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Practice, instruction and skill acquisition in soccer: Challenging tradition

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Abstract

The acquisition of soccer skills is fundamental to our enjoyment of the game and is essential to the attainment of expertise. Players spend most of their time in practice with the intention of improving technical skills. However, there is a lack of scientific research relating to the effective acquisition of soccer skills, especially when compared with the extensive research base on physiological aspects of performance. Current coaching practice is therefore based on tradition, intuition and emulation rather than empirical evidence. The aim of this review is to question some of the popular beliefs that guide current practice and instruction in soccer. Empirical evidence is presented to dispel many of these beliefs as myths, thereby challenging coaches to self-reflect and critically evaluate contemporary doctrine. The review should inform sports scientists and practitioners as to the important role that those interested in skill acquisition can play in enhancing performance at all levels of the game.

Keywords: *coaching, expertise, motor learning, performance*

Introduction

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 soccer, where the importance of sports science research and applied work is now more widely accepted (see Reilly & Williams, 2003). While the importance of sports science is appreciated by those involved with professional clubs and national governing bodies, the majority of work has been undertaken by exercise physiologists. Other traditional sports science disciplines, such as sport psychology and motor learning, are generally under-represented both in the applied and research fields (Reilly and Gilbourne, 2003). It appears that the soccer world has embraced the biological sciences with greater enthusiasm than the behavioural or social sciences.

Several reasons may be advocated for this leaning towards the so-called "harder" sciences. First, it is much easier to evaluate the effectiveness of fitness conditioning programmes than interventions which attempt to change behaviour. Meaningful changes in aerobic and anaerobic capacity or in anthropometric characteristics such as body composition and mass can be easily determined using standard laboratory- and/or field-based measures. In contrast, constructs such as anxiety, self-confidence, anticipation and decision-making are difficult to measure directly and can only be inferred from changes in behaviour over time. The difficulties involved in attempting to verify the effectiveness of interventions that alter behaviour have made it harder to demonstrate the value of such approaches to practitioners. Another reason for the reluctance of those working in the field to embrace more fully the behavioural and social sciences may be due to the historical precedence that certain aspects of player preparation and development should remain the domain of the coach. Current coaching practice is determined mainly by subjective evidence and the historical precedence established within the club and/or governing body, what others have referred to as the processes of intuition, tradition and emulation (see, for example, Abraham & Collins, 1998; Lyle, 1999), rather than on empirical research.

The most worrying aspect of this trend in favour of the biological rather than the behavioural sciences is that players spend most of their time attempting to refine and develop technical and behavioural skills,

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whereas much less effort is spent attempting to improve or refine aspects of fitness. 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. A significant investment of practice time and effort is required to reach an elite level of performance. Compared with the published work focusing on biological aspects of training, the research aimed at uncovering the important factors underpinning effective practice and instruction is noticeably limited. An important question to consider is whether the overemphasis on biologically based research at the expense of more behaviourally oriented work is leading to a situation where fitness training and conditioning are often given priority over the teaching of technical skills.

The intention of the current review is to highlight how the effectiveness of certain aspects of coaching practice can be questioned in light of recent empirical research from the field of motor learning. We present a number of commonly held beliefs about practice and instruction and, by reference to recent research, expose these views as potential myths that may be undermining the development of elite soccer players. The overall aim is to illustrate the need for coaches to rely on evidence-based practice in developing elite performers and to encourage other behavioural scientists to take up the mantle by exploring in greater detail the important factors underlying effective practice and instruction.

We begin by illustrating the importance of practice and instruction on the road to excellence. The intention is to promote the view that practice and instruction are key ingredients in the recipe for success, challenging the belief held by many lay people and some coaches, particularly at lower levels of the game, that skilled players are born to succeed because they are "gifted" or posses certain innate talents or abilities that predispose them towards achieving excellence within the sport. The premise that talented individuals are born with certain abilities that differentiate them from less gifted individuals, and that there are some indicators that enable trained people to identify the presence of these superior abilities at an early age, is fundamental to the talent identification process (Williams and Reilly, 2000). The remainder of this review focuses on the process of instruction in greater detail and attempts to provide practitioners with some guidelines as to how best to facilitate the skill acquisition process.

Practice and instruction: The key determining factors in attaining excellence

Coaches and spectators often imply that elite players are in some way "gifted" with unique abilities that ensure that they will achieve excellence within the sport in question. In support of this presumption, scientists argue that we are not all born equal and that certain individuals may be endowed with characteristics that predispose them towards achieving excellence more than others (Bouchard, Malina, & Pérusse, 1997; Rowe, 1998). However, 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 consistent observation is that elite performers in the sports, arts and sciences accumulate in excess of 10,000 hours of practice before reaching an international level of performance (i.e. the so called 10-year rule; Simon & Chase, 1973). It is likely that the development of expertise is dependent on a complex recipe where innate hereditary factors are blended with the correct environmental factors, such as the influence of parents and coaches, as well as an individual's commitment and motivation to practise (for a recent discussion, see Starkes & Ericsson, 2003).

