Learning in Football: The Role of Nonlinear Pedagogy in Skill Acquisition

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Summary

Based on the dynamical system theory and ecological psychology, in this report we explore the potential of a nonlinear pedagogical framework and his effectiveness to teach football. This was a report essentially conceived for coaches and where we intended to clarify some issues related with the most efficient way to teach football. The report is divided into 7 different chapters and is the result of a long revision of scientific literature. The discussions undertaken throughout the different chapters were always based on scientific evidence that have been produced in the motor learning area over the last years. All the report was based in how players learn and in what we coaches can do in order to promote efficient learning.

During the report we argue that coaches shall consider the development of motor skills as nonlinear, because variability is part of the learning process and people/ players learn in a nonlinear way. The nonlinear pedagogy provides a foundation to explain how game skills might be taught by football coaches. More specifically, the principles of nonlinear pedagogy inform coaches about how to structure their practices, and how to deliver instructions and provide feedback. A nonlinear pedagogy is a teaching method that involves the manipulation of different types of constraints (performer, environment, and task constraints) to make emerge the desired behaviour, and that puts the emphasis on exploratory learning within “gamelike” situations like small-sided and conditioned games.

According to the nonlinear pedagogy, one of the main tasks of the coaches is that they need to identify and adjust key task constraints of small-sided and conditioned games in order to promote the acquisition of specific game skills or tactical behaviour.

The present report highlights also that, in order to promote efficient learning, coaches shall: a) structure their practices in accordance with the principles of task simplification, rather than task decomposition; b) induce with their instructions and feedback an external focus of attention on their players; c) be careful with the amount of feedback provided to their players, because it’s proven that more feedback is not better than less; and d) use guided
discovery as a teaching method, because it presents several advantages when compared with teaching methods based on the prescription of behaviours.
I. Introduction

The present report is a result of a long revision of scientific literature. The work produced over the last years by the research groups of the professors Keith Davids and Duarte Araújo, is the main influence of this report. Among all the insightful papers published by both groups of research, the paper that probably more influenced this report, was a paper published by both, Davids and Araújo, as leading authors and that is entitled “Acquiring Skills in Sport: A Constraint-Led Perspective”. This report is also inspired in the previous work of J. J. Gibson, the father of the ecological psychology, and Karl Newell, the creator of the model of constraints.

Professor Duarte Araújo was my supervisor, while I was doing my PhD in the Faculty of Human Kinetics, in Lisbon. During the execution of my PhD program, I had the opportunity to study in depth many of the issues presented throughout the report, and that is why the revision of literature is so extensive. In fact, during all the report is made a concrete reference in the text to 69 different studies.

The report is divided into 7 different chapters. We begin the report emphasizing the importance of practice on the road to achieve excellence in football. Then, in the chapter 2 we do a brief presentation of the conceptual framework of the report. The chapters 3 and 4 can be seen as an extension of the conceptual framework, but each one of them is dedicated to a specific issue. In that sense, the chapter 3 is dedicated to expose the main features of the nonlinear pedagogy, and the 4th chapter is centred in the model of constraints of Newell. In this chapter we will use the model of Newell to explain how skill acquisition emerge as result of the interaction of different constraints.

The role of variability is investigated in the chapter 5, as well as the role of repetition in football practices. The last 2 chapters will provide many important and concrete practical implications for the coaches. Among other things, in these 2 chapters, the principles of nonlinear pedagogy will inform the coaches.
about how best structure their practices, deliver instructions, provide feedback and design their practices, in order to promote efficient learning.

The main aim of this report is to answer to the following questions of research:

**Main Question:** “Is a nonlinear pedagogy an effective method to teach football?”

Other questions that emerge as a product of the main question. From the learning point of view:

1. “What is the role of variability in skill acquisition?”
2. “What is the best way to structure the football practice?”
3. “What type of focus of attention shall the coaches induce in their players?”
4. “Is more feedback better than less?”
5. “Prescription of movements vs. guided discovery, what is the best method to promote learning?”

All the questions will be answered in accordance with the principles of the nonlinear pedagogy and based on scientific evidence that has been produced in the motor learning area, over the last years.
II. On the Road to the Top: The Importance of Practice

To achieve excellence in any domain, individuals have to spend a considerable amount of time trying to improve performance through practice-related activities (Ericsson, Krampe, & Tesch-Römer, 1993; Howe, Davidson, & Slaboda, 1998). A significant amount of research has been undertaken in recent years to identify the important factors underpinning elite sports performance. This increase in research activity has been particularly evident in football, where the importance of sports science research and applied work is now more accepted (Reilly & Williams, 2003).

Players who are offered full-time employment contracts by English Premier League Academies at the age of 16 years are likely to have devoted more than 10 years to the sport, investing an average of around 15 hours per week, 700 hours per year, and a total of 7000 hours in specific practice activities designed to enhance performance (Ward, Hodges, Williams, & Starkes, 2004). By the time a player makes his debut in the Premier League, the amount of accumulated practice is likely to exceed 10,000 hours.

