Talent Development & Excellence
Vol. 2, No. 2, 2010, 165–179

The Role of Ecological Constraints on Expertise Development

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Abstract: The role of ecological constraints on the acquisition of sport expertise is gaining attention in sport science, although more research is needed. In this position paper we provide an ecological explanation for expertise acquisition, as alluding to qualitative data that support the idea that unconventional, even aversive, environmental constraints may play an important role in the development of world-class athletes. We exemplify this argument by profiling the role of unconventional practice environments using association football in Brazilian society as a task vehicle. Contrary to the traditional idea that only deliberate training and development programmes can lead to the evolution of expertise, we propose how expert performance might be gained through highly unstructured activities in Brazilian football, that represent a powerful and little understood implicit environmental constraint that can lead to expertise development in sport.

Keywords:

ecological psychology, environmental constrains, development, expertise, association football

Sport expertise develops through interactions between an individual and specific performance environments (Davids & Baker, 2007; Farrow, Baker, & MacMahon, 2008). There have been some attempts to explain facilitative and structured characteristics of the environment (e.g., material facilities, coaching, family support networks) in the acquisition of expertise (Côté & Fraser-Thomas, 2008; Davids & Baker, 2007). In this position paper, we argue that the environment–performer interaction is most important in this process, contrary to the traditional organismic asymmetry (Dunwoody, 2006) observed in theoretical explanations of expertise acquisition in sport. The converse of this argument is that 'environmental asymmetry' will also not provide an adequate explanation of expertise acquisition. We argue that research on expertise, which has examined the role of environmental constraints in formally organized sports training programs, might be limited in scope (Davids & Baker, 2007; Starkes, Helsen, & Jack, 2001). In some societies more informal and even aversive environmental constraints exert a powerful, and little understood, influence on the acquisition of expertise in specific sports. Here we examine one example, football in Brazil, but expertise researchers need to identify other similar examples, such as ice hockey and basketball in the United States, or cricket in India and Australia (Phillips, Davids, Renshaw, & Portus, in press; Weissensteiner, Abernethy, Farrow, & Müller, 2008). Due to differences in athlete backgrounds, evidence suggests that the acquisition of expertise follows idiosyncratic pathways (Phillips, Davids, Renshaw, & Portus, 2010). In our analysis, we examine ecological theories and empirical research in a

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ISSN 1869-0459 (print)/ ISSN 1869-2885 (online)

http://www.iratde.org

systematic, but not exhaustive, literature review with a particular emphasis on research on Brazilian football. In support of these arguments we allude to qualitative data in the form of document analysis and verbally reported information from existing and past football experts in the public domain. Overall, we attempt to show how the path to expertise can emerge under multiple interacting constraints, as described by a dynamical systems theory approach (Phillips et al., 2010), and how it can be constrained by apparently aversive, unconventional learning contexts during development. These observations indicate the need for an ecological theory, such as Bronfenbrenner's bioecological framework (e.g., Bronfenbrenner & Morris, 2006), as a starting point to organize the study of all the multi-level dynamics of the different sub-systems involved in the acquisition of expertise. Our analysis of Brazilian football reveals the need for further work on studying the role of informal, unconventional environmental constraints on the development of expertise in sport. Undeniably high levels of football expertise exist in Brazil, whose players have achieved highly in international football, and whose national teams have won five World Cups, besides accumulating victories at younger age groups, and with their female, futsal, and beach-football teams. We start by examining some current literature on the acquisition of expertise, with an emphasis on environmental constraints, interpreting the ideas with Bronfenbrenner's bioecological framework.

How to Understand Sport Expertise: The Role of Ecological Psychology

A recent review concluded that: (i) the expert's advantage is selective to only some components of performance; (ii) experts use different sources of information to control their actions compared to non-experts; and (iii), practice and developmental experiences of experts differ from non-experts (Abernethy, 2008). With regard to the last point, Côté and Fraser-Thomas (2008) argued that coaching, play and practice are key variables that significantly influence the skill acquisition process. They highlighted the need to consider in skill acquisition, not only training time and specialized practice, but also physical and psycho-social constraints, such as injuries and enjoyment. They concluded that there were many unresolved questions regarding the amount and type of play and practice activities required at different stages of an athlete's progression towards expertise. Indeed, Davids and Baker's (2007) review highlighted that an increasing number of studies have considered the important influence that environmental constraints have on the acquisition of sport expertise. For example, the historical emphasis that a nation or community places on a particular sport can have a significant influence on international competitive success (e.g., Canada with ice hockey, Kenya with distance running, Brazil with football, Jamaica with sprinting, Australia with Cricket). Clearly, more research is needed to clarify the role of socio-cultural constraints in the acquisition of sport expertise. Currently, much more research has been conducted on specific practice environment variables such as the quantity and type of practice, and access to social and physical resources (Davids & Baker, 2007). Analysis of environmental constraints may be interpreted through the framework of ecological psychology (Araújo & Davids, 2009).