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. What is underestimated is the specific amount of practice needed before expertise is attained. Initial attempts to identify the practice history profiles of experts occurred in individual sports such as wrestling (Hodges and Starkes, 1996), figure skating (Starkes, Deakin, Allard, Hodges, & Hayes, 1996) and karate (Hodge and Deakin, 1998). The average amount of practice per week over a 10-year period in each of these sports was consistently high (approximately 26 hours per week in karate, 28 hours per week in figure skating, 25 hours per week in wrestling), and comparable with those reported for expert musicians (Ericsson *et al.*, 1993).

The practice history profiles of soccer players have also been examined (Helsen, Starkes, & Hodges, 1998; Ward *et al.*, 2004). Helsen and colleagues (1998) examined the practice history profiles of professional, semi-professional and amateur players in Belgium. The amount of time spent in team practice was the strongest discriminator across skill groups. The professional players also spent more time in individual practice than the semi-professional and amateur players at 6 years into their careers (11 years of age). The professional and semi-professional players reached their peak in terms of the number of hours per week spent in practice (individual and team practice combined) at 15 years into their careers (around 20 years of age). At 18 years into their careers, the professional, semi-professional and amateur players had accumulated a total of 9332, 7449 and 5079 practice hours respectively.

Ward and co-workers (2004) used a novel, quasi-longitudinal design to assess practice history profiles in elite and sub-elite soccer players between 8 and 18 years of age. The mean number of practice hours per week in soccer-specific team and individual practice, playful soccer activity and match-play is highlighted in Figures 1a (sub-elite) and 1b (elite). The elite players spent much more time in team and individual practice per week than the sub-elite players regardless of age, with the amount of time spent in team practice being the strongest predictor of skill. The elite players spent twice the number of hours per week in team practice compared with the sub-elite players in each age category.

While the notion that elite players practise more than their sub-elite counterparts is not altogether surprising, the amount of accumulated practice provides an astonishing portrayal of the immense commitment required to become an elite performer. This commitment fosters a clear "rage to master" in players at an early age (Winner, 1996); an almost obsessive desire to achieve excellence within the domain. It is this commitment and motivation to practise that may well be the most important precursors to expertise; players at Premier League Academies in England considered that the motivation to succeed allied with the commitment to practise were more important in achieving success than their initial skill level or talent (Ward *et al.*,

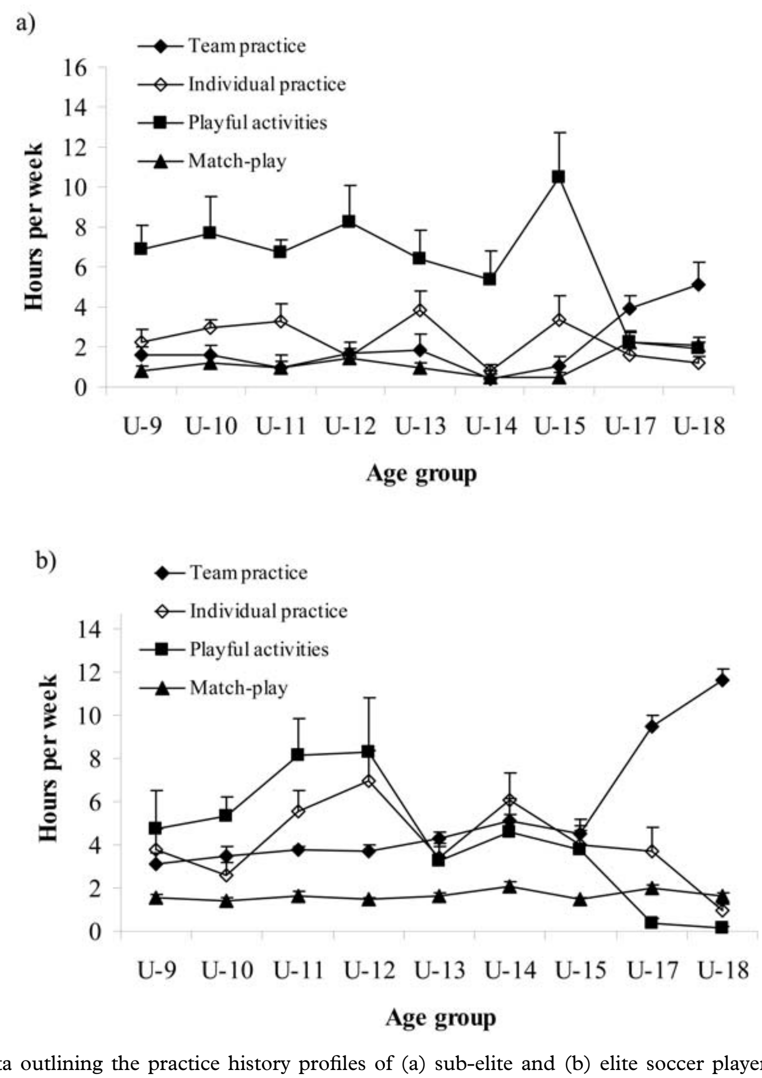

Fig. 1. Cross-sectional data outlining the practice history profiles of (a) sub-elite and (b) elite soccer players from 8 to 18 years of age (adapted from Ward *et al.*, 2004).

2004). Perhaps the most important question for coaches to ask is why some players choose to invest in practice whereas others do not (Côté, Baker, & Abernethy, 2003).