The crucial point for coaches is that while hereditary factors are likely to play a role in shaping an individual’s response to practice and training, skills are highly modifiable and adaptable to training and every player will need to practise for many hours to develop and refine these skills. For example, the study of Ward and colleagues (2004) revealed that when compared with sub-elite players, the elite players spent twice the number of hours per week in team practice.

The main aim of this section was to emphasize the big amount of time that the players spend in training activities with the intention to improve their skills and become top players. Researches who have documented the practice profiles of elite performers have contributed to our awareness of the significant investment of time and effort required to reach elite levels of performance. Therefore, knowing that the training activities are crucial for the development of players on the road to excellence, and that the players spend a huge
amount of time training, the question now is what can we coaches do to promote learning in a most efficient way? In order to answer to this question, during the next chapters we will analyse the literature produced in the motor control area and we will, based on evidence, clarify what is the most efficient way to teach football.
III. Conceptual Framework

In the last years, the football game (and football teams) has been characterized as a complex system (Gréhaigne, Bouthier, & David, 1997). This assumption that the football game is a complex system it seems today widely accepted by the football community. However to fully understand what this exactly means, it is important to go deep down in the analysis of the concept of complexity.

First it’s important to notice that it doesn’t exist in science, until the present date, a formal and consensual definition of complexity. What is consensual, is that in nature a system is considered complex, when is composed by many component parts that interact in numerous forms (Nicolis & Prigogine, 1989). In this sense, we have in nature many other examples of complex systems. An ant colony is one of those examples. The question is then, what are the common existent points between an ant colony and a football team? All the different complex systems have some common characteristics: 1) they are composed by many interacting parts; 2) they exhibit a nonlinear behaviour (similar system outputs being achieved in different ways); 3) they exhibit inherent tendencies for self-organization; and 4) the behaviour of the system is emergent.

The complexity of interactions between individuals in team sports, like football, makes them a rich context to study nonlinear phenomena such as the players’ behaviour. In the last 30 years, ideas from scientific paradigms such as chaos theory and the sciences of complexity have been integrated with concepts and tools from dynamical systems theory to re-shape our understanding of movement behaviour (Beek & Meijer, 1988; Davids, Button, & Bennett, 2003). Dynamical systems theory has been successfully applied to the study of movement development (Thelen & Smith, 1994; Newell, Liu, & Mayer-Kress, 2001; Piek, 2002), and skill acquisition (Davids, Button, et al., 2003; Newell, 1996). Moreover, applications of nonlinear dynamics to the study of skilled performance and learning, are beginning to provide useful
insights into processes of motor skill acquisition for players and coaches (Davids, Araújo, Shuttleworth, & Button, 2003).

Based on the dynamical systems theory and ecological psychology, in this report we will explore the potential of a nonlinear pedagogical framework and his effectiveness to teach football.
IV. Nonlinear Pedagogy

What then is nonlinear pedagogy and why should we consider the development of motor skills as being nonlinear? Nonlinear pedagogy is predicated on the concepts and ideas of ecological psychology and dynamical systems theory and can be defined as the “application of the concepts and tools of nonlinear dynamics” to teaching and coaching practice (Chow et al. 2006, 72). Coaches shall consider the development of motor skills as nonlinear, because variability is part of the learning process and people learn in a nonlinear way. In the words of Milner the development of a skill can be a process of “moving one step backwards for every two step forwards” (cit. by Adolph and Berger 2006, 173).

As we saw in the previous chapter, research coming from the motor learning area has advanced our knowledge about the processes involved in the acquisition of movement skills (Handford, Davids, Bennett, & Button, 1997; Magill, 2006; Schmidt & Lee, 2006). In fact, is now taken for granted the need of use nonlinear models to explain the development of motor skills. Following this idea, Adolph and Berger (2006) highlighted the complementarity and compatibility of ideas and methods that exists between the two most prominent nonlinear models to study skill acquisition, the dynamical system theory and the ecological psychology. In fact the ideas from dynamical systems theory have been allied to concepts of ecological psychology (Gibson, 1979) to understand how movements are coordinated and controlled in dynamic environments such as sports (Chow et al., 2007).

In summary, nonlinear pedagogy is a learner-centered method to teach sports (football), because is a method that is based in “how players learn” and not “how coaches teach”. Nonlinear pedagogy provides a foundation to explain how game play skills might be taught by sports practitioners (Chow et al., 2006). More Specifically, nonlinear pedagogy informs the coaches about how to structure their practices, and how to deliver instructions and provide feedback (Chow et al., 2006).
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As we will see in the next chapters, a nonlinear pedagogy is a teaching method that involves the manipulation of different types of constraints to make emerge the desired behaviour, and that puts the emphasis on exploratory learning within “gamelike” situations like small-sided and conditioned games.
V. Manipulation of Constraints and Skill Acquisition

A powerful framework for explaining how nonlinear pedagogy can be used to develop movement coordination and decision making skills in game play is captured by the constraints-led perspective with its basis in nonlinear dynamics (Araújo, Davids, Bennett, Button, & Chapman, 2004; Davids, Araújo, et al., 2003; Handford et al., 1997). Constraints have been defined as boundaries or features that shape the emergence of behaviour (Newell, 1986) and in a nonlinear dynamical interpretation of skill acquisition, constraints are influential factors within the practice environment. According to Newell (1986), constraints can be classified into three distinct categories to provide a coherent framework for understanding how coordination patterns emerge during task performance. The three categories of constraints are: performer, environment and task (see Figure 1).

