamics in the interpersonal coordination. As expected, the coordination patterns differed according to the role of the players. While attackers were successful when they could destabilize the defense player by sudden changes in the interpersonal coordination (*e.g.*, unexpected acceleration), defensive success was achieved when a lead-lag relation was imposed (pressing the attacker into specific zones). Notice that the authors also took up the challenge to translate these findings into some useful recommendations for practice. We will come back to this issue of practical implications in the last section of this paper.

The search for explaining tactical maneuvers as the expression of interpersonal coordination dynamics was not limited to soccer, as this phenomenon was also investigated in other team sports like basketball (Bourbousson *et al.*, 2010a, b) and rugby (Passos, *et al.*, 2008), as well as in individual sports like sailing (Araújo, *et al.*, 2015). For example, the results of this latter study showed that the positions of the racing boats were dynamically coupled during pre-start, resulting in the emergence of "tactical" behavior as a function of the continuous interaction with the competitors and other environmental constraints.

In spite of its importance for tactical decisions, the concept of affordances has only been exploited to a limited extent as far as tactical behavior in sports is concerned. Hettinga, Konings, & Pepping (2017) took up the challenge as they revealed that the pacing behavior in time-trials are mediated by the social affordances presented by their opponents. Therefore, the regulation of exercise intensity in head-to-head competition appeared to be the result of a strong athlete-environment relationship. Or as put by the authors, "*the opponents present a multitude of affordances that influence motivation, attentional focus (perception), the ability to tolerate fatigue and pain, positioning, drafting, falls risk and collective behaviour*" Hettinga *et al.* (2017, p. 5). Thus, even though the inner state of the athlete is of utmost importance, the environment will also act as a very powerful player.

So whatever the discipline, the intimate relationship between the actor and his/her environment defined how specific circumstances gave rise to specific tactical decision by the athlete/player. This observation is in line with the argument of Duarte *et al.* (2012, p. 876) that "*differing results can be attributed to the different nature of the task constraints*". In other words, the "playing field" of the distinct disciplines engenders the emergence of particular tactical behavior, corroborating the argument that a thorough knowledge of this playing field is a prerequisite for success.

## 6 A scale-based approach for strategy and tactics in sports

The scale-based approach to movement control thrives on the assumption that the task and the goals that define it are the epicenter from which the organization and execution of sport skills develop. Therefore, whatever the discipline one touches upon, the task (*i.e.*, the ecological scale) has to be the starting point for understanding how the complex game situations emerge on the playing field. This is also the case for strategic and tactical decisions. Before we develop this idea any further, it is important to point out that the task in sports can be situated at different operational levels of which the strategic level and the individual tactical level are the two opposing ends of a continuum (see Sect. 2). In between these two levels, intermediate levels can take form in which a limited number of team members are involved in the construction of specific game patterns.

For example, in volleyball, the organization of the attack patterns is regulated by the setter and involves at least two and mostly four other players. In the same vein, the organization of the block is in the hands of one designated player (often the middle blocker) who coordinates the position play of the other blockers. This intermediate level of tactical behavior, which we can label multiplayer tactics, encompasses the integration of the tactical maneuvers of more than one player. Note that the strategic level is supposed to take the lead in this chain of decisions, while the intermediate level is nested in the strategic level and the individual tactical level is on its turn nested into the intermediate level.

Taking the abovementioned reasoning a step further, we can consider decision-making in sports as a complex system where the strategic level constrains the space of possibilities within which tactical decisions take form. The embedding of these tactical decisions within this complex system can be situated at different execution levels (team, group, individual). This idea parallels the notions developed in the scale-based approach to expertise by Ibáñez-Gijón *et al.* (2017) in which the ecological scale and the underlying organic scale are the constituting elements of complex systems.