Although researchers 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 (i.e. the macrostructure of practice), there remains a lack of knowledge about the specific practice activities (i.e. the microstructure of practice) that players undertake on the road to excellence (Ward *et al.*, 2004). In particular, research is required to determine the "what" and "how" of practice (Janelle & Hillman, 2003) and how these interact with the instruction process.

Some key aspects of the instruction process are highlighted in Figure 2. Information is initially conveyed to the learner via a demonstration, typically accompanied by some form of verbal instruction. The learner is then given the opportunity to practise the skill before receiving augmented feedback from the coach as to how behaviour should be modified on subsequent practice attempts. The specific nature of the process is determined by the mode of instruction and philosophy adopted by the coach. In the sections that follow, we review research relating to each stage within the instruction process and highlight some potential misconceptions or myths that may undermine effective practice.

Myth 1: Demonstrations are always effective in conveying information to the learner

A demonstration is the most common method used by coaches to convey information to the learner. The assumption is that a demonstration is essential to inform the learner as to how best to practise the skill. Although demonstrations may be effective most of the time, important questions remain, such as who should provide the demonstration, what information should be presented and whether verbal instruction or augmented feedback may be just as, or even more, effective (see Hodges & Franks, 2004a).

In the motor learning literature, the role and effectiveness of demonstrations have been examined under the heading of *observational learning* (for detailed reviews, see Horn & Williams, 2004; McCullagh & Weiss, 2001). Traditionally, researchers have examined *how* the information presented in a demonstration is used to encourage learning (i.e. the cognitive processes involved in learning from observation). A more recent trend has been to examine *what* information is perceived and used to guide performance and encourage learning (see Scully & Newell, 1985). Although these questions are underpinned by different theoretical backdrops, the two lines of research have yielded complementary rather than contradictory evidence, which has helped to elucidate the conditions of practice that best promote observational learning.

The main reason for using a demonstration is to provide the learner with a visual template or criterion model for the desired movement pattern (see Hodges & Franks, 2002; Swinnen, 1996). The ability of a demonstration to direct the learner towards the intended goal is critical, as motor skills often require the attainment of multiple goals (e.g. speed, accuracy or form). Moreover, certain goals will be prioritized at the expense of others depending on the task to be learnt, the performer's skill level or the coach's preferences. A demonstration is frequently chosen as

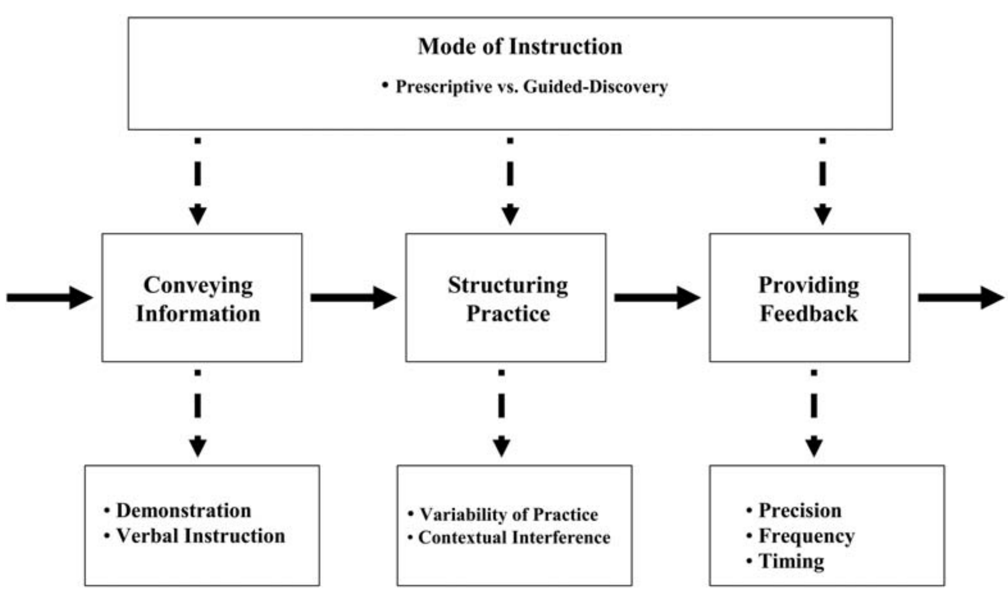

Fig. 2. Key stages within the instruction process (adapted from Lavalle *et al.*, 2003).

the preferred method when the specific replication of a technique or movement form is the primary learning goal (e.g. gymnastic or dance movement). A demonstration is likely to be successful when the strategy required for effective performance is clearly highlighted and the learner has the necessary motivation and motor ability to reproduce the action. A demonstration may be less effective when used to try and refine or scale an existing movement pattern (Horn & Williams, 2004).

When the goal is to help the learner to achieve a particular outcome that is not directly dependent on the replication of a specific technique (e.g. passing the ball towards a target), a demonstration may be no more effective than verbal instruction. The argument 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). In recent years, researchers have tried to determine how demonstrations may guide or constrain the learning process while ensuring that the learner has some degree of autonomy. For example, it has been suggested that a demonstration should always be coupled with its outcome effects so that learners are encouraged to problem-solve and determine how their actions and effects are related (Hodges & Franks, 2004a,b). This process engages learners in the problem-solving process, encouraging them to take greater responsibility for their learning and find novel solutions to the problem at hand.