![Figure 1: Emergence of movement behaviour from the interactions of key performer, environmental, and task constraints on the learner, as modelled by Newell (1986).](image)

**Performer Constraints**

The performer constraints refer to the unique structural and functional characteristics of learners and include factors related to their physical,
physiological, cognitive and emotional make up. The height, weight and body composition of an individual, or his motivations, emotions and intentions, are some concrete examples of performer constraints. In sports, one of the most important performer constraints is the skill level of a certain individual.

These person-related factors provide affordances (possibilities) for action and play a significant role in determining the performance style adopted by individuals. In other words, the fact that the players are all different, because they all possess different individual characteristics, gives them also different possibilities for act and solve task problems.

Environmental Constraints

Environmental constraints refer to the surroundings of learners and include features such as the ambient light, temperature, or altitude. In any movement task, gravity is a key environmental constraint that influences how movement coordination may be adjusted. Other environmental constraints are social, including factors such as peer groups, social norms, and cultural expectations.

Task Constraints

From the coaches point of view the task constraints are perhaps the most important category of constraints in developing football skills, since they include the rules of the game, equipment used, playing areas and markings, the number of players involved or the goal of a specific training task. One of the most important task constraints to consider is the information available in specific performance contexts that learners can use to coordinate their actions.

It’s crucial for the football coaches understand the need to keep key information sources and movements coupled together during their practices. As a pedagogical principle, information-movement coupling certainly mitigates against traditional approaches of teaching football such as task decomposition
and the isolation of movement skills from game contexts for practice execution (Davids, Button, & Bennett, 2007). The practical implication of these ideas is that the coaches need to make sure that the information present in the football game is made available also during the training. This means that, in order to facilitate learning, the coaches shall design training tasks that are representatives.

Knowing that the football drill is the main tool of the coach to change behaviour and promote learning, is extremely important that the football coaches full understand how to manipulate the task constraints in a most efficient way. The use of small sided and conditioned games is a good way to maintain the representativeness of the training tasks and avoid the traditional method of teaching football skills in isolation from the game context.

**Interacting Constraints**

To summarise, Newell’s (1986) constraints model provides an excellent conceptualisation to guide nonlinear pedagogical practice because it adequately captures the rich range of diverse constraints acting on learners during skills learning in team sports. It’s important to note that each of these categories of constraints does not act by itself to shape behaviour since behaviour self-organizes from the interaction of performer, environment and task constraints. Movement skill acquisition occurs, in that sense, as a consequence of the interplay of numerous interacting constraints, which need to be considered in pedagogical practice (Davids, Chow, & Shuttleworth, 2005).

According to this model, the main role of the coach is the identification and manipulation of the key constraints to facilitate the emergence of functional movement repertoires. Evidence shows that the manipulation of constraints by educators/ coaches can lead to the production of successful motor patterns, decision-making behaviour, and intentions that guide to the achievement of task goals (Chow et al., 2006).
VI. Repetition without Repetition: The Functional Role of Variability

Movement pattern variability has traditionally been viewed as dysfunctional and a reflection of “noise” in the central nervous system (Slifkin & Newell, 1998). This vision of variability as something negative that should be avoided, conducted the cognitive and behaviour sciences to search for motor invariance, what led to a narrow interpretation of variability in motor behaviour. From a dynamical systems theoretical perspective, variability in movement systems is considered to be a central theoretical issue. In recent years, concepts and tools from dynamical systems theory have been successfully applied to the study of movement systems, contradicting the traditional views of variability as noise or error. From this perspective, it is apparent that variability in movement systems is omnipresent and unavoidable due to the different constraints that shape each individual’s behaviour. This new vision of movement variability has important practical implications for all the areas that are in somehow related with the study of behaviour. Especially for areas like teaching/coaching that attempt to modulate behaviour, these implications are huge. Instead of dysfunctional, movement variability is now seen as an intrinsic feature of skilled motor performance that provides the flexibility required to adapt to complex dynamic sport environments (Williams, Davids, & Williams, 1999).

In resume, variability in motor performance is now seen as functional. This means that players can seek to achieve skilfulness and develop consistency of outcomes through movement variability, which emerges from the interacting constraints of performance. This emergent characteristic of movement coordination suggests that the existence of a common optimal motor pattern for performing a skill is a fallacy attributable to the variability often observed in human motor performance (Brisson & Alain, 1996). Different players can in that sense, use the great abundance of movement possibilities offered by the human musculoskeletal apparatus to vary the ways in which they solve movement problems, and an optimal movement pattern for one individual may not be optimal for another in relation to a specific task goal.
This idea contradicts many of the traditional approaches to teaching motor skills predicated on the notion of an idealized, common optimal motor pattern toward which all learners may aspire (often presented by demonstrations from an expert model).