From an ecological perspective, it is important to understand how some individuals are able to interact with environmental constraints in a specific performance context, functioning effectively with available physical and social resources (Araújo, 2007). Therefore, an important part of exhibiting expertise involves realizing actions, which are consistent with socio-cultural mores (Barab & Plucker, 2002). Social, historical, and possibly other external processes need to be considered as integral constraints on skilled action. The performance of an expert should be conceived as being influenced by an interaction of external and internal constraints (Barab & Plucker, 2002). Only through acknowledgement of the ecological nature of expert performance can meaningful practice contexts be designed. In this analysis, Bronfenbrenner's bioecological framework may provide a useful start point.

Bronfenbrenner's Bioecological Model to Guide Research on Expertise Development

To understand sport expertise, multi-scale and multi-disciplinary theoretical descriptions are needed (for a good example see Phillips et al., 2010). Bronfenbrenner's bioecological model (e.g., Bronfenbrenner & Morris, 2006) provides an evolving theoretical framework for analysing how the environment shapes human development throughout the lifespan (see also Bronfenbrenner, 2005). An important characteristic of the model is its interdisciplinarity and its integrative focus on youth, as well as policies and programs for enhancing youth development. Bronfenbrenner was also influenced by systems theory in biology, emphasizing interaction, change and stability over the lifespan. He explicitly acknowledged the importance of time for understanding human development (Krebs, 2009).

The defining four interactive dimensions of the bioecological model are process (e.g., quality of practice according to the individual), person (e.g., somatotype), context (e.g., parents involvement) and time (e.g., a practice session, a career; Bronfenbrenner & Morris, 2006; see Figure 1). Davids and Baker (2007) noted effects of interacting constraints on the development of expert performance, despite variations in genetic structure, since high heritability of particular traits is clearly influenced by environmental components. For example, the approach of Weissensteiner et al. (2009) is generative in its methodological approach, and has emphasized the role of critical constraints. This is an invaluable contribution to our understanding of expertise in sports, which provides conceptualization beyond the limitations of existing research (see e.g., Williams & Reilly, 2000). However, their approach contrasts with the approach taken in this article in several meta-theoretical aspects. For example the model presented by Weissmentreiner et al. (2009) interpreted the individual athlete and the environment as separate and interactive. This dualist approach is characterized by viewing the socio-cultural background as sustaining individual characteristics (e.g., cognitive, perceptual and technical). An ecological approach focuses on individual adaptability in evolutionary functional contexts and views the individual and environment as equally contributing to the relevant scale of analysis for understanding human behaviour and performance. In line with this focus, expert performers are not seen as an aggregate of attributes, factors or components, but