A more extreme viewpoint is that the learners' attention should be guided almost exclusively towards the goal of the action (see Wulf *et al.*, 1999). This external, goal-focused instruction is presumed to be beneficial since it does not constrain the learner to reproduce an inappropriate movement pattern (the so called constrained-action hypothesis; see Wulf, Lauterbach, & Toole, 2001; Wulf & Prinz, 2001). For example, Hodges, Hayes, Eaves, Horn and Williams (2004) showed that participants who viewed a demonstration of the expected ball trajectory in a soccer chip shot produced better performance on a retention test than a matched group of participants who observed the entire movement pattern. The movements displayed by the participants who viewed the dynamic template of the skilled player's ball trajectory were also similar to that of the model even though they had never seen the model's movement form.

Another technique that may be used to encourage learners to explore various solutions to the movement problem, while at the same time providing some degree of constraining information, is to ask them to focus on the movement's end-point (see Hodges *et al.*, in press; Mataric and Pomplun, 1998). For example, Hodges, Hayes, Breslin and Williams (in press) showed that presenting a video of the model's toe was just as effective as being able to view the entire body when imitating the chip pass technique in soccer. Similarly, Mataric and Pomplun (1998) reported that when observing a grasp motion involving the whole arm, observers directed their attention towards the movement end-point (i.e. hand and fingers). The key issue is that there may be many different ways to achieve the same end result and learners should be encouraged to explore these opportunities so as to develop flexible and adaptable movement patterns.

In a similar vein, participants who view a *learning* model have been shown to produce better eventual performance than a matched group of learners who observe a *correct* or *skilled* model, particularly when the learner is able to hear the prescriptive feedback provided by the coach to the learner (see, for example, McCullagh & Caird, 1990). The learning model can encourage the learner to partake in some degree of error detection and correction. It may also be helpful to allow the learner to observe demonstrations from a variety of people so that they can appreciate subtle variations in technique and how these may alter ball flight characteristics. A final suggestion is that it may be beneficial to provide the learner with an opportunity to practise the skill before observing a demonstration (Weeks & Anderson, 2000). Coaches should consider providing simple verbal instruction as to the intended outcome of the skill (e.g. "Can you pass the ball into the 'near post' region?") rather than on how this outcome should be achieved (Hodges & Franks, 2002). Demonstrations may then be introduced selectively as and when needed to prompt and guide the learning process.

The important message is that the widespread acceptance of demonstrations as an essential method of conveying information to the learner should be questioned. Although demonstrations usually facilitate the instruction process, they are sometimes no more effective than verbal instruction and, in certain instances, they may actually hinder the learning and long-term retention of motor skills. The difficult task for the coach is determining how and when to demonstrate so that learners are not overly constrained and are able to develop a movement pattern to suit their individual needs.

Myth 2: Specific, blocked practice of a single skill is essential for skill learning

An important question for the coach is how best to structure practice for effective learning. Skills can be practised in a blocked or random manner under constant (specific) or variable conditions. It is traditional for coaches to begin the instruction process with blocked, constant practice of a single skill before progressing via grid and drill practices towards random, variable practice conditions as personified by small-sided games and match-play. This progression is highlighted by the shaded zone and directional arrow presented in Figure 3. A potential criticism of this approach is that coaches move too slowly along the continuum, highlighted by the arrow running from the bottom-left to the top-right corner of the figure, preferring the security of grid and drill type practices to the instability presented by conditioned games and match-play. The problem is confounded by the fact that coaches typically judge their effectiveness by observing players' performance during the practice session. The difficulty for coaches is that considerable evidence exists to suggest that several of the interventions used during the instruction process affect performance and learning in different ways. We consider some of this evidence below and challenge popular conceptions of how practice should be structured for effective learning.

According to traditional cognitive models of motor skill learning, such as Schmidt's (1975) schema theory, variability in movement and context characteristics is essential to develop a more expansive, generative rule or generalized motor program to cope with a variety of similar but different situations. The presumption is that when variability is introduced into the practice environment, the learner has to parameterize the motor program differently from one trial to the next resulting in a more flexible and adaptable movement schema (Schmidt & Lee, 1999). In a similar vein, more recent theorizing from the perspective of dynamical systems theory argues that variability in practice and movement provides the learner with a larger "workspace" and greater opportunity to search and discover the laws that organize information and action (Davids, Williams, Button, & Court, 2001; Davids, Button, & Bennett, in press).

Although there have been few well-controlled studies using complex sport tasks, research using novel laboratory-based tasks has demonstrated fairly conclusively (albeit with some concerns; see Van Rossum, 1990) that while specific or constant practice (i.e. one skill, no variations in conditions) results in better performance during acquisition, variable practice (i.e. different variations of the same skill) results in better learning when tested using a delayed retention and/or transfer test (see Lee, Magill, & Weeks, 1985). The benefits of variable practice appear to be particularly pronounced with children (e.g. see Wulf, 1991; Yan, Thomas, & Thomas, 1998) and when the schedules of practice are somewhat unpredictable (see Handford, Davids, Bennett, & Button, 1997). When teaching children the soccer instep pass, for instance, coaches should ensure that they vary the practice conditions by manipulating factors such as distance, speed, height or direction of pass, and that the practice session mimics the range of variations experienced during a match.