As Werner, Thorpe, and Bunker (1996) pointed out, traditional approaches to teach football were viewed as being technique dominated, following a series of highly structured practices in which a list of movement skills was sequentially taught to groups of learners. Such pedagogical approaches have tended to overemphasize (a) the isolation of movement skills from performance contexts during practice, (b) task decomposition during learning, and (c) the role of repetition in skill practices to allow learners to transfer acquired technical skills into game situations (Rink, 2005).

Although similar movement patterns can be adapted and refined, detailed analysis of movement kinematics are revealing that the specific movement patterns used by different individuals to achieve similar outcomes are not the same (Davids, Shuttleworth, Araújo, & Renshaw, 2003). In fact, individuals find it extremely challenging to repeat a movement pattern identically across trials (Davids, Button, & Bennett, 2008). Even though it is important for a player to consistently repeat a performance outcome during a football match, the movement pattern used to achieve this outcome may not be repeated in an identical way every time. This feature of “repetition without repetition” (Bernstein, 1967) in human movement systems provides learners with the capacity to invent novel adaptations to solve typical motor problems. As a matter of fact, research has revealed that expert performers are more consistent in their performances, and that they achieve that consistency through more variable ways of performing.

From the learning point of view, the take home message of this chapter is that coaches shall definitely rethink the role of repetition in their own practices. As we saw, the use of teaching methods that are based in the teaching of the “perfect technical skills” is something that doesn’t take into consideration how people learn. Instead of educate the players for the predictability, through the use of repetitive technical drills in closed environments, the coaches shall
induce variability in their practices and promote the learning of football skills in game contexts, where the players can train/ repeat different skills in many different ways (repetition without repetition). The functional role that variability assumes in skill acquisition encourages also the use of exploratory learning methods, because functional movement solutions may be founded through exploratory behaviour during performance. However, this is not to say that coaches should simply allow “free play” and hope that the players “solve” the different game situations in whatever way they deem appropriate. Instead, the coaches shall be able to manipulate the different task constraints to promote the emergence of the desired learning outcomes planned for the session. In other words, the coach shall be able to guide the discovery of the players.
VII. Practice Structure: Task Simplification vs. Task Decomposition

An important question for the coaches is how best structure practice for effective learning. A common belief in sports coaching is that there are benefits for learners in the strategy of breaking down complex skills. Task decomposition techniques include, part-task training programmes and adaptive instruction. Part-task training involves practising some subset of task components as a precursor to practice or performance of the whole task. Adaptive training is a technique in which task difficulty is progressively increased as its performance is mastered. This coaching strategy, where practice routines start at an easy level and then increase in movement demands and time pressure, is used in teaching many complex skills in sport.

As we already saw in previous chapters, traditional approaches to teaching games skills are centred on acquiring relevant movement patterns in isolation of a game context, before using these skills in adult versions of a particular game (Turner & Martinek, 1995). In many team games, not only in football, teaching movement skills by decomposing the task into manageable components is commonly used with the intention of manage the information load on learners. However, this traditional approach of task decomposition may decouple the relevant information–movement coupling so that it becomes quite challenging for learners to perform the action in game context (Handford, 2006). An example of task decomposition in football that is often used by many coaches with the intention of improve the dribble capabilities of their own players, is the use of training tasks where the players have to dribble around cones.

Instead, task simplification is a method which allows different components of complex coordination patterns to be learned in tandem, allowing information and movements to remain coupled throughout. Task simplification refers to the process whereby scaled-down versions of tasks are created in practice with the aim of simplify the process of information pickup by the players (Davids, Shuttleworth, et al., 2003). The use of modified versions of games,
like small-sided and conditioned games during the football practice is an example of task simplification.

Literature has provided a significant amount of knowledge about structuring practices and the provision of learning opportunities (Siedentop & Tannehill, 1999; Metzler, 2000). This applied research has informed teachers and coaches about the “art” of helping learners acquire game skills. The implication from these theoretical and empirical findings is that, in order to promote learning, practice structure should emphasize task simplification rather than the more traditional technique of task decomposition, because a decoupling of the demands on the perceptual and motor-systems during practice prevents learners from developing the cortical neural pathways underlying perception-for-action (Davids, Araújo, et al., 2003).

**Practice Design**

As we saw also in the previous chapters, traditional utilization of practice drills has been criticized because, among other things, they neglect the active role of the performance environment in shaping movement behaviour and decision-making (Davids, Araújo, Hristovski, Passos, & Chow, 2012), sustaining a dysfunctional rupture in the performer-environment relationship. In that sense, training task design in team sports needs to represent the key informational variables from a competitive performance environment that individuals use to regulate actions and make decisions. These findings imply that coaches need to design dynamic training simulations that capture the inherent variability of the competitive performance environment, leading performers to use information that is relevant (Pinder, Renshaw, & Davids, 2009; Pinder, Davids, Renshaw, & Araújo, 2011).