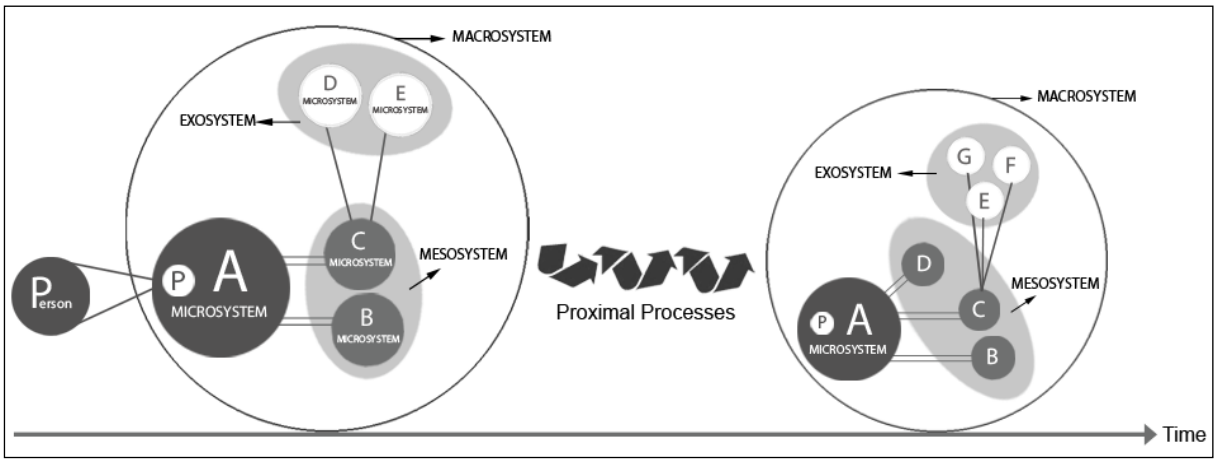

Figure 1. Pictorial description of Bronfenbrenner´s bioecological model. N.B.: Concerning the context, only microsystems are physically located. The others are "system forces", i.e., describing how other microsystems influence the person and the particular microsystem under analysis. The mesosystem is formed by other microsystems frequented by the person. The exosystem is formed by the microsystems that are not frequented by the person under analysis, i.e. those which influence the mycrosystem under analysis. The macrosystem is a network of microsystems of a certain culture delimited by the researcher. Beyond the person and the context, the bioecological model includes time and process. Process describes the characteristics of person-context interactions over time. Also, person and context change over time.

active individuals engaged in dynamical transactions with their functionally-defined environments (Araújo, 2007). Also, it is important to note that although Weissensteiner et al. (2009) discussed the role of the environment, they did not directly present explicit processes for how interactions between individuals and a particular environment might occur. When they referred to attributes and factors, they described components that exist in an individual, with allusions to context simply being the foundation for the possession/acquisition of expertise, not its ontological existence. Much of the discussion in Weissensteiner et al.'s (2009) study concerned how context enriches the internal factors acquired by performers, i.e., how the environment "molds essential player characteristics for task success" (p. 280). This "identification of the important components" (p. 291) contrasts sharply with how individuals and contexts co-determine each other through ecological practice (Barab & Plucker, 2002). Instead of a performance that is dependent on the internal functioning of linked components, which interact but are not co-determinate, both individual and environment have the potential to be impacted and transformed by the interactions. The ecological dynamics approach that may be initiated with Bronfenbrenner's bioecological model (Bronfenbrenner & Morris, 2006) views dynamics as dominated by these interactions, by highlighting the capability for self-organization and expression of emergent properties. Apart from exhibiting this organismic asymmetry (Dunwoody, 2006) at a meta-theoretical level the studies of Weissensteiner et al. (2008, 2009) provided important evidence for the role of informal environmental constraints on the development of sport expertise.

In highlighting this issue in their work, we draw attention to Bronfenbrenner's views about the environment, in which he emphasises the interactions between the individual and the behavioural process, along historical and personal timescales (see Figure 1). Therefore, examples from the existing literature about the nature of environmental constraints on the acquisition of expertise, particularly related to Brazilian football, are interpreted with insights from the bioecological model. In 1979, Bronfenbrenner conceptualized the environment in terms of nested systems: the microsystem, mesosystem, exosystem and macrosystem. These nested sub-divisions form the basis of our exposition in the following section of the paper.

Bronfenbrenner's Microsystem

The foundation of the bioecological framework is the microsystem, defined as a pattern of activities, social roles, and interpersonal relations experienced by the developing person in a given setting with particular features that influence engagement with the immediate environment. Therefore, effects of the physical environment in football, such as the quantity and the quality of practice, facilities, types of surfaces, or ball materials afford exploration that influences development. This topic is explored on this article using Brazilian football practice as a task vehicle to show how uncommon, even aversive, social and self-generated exploration can be.

Previous research has proposed the importance of the power law of practice as the basis for performance improvement (Newell & Rosenbloom, 1981). Although this apparent power law characteristic of practice has been exposed as an artefact of group analyses, more recently, it has been argued that the amount of *deliberate practice* – intense practice requiring concentrated effort to specifically improve performance – is predictive of expertise attainment (Ericsson, Krampe, & Tesch-Römer, 1993; Ericsson, 2007). Other work has suggested that it is not simply the total amount of practice that is important, but also the nature of experiences during practice that is critical to the acquisition of expertise (Côté, Baker, & Abernethy, 2007). It has been observed that experts do spend more time overall in practice, but also devote more time participating in specific activities which are most relevant for developing essential skills for the highest level of performance. Recent evidence (e.g. Côté et al., 2007) in several sports suggested that although deliberate practice may be critical, so too may be exposure, during development, to many hours of games that resemble sports – the concept of *deliberate play* (Coté & Hay, 2002). Deliberate