Another important issue for coaches to consider is whether to practise the skill in a blocked or random manner. The extent to which the coach emphasizes

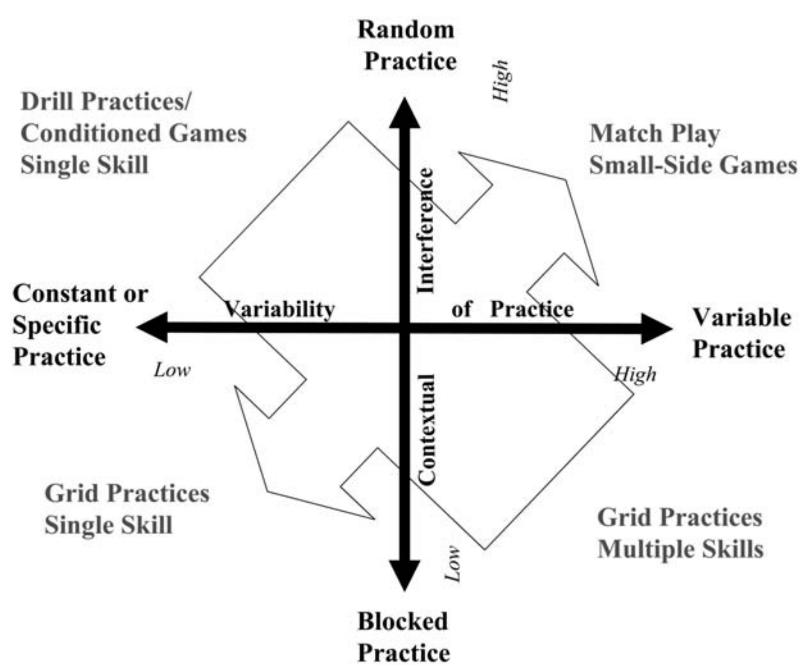

Fig. 3. The relationship between variability of practice, contextual interference and practice activity (adapted from Stratton *et al.*, in press).

one type of schedule over the other determines the degree of contextual interference presented within each practice session (Battig, 1979). A low contextual interference practice schedule may involve practising one skill per session, or perhaps two separate skills (e.g. shooting and passing) in blocks of 20 – 30 min each (i.e. blocked practice). Higher levels of contextual interference would arise if a variety of skills (e.g. shooting, passing, dribbling) were practised in a somewhat random manner throughout the session (i.e. random practice). In the most random practice schedule, a player never practises the same skill on consecutive trials.

The assumption is that although random practice has detrimental effects on performance during acquisition, it facilitates learning either by encouraging the performer to undertake more elaborate and distinctive processing from one trial to the next (i.e. the elaboration hypothesis; see Shea & Morgan, 1979) or through the forgetting and subsequent reconstruction of an action plan each time a skill is performed (i.e. the action plan reconstruction hypothesis; see Lee & Magill, 1985). Alternatively, random practice may broaden the learning workspace, thereby allowing more opportunity for players to engage in discovery learning to find different solutions to each movement problem presented (Handford *et al.*, 1997).

A random or high contextual interference practice schedule, while detrimental to short-term performance, is better for long-term retention and learning than blocked conditions. These findings have been demonstrated using sport-related skills such as badminton (Goode & Magill, 1986), baseball (Hall, Domingues, & Cavazos, 1994) and basketball (Landin & Herbert, 1997). The clear message is that to promote learning coaches should try to avoid repetitious, blocked practice by presenting a variety of skills within the same session. The benefits of random practice also appear to be enhanced when skills differ more markedly (e.g. dribbling and the chest pass may be more distinct than the chest pass and the overhead pass in basketball) (for an interesting discussion, see Brady, 1998). One exception to this rule may potentially arise very early in learning, when there is some empirical evidence to suggest that blocked practice may have some benefits over random practice (Shea, Kohl, & Indermill, 1990).

The important message is that while specific, blocked practice is better for performance, variable, random practice is more effective for skill learning. The question of when to introduce variety and random practice conditions presents an interesting challenge for the coach. The task is one of maintaining positive performance effects on the one hand, so that learners remain motivated to practise, while encouraging effective learning on the other (Simon & Bjork, 2001). Although coaches have the natural inclination towards introducing variable, random practice as the learner progresses, typically this progression may occur at a slower rate than optimal. Coaches may wait for performance to improve before moving on to more difficult practices. Coaches should try to evaluate performance over an extended period of time (e.g. several practice sessions) rather than during a single session and consider whether players would benefit from an earlier progression towards more variable and random practice conditions. A radical view, for which there is some scientific support, would be to dispense with specific, blocked practice altogether and to start with variable and random practice through small-sided and conditioned games. Perhaps this shift from grid and drill practices towards small-sided games and matches may be indicative of the perceived success of "street football" in developing elite players in bygone years.

Myth 3: Augmented feedback from a coach should be frequent, detailed and provided as soon as possible after the skill has been performed

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 skill and influences the learner's motivation to persist with practice. Traditionally, coaches have tended to provide copious amounts of feedback in the belief that "more is better" for the effective acquisition of soccer skills. 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.