The work of Davids and colleagues (2012) suggest that training needs to be refocused on the performer-environment relationship. To exemplify, tasks are often designed for performance without opponents or with passive opposition to simplify decision-making during repetitive drill practice under conditions of reduced uncertainty (Passos, Araújo, Davids, & Shuttleworth, 2008).
However, these types of drills, designed to improve physiological or technique performance, tend to isolate an action from the performance context and may not allow functional performance behaviours to emerge during interpersonal interactions of players in more open environments (Passos, Araújo, et al., 2008).

To summarize, attempting to prepare for team games performance through repetitive practice of isolated and discrete movement patterns is a reductionist approach that is only an adequate preparation for producing consistent movement patterns in closed predictable performance environments. However, competitive team games are complex, dynamic and unpredictable environments in which information sources are rarely assured in advance and emergent actions are highly context dependent (Travassos, Duarte, Vilar, Araújo, & Davids, 2012; Vilar, Araújo, Davids, & Button, 2012). What means that training should in that case mainly consist of recreating simulations of the game by not only, manipulating practice areas (e.g., width and length of fields) but also the objectives and rules of play (through conditioned games).

Training in small-sided and conditioned games can result in more functional acquisition of performance behaviours (Davids et al., 2012; Passos, Cordovil, Fernandes, & Barreiros, 2012; Vilar, Araújo, Davids, & Renshaw, 2010), because players can learn how to guide their actions according to the informational specificity of their performance context. The work produced by Pinder, Davids, Renshaw and Araújo (2011) highlights this point demonstrating that, when participants are required to perform actions under controlled laboratory conditions, in which possibilities to act differed from his performance environment, observed patterns of movement coordination significantly differed.

Small-sided and Conditioned Games

The importance of use small-sided and conditioned games as a training method in football has been highlighted by many different studies. For example, in a report related with the use of small-sided and conditioned
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games at the Manchester United academy, Fenoglio (2003) showed that by playing 4 vs. 4 rather than 8 vs. 8 games, players made 135% more passes, had 260% more scoring attempts and scored 500% more goals. In addition, the number of 1 vs. 1 encounters between attackers and defenders increased by 225% while the number of dribbling tricks demonstrated by learners increased by 280%. The increased frequency of these important sub-phases of football during practice tasks clearly allows learners greater opportunities to practice basic skills and to gain more experience of tactical requirements in game contexts. The advantages of small-sided and conditioned games for physical conditioning have also been demonstrated. A study conducted by Impellizzeri and colleagues (2006) found that using small-sided and conditioned games, compared to interval training for example, resulted in similar levels of improvement in aerobic fitness and match performance for junior soccer players.

As Fenoglio (2003) and Davids and colleagues (2013) demonstrated with their studies, an important strategy to promote skill acquisition and learning in team games is the use of small-sided and conditioned games. From the learning point of view, two of the main “strengths” of the small-sided and conditioned games is that they contain functional levels of contextual variability, and they amplify information for action by promoting increased frequency of opportunities for interpersonal interactions to occur. In that sense, small-sided and conditioned games can be used to help learners gaining experience in picking up functionally relevant information for continuously regulating interpersonal interactions with teammates and opponents during performance (Fenoglio, 2003).

According to the nonlinear pedagogical principles, one of the main tasks of the coaches is that they need to identify and adjust key task constraints of small-sided and conditioned games in order to promote the acquisition of specific game skills or tactical behaviours. Therefore, instead of learners practicing static drills or playing only in full-sided games, manipulation of objectives and/or rules in small-sided and conditioned games made by the coaches can increase opportunities for common attacking and defensive subphases to emerge frequently. The structure and organization of small-
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sided and conditioned games need to be designed by coaches, specifically for individual learners to practice exploring different performance solutions as performance environment contexts change, rather than practicing the same actions repetitively. Following this principles, rather than encouraging learners to dribble a ball around cones, pass in straight lines to each other, or shoot a stationary ball in drills, the coaches shall manipulate task constraints of small-sided and conditioned games to encourage adaptive movement behaviours through facilitating continuous interpersonal interactions of learners with teammates (Araújo, Davids, & Hristovski, 2006; Passos, Araújo, Davids, Gouveia et al., 2008; Passos et al., 2009), opponents (Correia et al., 2012), and key field markings (Esteves et al., 2012).