After laying out the general framework of the scale-based approach to tactics and strategy, we turn now to define in more detail what counts as strategic and tactical goals, and how they are to be related at the unifying ecological scale. The scale-based approach considers as starting point that to analyze a certain process we must first understand the relevant task that we want to study. It is this higher-level task that will set the global constraints that define the possible evolutions of the system. As detailed in Ibáñez-Gijón *et al.* (2017), a task is defined by its goals, regardless of the level of abstraction required to express such goals. The goals of a task establish a set of constraints on the possible evolution at the ecological scale. For example, the goal of a volleyball match is to try and hit the ball into the court of the adversary according to the set of rules of volleyball, in such a way that the opponent team cannot return the ball. Moreover, they need to repeat this process such that they win three sets with at least two points of difference. For a basketball match, the description would be to introduce the ball through the rim according to the set of rules of basketball. To win the game, they need to score more points than the opponent team after 4 periods of 10 minutes playing time.

In the previous section, we defined tactics from an ecological perspective as behavioral settings determined by a certain set of prevailing affordances or action possibilities to achieve the tactical goals. To reiterate this important notion, these tactical behavioral settings are specific engagements between the opponents and teammates, in which there is information here and now to specify the dynamic layout of affordances prevailing in each tactical setting. These complex systems of engagements are the immediate result of the tactical goals and the elements in interaction.

In a similar way, strategies are defined with respect to their goals. Compared to tactical goals, the strategic goals are typically effective at longer spatiotemporal scales, and can include processes far beyond the immediate engagements of a game. They are usually established using extensive knowledge of the rules of the game, the typical engagements that these rules bring about, but also about the recent history and current competitive state of both teams and their players. Therefore, the same definition of its goals clearly locates strategy far from the scale of the here and now that define the tactical engagements, acting as a global constraint on the actual dynamics of a match. As a consequence, there is not enough information to lawfully specify the relevant properties of the strategic constraints in the dynamic engagements of a match. To better understand from a lawful perspective how strategies constraint tactical engagements, we turn now to a discussion about the ecological notion of information, and how to apply it to account for the tactical and strategic dimensions of sports.

In the ecological approach, the notion of information indicates properties of the animal-environment system that are not actively constructed by the organisms, but merely detected and used to control actions. This appears to be in contradiction with the active role that players have in a match, but we think that there is simply a semantic problem here, and not an intrinsic limitation of the ecological approach. In essence, players do not create new information, as the information was already present in the environment. However, players do have an active role in the process (*e.g.*, the search for invariants) as they can actively use current and prospective information to purposefully make the engagement evolve in such a way as to make it more favorable for their tactical goals. The information-guided evolution of the engagements can certainly produce situations in which different information becomes relevant to specify how to control newly available actions and can also improve the detection of an already relevant information.

In a similar vein, we can reconsider the issue of the non-specifying conditions for the strategic constraints in a reverse sense. What we mean is that the strategy of a team can be understood from a lawful theory of action as extraordinary constraints that (attempt to) produce game engagements that are tactically more favorable to achieve their own strategic goals. Just as players can act in an engagement to make it evolve in a way that is more favorable to its tactical goals, strategy sets the conditions for different engagements to appear.

As mentioned, both tactical and strategic settings can be put in place using explicit commands from the coach to the players. These explicit (usually linguistic) commands try to condense all the knowledge about the sport and the game of the coach, including the best ways to win a specific match. There is, however, an alternative way to embed strategic constraints in a team or individual behavior that does not require all the cognitive burden of dealing with explicit context-dependent rules. Just as termites are able to cooperate through local interactions with a globally determined chemical field to obtain a goal that overarches them, and creates a new scale of interaction: the colony. In a similar vein, the extensive knowledge the coach has about the game and his players enables him/her to promote sets of local interactions that can incarnate a global strategy. In the concluding section that follows, we will try to illustrate this in providing some examples of how coaches can benefit from a lawful perspective rather than relying on symbolic instructions.

## 7 Wrap-up: what coaches can learn from nature, and what scientists can learn from coaches

The objective of the present paper was not only to provide an original approach to the understanding of strategy and tactics in sports. We also want to illustrate how these new insights can be translated to the actual coaching and training practice.