Feedback is available as a natural consequence of performing an action, often referred to as *intrinsic* feedback. For example, a performer will be able to see, feel and sometimes hear the consequence of a pass in soccer without receiving any *extrinsic* or *augmented* feedback from the coach. What might be missing in these situations is information concerning the exact location or precision of the pass, particularly if a long pass was delivered and other players obscure the passer's line of vision. Also, more detailed information concerning the ball's trajectory and the technique employed may be missing, such as the maximum height of the ball, its time to reach peak velocity and the position of the hip, knee and foot during and after the pass has been executed. Information provided about the outcome of an action such as the exact distance that the ball travelled or the degree of error from the target is referred to as "knowledge of results". Information about *how* the movement was executed is referred to as "knowledge of performance". Verbal statements or video feedback pertaining to the player's technique would be considered knowledge of performance.

Coaches need to be aware of how these different sources of feedback work both alone and in conjunction with other instructional techniques. This knowledge is essential so that coaches can determine *when* and *how* augmented information should be provided to best encourage learning. Important questions to consider are how often should augmented feedback be provided, how precise this should be and when it should be provided.

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. The key issue is that learners should be encouraged to rely on their own intrinsic feedback mechanisms rather than on information provided by the coach. Learners must eventually perform without augmented feedback and unless they are encouraged to become active problem-solvers during practice, they will be unable to adequately draw upon their own intrinsic processes to guide performance when augmented feedback is removed. The optimal frequency of augmented feedback appears to be dependent on the player's stage of learning as well as the complexity or difficulty of the task. In the initial stages of learning or when the task to be learnt is fairly difficult, players may require feedback more frequently to improve performance (Wulf, Shea, & Matschiner, 1998). As skill develops, the frequency of feedback provision may be reduced or "faded out" to encourage learners to detect and correct their own errors.

The negative effects of providing feedback too frequently can also be overcome if learners are encouraged during practice to evaluate their own performance in the interval between the end of the action and the provision of feedback. This technique may be encouraged simply by increasing the interval between the action and presentation of augmented feedback, allowing the learner time to process and evaluate error information from the preceding practice attempt (Swinnen, Schmidt, Nicholson, & Shapiro, 1990). A question and answer approach should also be encouraged so that learners are explicitly directed to focus on certain aspects of the movement during this time (see Liu & Wrisberg, 1997).

Other methods that may be employed to decrease learners' reliance on augmented feedback are highlighted in Table 1. These techniques include a reduction in the relative frequency of feedback provision, providing only summary feedback after a series of practice trials, or allowing performers to determine when they feel more information would be useful (for detailed reviews, see Swinnen, 1996; Wulf & Shea, 2004). The process of gradually reducing or "fading out" the amount of feedback available during practice has the dual benefit of ensuring that movements are consistent and well informed early in practice, thereby helping to motivate the learner, while reducing potential guidance effects as practice progresses. It is crucial for the coach 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. Also, because the reduction in feedback frequency encourages problem-solving, the performer is likely to develop skills that transfer effectively to similar situations (Magill, 1988).

The nature of the feedback presented and its precision may also interact with the optimal frequency of feedback. For relatively simple movements, feedback often provides both a descriptive role, alerting the learner of the error committed, as well as a prescriptive role, informing the performer as to what to do to correct the error. For example, feedback concerning how a simple instep pass in soccer was too long or short provides enough

Table 1. Techniques that can be employed by coaches to "fade out" learners' reliance on prescriptive feedback

Summary feedback	Feedback provided as a 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 versus 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?")

information for the learner to alter performance on the next trial by adjusting the "weight" of the pass. As the complexity of the pass or skill increases, the adjustments required to facilitate performance on subsequent practice attempts may not be readily apparent and consequently the absence of prescriptive guidance from the coach may encourage learners to become more involved in the problem-solving process (Wulf & Shea, 2004). The implication is that early in learning or when the task to be learnt is fairly difficult, players may require prescriptive feedback to improve performance, whereas later in learning descriptive feedback should suffice (Wulf *et al.*, 1998).

There is also evidence to suggest that the precision of feedback should be increased with more difficult tasks and/or as performance improves (Magill & Wood, 1986). The suggestion is that skilled performers require more detailed information to initiate further refinements to the task, particularly when the task is very difficult. These latter statements may initially appear at odds with some of the earlier conclusions in relation to feedback frequency. The distinction is that while the frequency of feedback provision should decrease as skill develops, the level of precision may be increased and there should be a qualitative shift from prescriptive to descriptive feedback. The important message for coaches is that learners should be viewed as active problem-solvers rather than "empty vessels" or passive recipients of information.

Myth 4: Prescriptive coaching is always better for skill acquisition than instructional approaches based on learning by guided discovery

A factor underlying much of the discussion in preceding sections is the philosophy adopted by the coach during the instruction process. The approach favoured is essentially prescriptive or "hands-on", the belief being that the coach possesses all the necessary knowledge and that this information must be passed on to the learner. This authoritarian approach is personified by the frequent use of demonstrations and verbal instruction when conveying information to the learner, and the over-abundance of augmented feedback and guidance as to how behaviour should be modified on subsequent practice attempts. The coach typically has a criterion or goal standard model for the skill in question and the overall aim is to cajole the learner to mimic this particular movement pattern.