Achievement Goal Theory

The use of small-sided and conditioned games as a teaching method has also other advantages such as, increase the amount of time spent in playful and enjoyable activities by allowing learners to experience simulations of competitive team games (Davids et al., 2013). In that sense, its important to note that studies conducted in the domain of the achievement goal theory have demonstrated that when the goal is to develop an individual’s ability through learning a task (task mastery), game related practices provide the relevant opportunities to increase students' motivation. Such an observation is based on the report that games provide increase situational interest because they have structure and outcomes that are meaningful to performance (Griffin, Brooker, & Patton, 2005). From a psychological and affective perspective, achievement goal theory provides also a relevant theoretical evidence to support the efficacy of task simplification methods such as the use of small-sided and conditioned games.
VIII. Augmented Information and Skill Acquisition

An important aspect of pedagogical practice is related with the provision of augmented information to learners. The provision of verbal instructions, feedback, and the use of demonstrations are examples of augmented information given by the coaches to the learners with the intention of promoting learning. The delivery of augmented information to the learners has been a primary concern for motor learning theorists for many years (Newell, Broderick, Deutsch, & Slifkin, 2003). From a nonlinear pedagogical perspective, the transmission of verbal instructions and visual demonstrations during practice are seen as important instructional constraints (Newell, 1986).

The literature produced in this area tells us that an important task for coaches is to provide learners with feedback so that they can improve performance on subsequent practice attempts. The provision of feedback helps to promote efficient learning, ensures correct development of the skills, and influences the learner’s motivation to persist with practice. However, while learners require feedback to refine and develop their skills, it is important to realize that this information can be acquired through many different routes and methods, not all of which are as effective as each other. In that sense, coaches need to be aware of how these different sources of feedback work, because this knowledge is essential so that coaches can determine when and how augmented information should be provided to best encourage learning.

In the next sections we will analyse several studies produced in the area of motor learning, and based on evidence we will discuss, if coaches shall with their instructions induce an internal or an external focus of attention on their players; if more feedback is better than less; and in the last section of this chapter we will discuss the role of demonstrations in skill acquisition and the use of guided discovery as a teaching method.

*Internal Focus of Attention vs. External Focus of Attention*
Withing and Brinker (1982) proposed that during skill acquisition learners can be concerned with information about the “image of the act” (focus on movement dynamics) or the “image of achievement” (focus on the movement effects to be achieved). This means that during practice, the coach can with his instructions and feedback direct the attention of the players for internal or external aspects. In other words, if a coach provides information related with the “image of the act”, he is inducing an internal focus of attention on the players. As an example, when the coaches centre their intervention in the correction/prescription of technical aspects like “how to position the feet to perform a long pass” or “how and where to quick the ball”, they are inducing an internal focus of attention on the players.

In the other hand, if a coach provides information related with the “image of achievement”, he is inducing an external focus of attention on the players. For example, if instead of give instructions about how to perform a long pass, the coach says to the player something like “your task is to perform a long pass for the chest of your colleague”, then the coach is inducing an external focus of attention on his player.

![Figure 2: Accuracy scores of the experiment 1 conducted by Wulf, McConnel, Gartner and Schwarz (2002).]
The figure 2 was taken from a study conducted by Wulf et al., (2002). In this study Wulf and colleagues used 4 different groups of learners with identical tasks. The differences between groups are that, Adv-Ext: group composed by advanced players that performed the task through the use of an external focus of attention; Adv-Int: group composed by advanced players that performed the task through the use of an internal focus of attention; Nov-Ext: group composed by novice players that performed the task through the use of an external focus of attention; and Nov-Int: group composed by novice players that performed the task through the use of an internal focus of attention.

The results of this study reveals that an external focus that directed performers’ attention toward the movement effects, yield better learning and performance of complex skills (see figure 2). They proposed that an external focus of attention did not distract learners from the movements required but instead allowed the implicit regulation of task performance and learning. Davids, Button and Bennett (2004) argued also that the efficiency of the use of an external focus of attention is related with the fact that this attention focus doesn’t interfere with self-organization processes of the movement dynamics as performers explore the task. Instructional constraints that direct a learners search to movement dynamics (internal focus) may deprive them of the opportunity to discover and satisfy the multiple task constraints unique to each individual.

The current research supports also the idea that the use of an external focus of attention, rather than a prescriptive internal focus of attention, allows learners to use discovery learning processes during skill acquisition.

**Frequency of Feedback**

Another important instructional constraint it’s related with the frequency of feedback to be provided for effective skill learning. Traditionally, coaches have tended to provide copious amounts of feedback in the belief that “more is
better” for the effective acquisition of football skills. According to the guidance hypothesis proposed by Salmoni, Schmidt and Walter (1984), providing augmented feedback on every trial has a beneficial effect on performance but a detrimental effect on skill learning. Providing feedback on every practice attempt can lead to an “overload” of information, result in over-reliance on augmented feedback, and prevent the learner from becoming adequately involved in the problem-solving process.

Figure 3: Accuracy scores of the experiment 2 conducted by Wulf et al., (2002). Meaning of the abbreviations of the different groups:

- **Ext-100** = external focus induced + feedback provided in 100% of the trials;
- **Ext-33** = external focus induced + feedback provided in 33% of the trials;
- **Int-100** = internal focus induced + feedback provided in 100% of the trials;
- **Int-33** = internal focus induced + feedback provided in 33% of the trials.
Wulf and colleagues (2002, experiment 2) studied the effects of the frequency of feedback in relation with the focus of attention induced (external or internal) on the learning of a lofted pass in football. These data indicated that receiving external focus feedback once in every three trials is as functional for learning as receiving external focus feedback on every trial. The findings highlight once again the detrimental effect that directing search to movement dynamic and body parts (internal focus) has on learning and performance in complex skills.