play consists of activities, such as "street matches/backyard games", that encourage adaptive skill, creativity and improvisation and role-playing rather than pure sport skill repetition, where enjoyment rather than skill improvement, is the main participant motive. This idea fits with data from long-term studies of Soviet and Russian swimmers demonstrating that athletes with better results in international adult competitions undertook smaller training volumes and had poorer results in age-group competitions when younger (Barynina & Vaitsekhovskii,1992; Bulgakova, Popov, & Partyka, 2002; Platonov, 1994).

The approach advocated by Ericsson and his colleagues (1993), where expertise is simply the end result of amassing a putative number of hours of deliberate practice, has come under some criticism. For instance, this approach reinforces the idea that specialization during early stages of development is necessary in order to attain elite performance as an adult. Early specialization is defined by an early start age in sport, an early involvement in one sport, an early involvement in high intensity formalised training, and an early involvement in high competitive sport (Baker, Cobley, & Fraser-Thomas, 2009). In fact, the early specialization approach has also been associated with several negative consequences in developing athletes (Baker, 2003), including the risk of burn out and dropping out of sport (Petlichkoff, 1993, see also Côté, Baker, & Abernethy, 2003). Moreover, there have been some inconsistent associations between early specialization and expertise acquisition (see Baker et al., 2009). Research indicates that sport is not the only domain where these inconsistencies have been observed. In the music domain there is a growing interest in informal learning that, according to Wright and Kanellopoulos (2010, p. 73), is defined as an "attempt to be immersed in intense situations of non-formal learning, and therefore results in the creation of non-traditional social learning environments, combining interactive, non-linear and self-directed processes". Moreover, qualitative data have indicated the existence of more than the one (i.e., traditional) route for music learning (Cope, 2002) and evidence suggests that musicians combine formal and informal learning strategies in their practice (Folkestad, 2005). Folkestad (2005) highlighted that in formal learning situations, both teacher and student are directed towards how to make music, whereas in the informal learning situations musicians are directed towards how to play music, raising the question of: should performers "learn to play or play to learn?" It seems that the relationship between practice and proficiency is more complex than originally thought, and depends on more than simply assessing the number of hours spent deliberately practicing.

There is some indicative evidence for the success of players who have received little systematic coaching. For instance, as stated by Salmela and Moraes (2004), Brazilian Football is quite intriguing, since many players aged 16 to 17 years, have received little, or any, structured coaching, in contrast to a multitude of unstructured football experiences played on the streets. Fonseca and Garganta (2008) interviewed elite players, elite coaches and sport scientists, in order to garner perceptions about the implications of unstructured football played on the street for game skill learning. In general, elite players revealed that they had widely experienced unstructured street football from very young, and they considered this type of activity at least as important as structured training, undertaken in later years. Moreover, all the interviewees corroborated the perception that unstructured football played on the street improved skill learning. The pleasure and the passion that a child gains from playing football and the possibilities for exploration, creativity and goal achievement under unpredictably variable performance conditions, were considered essential for developing football expertise. Players interviewed also considered that unstructured street football allowed them to become familiar with assorted features of the game, because it is feasible for players to try many skills in different conditions without fear of ridicule or recrimination from observing coaches. According to Rinus Michels (2001), designated by FIFA (Fédération Internationale de Football Association) as the *Coach of the Twentieth Century*, unstructured football played on the streets is a most natural learning environment. He argued that it is played daily in a

competitive form, under all sorts of conditions. He noted that, it is rare to see young players busy practicing isolated technical or tactical drills in an explicit way. On the contrary, learning almost always occurs implicitly within the competitive form of the street game, where children can learn from their mistakes, unaware of the technical, tactical, psychological and physiological abilities they are developing through their less formalized scrimmages. Indeed many generations of world-class Brazilian football players have mentioned the value of their early specialization in football through exposure to enjoyable, uncoached and unconventional practices. Importantly, their early specialization is in agreement with the definition of Baker and colleagues (Baker et al. 2009). However, these experiences contrast with traditional practices, mainly because of its variable, unstructured way of practicing, with high intensity, from an early age, and with an abundance of unplanned competitive situations (see Table 1). This kind of practice also differs from the notion of "deliberate play" highlighted earlier (Coté & Hay, 2002), in that these activities were not games that resembled football, but they were *real* football experiences practiced under changing ecological constraints. Similarities in the nature of the specific task goals, as well as a number of rules and conditions for that activity, were such that players and observers perceived that a football match was being played. These insights suggest a role for non-deliberate practice (or play) in expertise development, since these practices socially emerge and their purpose is not performance improvement *per se*, but intrinsic motivation and achievement (Araújo & Davids, 2009, Baker et al., 2009). As can be seen, Brazilian cultural constraints provide a rich and stimulating context for illuminating evidence on acquiring expertise in football (see Table 1). In this respect, an important activity practiced by all Brazilian footballers is *pelada*.