The major consequence for practice of the insights gained from the ecological approach for tactics and strategy appears to lie in the presumption that *the training of strategy and tactics should not be reductionist in nature, i.e., a coach assigning an overall system of (symbolic) barriers of actions to the players, but engender the exploration of action possibilities within a given context.* In the next few paragraphs, we will elucidate these assumptions and add some validity to it by means of some personal coaching experiences from the field.

We will focus first on the training of strategy. The question is whether the apprehension of the strategic elements of the game is merely a matter of following the overall guidelines from the coach meticulously, or if the players dispose of a certain degree of freedom in discovering the strategic options of the game. The usual way to translate the strategic options defined by the coach to the players is through explaining a general game plan. For example in volleyball[1] practice the serve receive organization is of utmost importance, and can and should be conceived before the game and even the season starts. We have been anchored to this approach for many years ourselves, feeling comfortable with the idea that most of the elements that could influence the outcome of the serve receive were incorporated in the strategic game plan. Actually this approach proved to be successful in many cases, as it helped the players to get a shared and common conception of the goals that had to be met, the organization that underpinned these goals and the specific assignments that could lead to a successful performance. In other words, the game plan gave the players a solid grip on the match. In spite of the obvious profit such a plan can provide, there are some caveats hidden in a straightforward implementation of such an approach. As long as players can cope with the pressure (*e.g.*, hostile fans, away game, importance of the game), all goes well. However, when pressure is increasing players tend to forget the basic elements of the game plan, and as a consequence loose track of the game. Of course, stress resistance is linked to the performance level of the players, the elite players being able to show a much higher coping behavior. Yet even for these players the breakdown of so-called highly stable game plans can be observed, just remember the devastating performance of the Brazilian soccer team against Germany during the finale of the World Cup 2016 in Brazil. The question then arises how to prepare the players to overcome this problem. The first reaction would be to follow the psychological trail and increase the coping level. Without minimizing the usefulness of this solution, we propose a complementary approach in which the players should be actively engaged in finding solutions at the strategic level. This can be achieved by designing game situations in which the tight organization is set aside and the players can freely explore the available game options. For example, the strict serve-reception organization with designated positions for each of the three players can be broken giving the players the opportunity to exploit different serve receive organizations. Note that this approach is closely related to the concepts of the Teaching Games for Understanding (TGfU) of Bunker & Thorpe (1982), and to the processes of direct learning in the ecological approach (Ibáñez-Gijón, Travieso, & Jacobs, 2011; Jacobs & Michaels, 2007).

The second issue relates to the training of tactics. As we discussed in the previous sections, the overall constraints defined by the strategy engender specific types of engagements of the players during the game. For example, when the strategy entails a serve receive organization with three players, in which one of the players is the designated receiver, the spatial coverage of the players is asymmetrical. During the game, the communication, in principal led by the designated receiver, within this triad is of utmost importance to perform successfully. To prepare the players for this task, practice sessions should be organized in such a way that the players who are involved can exploit the different spaces and act accordingly. One of the organizing principles that we used for serve reception is to make the players only responsible for balls that are directed straight at them or to their left side. The task of the designated receiver is to define the width of the different spaces to arrive at the highest success level. The decision to adapt the spatial serve receive contours is guided by the constraints set by the player serving the ball. At the individual level, the decision to move to a particular position at the court can be explained in terms of the mechanisms of the perception-action cycle (see Sect. 3).

To conclude, it appears that, for the coach, practice in the decision-making area is a matter of defining constraints. The main role of the coach would be to organize his practice sessions such that favorable constraints are elicited as often as possible. In the end, players need to be prepared to handle and take advantage of the many constraints they encounter during a match. However, when reality slips in, game plans and predefined organizations and assignments appear to be necessary. The best coach might be the one who makes the players aware of the constraints and teaches them how to use them during the game.

[1] The example given here is related to team sports in which many players need to cooperate to reach a common goal. Even though the individual sports also require significant strategic planning, the presence of a multitude of players on a court increases the need for a common and shared understanding and acting during the game.

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