It seems difficult to determine what is the ideal quantity/ frequency of feedback that we coaches should provide to the learners. However if we analyse the figure 3, we understand that the worse thing that a coach can do is to provide a big amount of feedback while inducing an internal focus of attention. In other words, the worse thing that a coach can do to promote the acquisition of skills, is giving a big amount of feedback related with technical prescriptions of movement. This is a very powerful and important message that definitely goes against the most traditional ways to teach football.

In resume, it is proven that provide more feedback is not better than provide less. In that sense, it is crucial for the coaches to achieve the correct balance between providing feedback often enough to facilitate learning, while at the same time not providing feedback too frequently so that the learner fails to become adequately involved in the problem-solving process.

Although a decrement in performance may be observed during practice as a result of the reduction in feedback frequency, performance is likely to be enhanced during retention and in competition. Following this idea, we decided to include in this report a table where are highlighted some methods that may be employed by the coaches to decrease learners’ reliance on augmented feedback (see table 1).
Summary Feedback

Feedback provided as summary of performance on the preceding block of practice attempts

Bandwidth Feedback

Provision of feedback only when performance falls outside some agreed upon criterion or bandwidth

Descriptive vs. Prescriptive Feedback

Provision of descriptive feedback rather than prescriptive guidance encourages learners to find their own solutions

Question and Answer style

Asking learners to come up with their own solution through a question and answer approach (e.g. “What could you have done better on that attempt?”

Table 1: Techniques that can be employed by coaches to decrease learners’ reliance on prescriptive feedback (table adapted from Williams & Hodges 2005).

**Demonstration vs. Guided Discovery**

A demonstration is the most common method used by coaches to convey information to the players. The main reason for using a demonstration is to provide the learner with a visual template or criterion model for the desired movement pattern (Hodges & Franks, 2002; Swinnen, 1996). Coaches use the demonstrations based in the assumption that a demonstration is essential to inform players about how best to perform a skill. However, the role and effectiveness of demonstrations have been examined in the motor learning literature and as Horn and Williams (2004) pointed out, the use of demonstrations might not be the most effective method when the aim is to improve a technical skill. The argument in the basis of this claim is that demonstrations are overly constraining, forcing the learner to adopt a movement pattern that may not be the most effective for that individual (i.e. a “one size fits all” assumption).

When the method chosen by the coach to provide information to the players is based in demonstrations, the coach is directing the attention of players to the
“image of the act”, what means that he is inducing an internal focus of attention on the players. However as we already saw in the previous sections of this chapter, the use of instructions that induce an external focus of attention are more beneficial for learning since it does not constrain the learner to reproduce an inappropriate movement pattern (Wulf, Lauterbach, & Toole, 1999; Wulf & Prinz, 2001).

The key issue here is that from the nonlinear pedagogy perspective, there may be many different ways to achieve the same end result (repetition without repetition) and learners should be encouraged to explore these opportunities with the intention to develop flexible and adaptable movement patterns. In that sense, the widespread acceptance of demonstrations as an essential method of conveying information to the learner shall be questioned, because although demonstrations usually facilitate the instruction process, they are not the best method to promote learning. The most important message for the coaches is then, that players shall be viewed as active problem-solvers rather than “empty vessels” or passive recipients of information.

A common idea that has been presented along the different chapters of this report is that teaching methods that are overly prescriptive may be detrimental to skill acquisition. This idea is also supported by evidence that suggests that skills taught using such approaches are less resistant to the effects of psychological stress and more prone to forgetting over time than skills learnt through guided discovery (Abrams & Reber, 1988; Masters, 1992). Moreover, while prescriptive instructional approaches are likely to produce faster performance gains initially, they may result in less efficient and reliable performance in the long term. The advantages of less prescriptive approaches such as guided discovery have been advocated by many scientists and practitioners (Araújo et al., 2004; Davids, Williams, Button, & Court, 2001).

The emphasis when learning by guided discovery is on players finding unique solutions to movement problems through exploration and discovery. This approach may be more effective in developing “smart” players who are able to apply their skills in a variety of performance situations (Williams & Hodges, 2005). As Holyoak (1991) highlighted, teaching through guided discovery
methods conduct the players to “adaptive” expertise, rather than “routine” expertise.

In resume, the use of guided discovery methods is in accordance with principles of nonlinear pedagogy. According to a nonlinear way to teach football, the main task of the coaches is to manipulate constraints (especially task constraints) in order to make emerge the desired behaviour through guided discovery and self-exploration, rather than via prescriptive instructions. It’s important to note that, the use of guided discovery as a teaching method doesn’t imply that the importance of coaching is diminished, merely that the coach need to have greater awareness of how shape and guide the behaviour of his players. In that sense, in the table 2 are presented some concrete examples of how task constraints may be manipulated in order to make emerge behaviour through guided discovery and thus promote effective learning in football.
Table 2: Examples of how behaviours can be encouraged during practice by manipulating different constraints. Table taken from the study conducted by Williams and Hodges (2005).