A common theme throughout this review is that an approach which is overly prescriptive may be detrimental to skill acquisition. Recent evidence 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 recently by many scientists and practitioners (see, for example, Araújo, Davids, Bennett, Button, & Chapman, 2004; Davids *et al.*, 2001, in press). The emphasis when learning by guided discovery is on players taking responsibility for their own development, finding unique solutions to movement problems through exploration and discovery. These more "hands-off" approaches may be more effective in developing "smart" learners who are able to apply their skills in a variety of performance situations (i.e. what has been termed "adaptive" rather than "routine" expertise; see Holyoak, 1991).

The renewed interest in less prescriptive approaches is partly due the development of alternative theoretical perspectives based on ecological psychology and dynamical systems theory (for reviews, see Beek, Jacobs, Daffertshofer, & Huys, 2003; Davids *et al.*, 2001; Williams, Davids, & Williams, 1999). These perspectives view the performer as a dynamic and complex system with the observed pattern of behaviour being a by-product of the unique constraints imposed on the learner. According to this viewpoint, movement coordination is achieved as a result of learners adapting to the constraints imposed on them during practice. These constraints include the individual characteristics of the learner, the nature of the task and the environmental conditions. The relationship between these constraints and the emergence of movement behaviour is illustrated in Figure 4.

The individual characteristics of the learner include chronological and biological age, body morphology, fitness levels, perceptual and cognitive development, and emotions such as anxiety and self-confidence. Important task constraints include the rules and laws of the game, any conditions imposed by the coach and the equipment employed, such as the size of the ball (i.e. scaling of equipment relative to body size). Environmental constraints include the playing surface and weather conditions as well as access to different sources of sensory information, such as vision and proprioception. Coaches are encouraged to manipulate these constraints such that the desired behaviour emerges through guided discovery and self-exploration rather than via prescriptive instruction. Some examples of how constraints may be manipulated to encourage effective learning in soccer are highlighted in Table 2. A

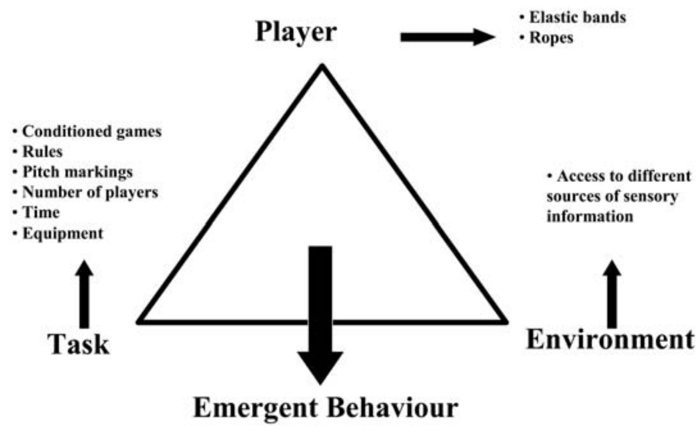

Fig. 4. A constraints-based model of skill acquisition (adapted from Newell, 1985).

more detailed review of this topic is provided elsewhere (see, for example, Araújo *et al.*, 2004; Davids *et al.*, in press; Lavalle, Kremer, Moran, & Williams, 2003).

If the philosophy endorsed by "constraints-led" approaches to instruction is to be embraced, the challenge for coaches is to determine how best to create practice opportunities for players to learn on their own. This task does not imply that the importance of coaching is diminished, merely that the role needs to be re-defined so that there is greater awareness of how coaches can shape and guide rather than dictate the learning process. The successful implementation of such an instructional approach may require that parents, administrators and players are aware of the philosophy underpinning the instruction process. Unfortunately, some coaches feel the need to justify their existence and consider that this is best achieved through a vociferous, authoritarian style. Perhaps the saying "children should be seen but not heard" should occasionally be extended to coaches given the preceding discussion.

Myth 5: Game intelligence skills are not amenable to practice and instruction

Although this review has mainly focused on the acquisition of motor skills, there is a need to increase awareness of various myths that have been perpetuated regarding the development of perceptual-cognitive skills, such as anticipation and decision-making. In lay terms, these skills are often referred to as "game intelligence" (see, for example, Stratton, Reilly, Richardson, & Williams, in press). The elite soccer players' superior game intelligence when compared with their sub-elite counterparts is now well documented (see, for example, Williams, 2000; Williams *et al.*, 1999). The general viewpoint shared by many coaches, however, is that these skills are innate and not amenable to practice and instruction. Coaches consider that game intelligence improves purely as a result of playing experience and that it is not possible, or at best too difficult, to develop structured training programmes to improve these skills. In contrast to this intuitive perspective, compelling empirical evidence now exists to indicate that the acquisition of game intelligence skills can be mediated through appropriate interventions.