<table>
<thead>
<tr>
<th>Constraints on behaviour</th>
<th>What can be manipulated?</th>
<th>Some examples</th>
<th>Emergent behaviour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Task</td>
<td>Conditions or rules</td>
<td>One- and two-touch</td>
<td>Pass and move, awareness of other players</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Score off a cross only</td>
<td>Heading and volleying</td>
</tr>
<tr>
<td></td>
<td></td>
<td>One-touch finish</td>
<td>Positioning, sharp finishing, quick feet</td>
</tr>
<tr>
<td>Pitch markings</td>
<td>Flank corridors</td>
<td>Crossing</td>
<td>Crossing</td>
</tr>
<tr>
<td></td>
<td>No tackle zones</td>
<td>Containment, staying on feet</td>
<td>Containment, staying on feet</td>
</tr>
<tr>
<td></td>
<td>Shooting zones</td>
<td>Shooting and finishing</td>
<td>Shooting and finishing</td>
</tr>
<tr>
<td>Number of players</td>
<td>5 vs 3 defence vs attack</td>
<td>Playing out from back</td>
<td>Playing out from back</td>
</tr>
<tr>
<td></td>
<td>6 vs 4 attack vs defence</td>
<td>Width and penetration in attack</td>
<td>Width and penetration in attack</td>
</tr>
<tr>
<td>Time</td>
<td>Restricting time in possession of ball</td>
<td>Fast counter-attacking</td>
<td>Fast counter-attacking</td>
</tr>
<tr>
<td>Equipment</td>
<td>Futebol de Salão (juggling practice and matches)</td>
<td>Encourages development of kinaesthetic touch/feel</td>
<td>Encourages development of kinaesthetic touch/feel</td>
</tr>
<tr>
<td>Player</td>
<td>Coupling between limbs</td>
<td>Goalkeepers move the feet together rather than cross the feet when moving across goal</td>
<td>Goalkeepers move the feet together rather than cross the feet when moving across goal</td>
</tr>
<tr>
<td></td>
<td>Using rubber bands around the ankles with goalkeepers</td>
<td>Greater awareness of goal position and angles during one vs one encounters</td>
<td>Greater awareness of goal position and angles during one vs one encounters</td>
</tr>
<tr>
<td>Environment</td>
<td>Access to sensory information</td>
<td>Players rely on touch/feel rather than vision when orienting the foot to control the ball</td>
<td>Players rely on touch/feel rather than vision when orienting the foot to control the ball</td>
</tr>
</tbody>
</table>
IX. Conclusions/ Take Home Messages

This was a report essentially conceived for coaches and where we intended to clarify some issues related with the most efficient way to teach football. The discussions undertaken throughout the different chapters of the present report were always based on scientific evidence that have been produced in the motor learning area and that form the basis of a nonlinear pedagogy framework. All the report was based in how players learn and in what we coaches can do in order to promote efficient learning.

With the aim of make this last section the most clear and accessible possible for the coaches, we decided to synthesize the conclusions of this report in brief “take home messages”. In that sense, coaches should know, that:

1) A nonlinear pedagogy is an efficient method to teach football that is based in how players learn;

2) The principles of nonlinear pedagogy inform the coaches about how best structure their practices, deliver instructions, provide feedback, and design their practices, in order to promote effective learning;

3) Nonlinear pedagogy involves the manipulation of different types of constraints to make emerge the desired behaviour;

4) Movement variability has a functional role in learning, because is an intrinsic feature of skilled motor performance that provides the flexibility required to adapt to complex dynamic sport environments;

5) In order to promote learning, the coaches shall structure their practices in accordance with the principles of task simplification, rather than task decomposition;
6) The training tasks designed by the coaches need to represent the key informational variables from a competitive performance environment that players use to regulate their actions and make decisions;

7) Coaches need to design dynamic training simulations that capture the inherent variability of the competitive performance environment;

8) Training shall mainly consist in recreating simulations of the game, through small-sided and conditioned games;

9) Nonlinear pedagogy puts the emphasis on exploratory learning within small-sided and conditioned games.

10) One of the main tasks of the coaches is that they need to identify and adjust key task constraints of small-sided and conditioned games in order to promote the acquisition of specific game skills or tactical behaviours;

11) Coaches shall with their instructions and feedback induce an external focus of attention on their players;

12) It is proven that more feedback is not better than less;

13) It is crucial for the coaches to achieve the correct balance between providing feedback often enough to facilitate learning, while at the same time not providing feedback too frequently so that the learner fails to become adequately involved in the problem-solving process;

14) Skills learnt through guided discovery are more resistant to the effects of psychological stress and less prone to forgetting over time;

15) Guided discovery may be a more effective approach in developing “smart” players, who are able to apply their skills in a variety of performance situations.
X. References


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