The general consensus is that interventions that develop the knowledge structures underlying anticipation and decision-making skill are likely to offer more practical utility for performance enhancement than clinically based programmes that attempt to improve basic visual function (for detailed reviews, see Williams & Grant, 1999; Williams & Ward, 2003). Skilled soccer players do not possess superior visual abilities – such as visual acuity, depth perception and peripheral awareness – when compared with less skilled performers and, consequently, there is little to be gained from attempting to improve these aspects of visual function beyond "normal" levels. Ward and Williams (2003) reported that performance on standard measures of visual function, typical of those employed by opticians or vision scientists, accounted for less than 5% of the variance in anticipation skill between groups of elite and sub-elite soccer players ranging in age from 8 to 18 years. Although a few published studies indicate that performance on standard tests of visual function can be improved through specific eye exercises (sometimes referred to as "eyerobics"; see Revien, 1987), the absence of some measure of transfer to determine whether the observed improvement facilitates performance in the field setting ensures that the validity of this work is easily questioned. Similarly, researchers have neglected to employ suitable control (i.e. completed pre- and post-test

Table 2. Examples of how certain behaviours can be encouraged during practice by manipulating various constraints.

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

only) and/or placebo (e.g. technical training) groups to eliminate the potential confounding effects of test familiarity or habituation.

A growing body of research exists to indicate that perceptual-cognitive skills can be enhanced through appropriate interventions and, more importantly, that this improvement transfers to the performance context. The typical approach has been to film the event (e.g. soccer penalty kick) from the perspective of the learner (i.e. goalkeeper) and to provide instruction as to the specific postural cues (e.g. orientation of the penalty-taker's hips or non-kicking leg) underlying effective anticipation. Feedback is provided about the expected response requirements and to ensure refinement of the skill on subsequent practice attempts. Such an approach has been used to improve anticipation performance in closed-skill tasks such as the penalty-flick in field-hockey (Williams, Ward, & Chapman, 2002a) and in returning forehand and backhand drive shots in tennis (Williams, Ward, Knowles, & Smeeton, 2002b). Field-based practices have also been developed to improve players' abilities to pick up advance information cues from an opponent's postural orientation (e.g. see Willliams, Ward, Allen, & Smeeton, in press). Recent advances in virtual reality technology offer many exciting opportunities for those interested in creating realistic simulations for the purposes of performance enhancement (Williams & Ward, 2003).

There have been few attempts to improve other perceptual-cognitive skills, such as a player's ability to identify opponents' patterns of play or to predict the passing options facing an opponent in possession of the ball. The variability inherent within dynamic open-play in soccer ensures that the development of appropriate interventions is a more complex proposition than envisaged for closed skills such as the penalty-kick. However, research using American football and volleyball suggests that pattern recognition skills can be improved through repeated exposure to a variety of related action sequences (see Christina, Barresi, & Shaffner, 1990; Wilkinson, 1992). A suggestion is that exposure to different types of offensive sequences (e.g. patterns of play involving overlap runs, split runs or "third man running") via video simulation can facilitate the recognition of similar patterns of play in soccer. Similarly, there is recent evidence to suggest that knowledge of situational probabilities can be trained (see Williams, Heron, Ward, & Smeeton, 2004). The proposal is that the presentation of quantitative statistics and/or video footage regarding the moves and actions typically performed by forthcoming opponents improves players' abilities to make accurate predictions regarding the opposition's intentions during the match. The take home message is that players' perceptual-cognitive skills are amenable to practice and instruction and, consequently, important tasks for coaches are to determine how best to design, implement and evaluate such training programmes.

Summary and conclusions

The aim of this review has been to summarize contemporary research on motor learning, particularly as it relates to the acquisition of soccer skills. We wished to highlight several potential myths about practice and instruction that have permeated coaching doctrine in soccer. Initially, we highlighted the important role that practice plays in the acquisition of expertise. The motivation to succeed and the commitment to practice are perhaps the most important attributes to possess on the road to excellence.

A model of instruction was then presented and used as a framework for much of the ensuing discussion. The traditional belief that demonstrations are essential for effective instruction was questioned. We identified the conditions under which demonstrations may be detrimental to skill acquisition and highlighted the need to direct attention to the action effects, rather than the actual bodily consequences. Next, we highlighted the importance of variable and random practice conditions and argued that coaches may be too conservative when structuring practice, preferring the stability and security of grid and drill practices over more dynamic small-sided games. The importance of encouraging players to take responsibility for their learning by developing effective problem-solving skills was highlighted. A variety of techniques were identified that may help coaches "fade out" the importance of augmented feedback early in learning. The merits of the traditional, prescriptive approach to coaching were then considered and evidence was presented to illustrate how a more "hands-off", less prescriptive approach based on learning through guided discovery may offer several advantages in developing "smarter" players. Various examples of how to manipulate the constraints evident within the learning environment so that the desired behaviour emerges through guided discovery were illustrated. Finally, we presented evidence to demonstrate that "game intelligence", skills such as anticipation and decision-making, are amenable to practice and instruction and suggested that such interventions should be routinely used in the talent development process.

Popular coaching beliefs have been challenged to highlight the important role that sport scientists with a background in skill acquisition can play in developing elite players. The material presented should encourage coaches to reflect on their current beliefs and appreciate the need to embrace a culture where "evidence-based" practice permeates all aspects of the profession. At the very least, the discussion should provide "food for thought" and encourage coaches to integrate and apply some of the principles outlined in developing future generations of elite performers.

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