In the Brazilian football context *pelada* provides variable practice experiences ("nude" is a direct translation, perhaps alluding to the "naked" environments where these football games occur). It is the cultural term used to describe football played with adapted norms and rules in a variety of locations – such as streets, beaches, town squares, yards, courts and dirt fields (Fonseca, 2007). Pelé said of *pelada* that: "It is necessary to grasp these opportunities with one's fingernails. All those experiences, and that conviviality, helped me a lot in my preparation" (Manual do Atleta Inteligente, 2008, p. 48, our translation).

Table 1. Quotes From World Class Brazilian Football Players Identifying the Value of Their Early Specialization in Football by Means of Unstructured, Non-Coached and Enjoyable Practice (Our Translation)

Sócrates n/d Sócrates is one of the top 125 FIFA best players in history still. He played as a midfielder and striker in the Brazilian national team in the World Cups of 1982 and 1986.	We started playing football on the street with an avocado seed (…) the fact that I had learned this way was excellent. When you play in orchard, with irregular surfaces and surrounded by trees, there is a need for developing a bunch of abilities in order to prevent injuries. To not get hurt, and to you're your eye on the look to the ball and on the game, we also needed to keep an eye out for the mango trees and their roots on the ground.
Zico in Assaf & Garcia, 2003, pp. 28 Zico is one of the best Brazilian players ever; and the 14th best player of all time in the world elected by FIFA. Zico played as a midfielder in the Brazilian national team in the World Cups of 1982 and 1986.	I used to spend my whole day with the ball. Sometimes I made little sock-balls and sometimes I played with those rubber balls. I threw it at the wall and then I tried to master the ball alone in my room. Sometimes, I played as a goalkeeper and all those things gave us reflexes. Maybe, a portion of my ability is a result of all these practices.
Castro, 1995, pp. 38, Castro wrote Garrincha's biography Garrincha was a Brazilian right winger and forward who helped the Brazilian national team win the World Cups of 1958 and 1962. FIFA considers him the best Brazilian player ever after Pelé. He is also widely regarded as the best dribbler in football history.	Dribbling the ball barefeet, without twisting or damaging your ankle on uneven surfaces is a considerable feat in itself. Dribbling on the border of a slope and not allowing the ball to drop down was another great challenge. Garrincha performed both of these tasks in a very easy way. After losing control of the ball on the uneven surface so often he learned how to dribble on uneven surfaces and against the opponents. Garrincha really hated to go down a slope to retrieve the ball – so he tried not to let it drop out of control down there.

In a sample of 93 Brazilian woman elite players, Rosa, Costa, and Navarro (2009) identified the surfaces for football practices before and after players had reached 14 years of age. Findings are described in Figure 2.

In Figure 2 it is clear that all the contexts involved high levels of practice until 14 years of age. Moreover, the highest levels were associated with practice on streets and courts (i.e., futsal). The only surface more prominent in practice after 14 years of age is grass. Importantly, even after 14 years of age, players continue to be engaged in futsal, playing on cement and wooden surfaces, continuing their early diversification. However, this is not a diversification achieved by practicing a range of different sports (Baker et al., 2009; Côté, 1999). This experience exemplifies a 'diversification within specialization' in football.

Futsal is a 5 vs. 5 version of football that is played officially on indoor courts (FIFA official area is 40 m x 20 m). However, it is also played in unofficial ways outdoors on courts of different sizes. Its roots are associated with the scarcity of available football fields in the 1930s, with games taking place on empty basketball courts and other small-sized areas (Fonseca 2007; Tolussi, 1982). Futsal has been seen as another major contributor to the development of Brazilian football players, particularly in football schools. In 2002 (i.e., the last time Brazil won a World Cup) at least eight of the eleven players on the pitch, of the Brazil National Team, practiced Futsal (Fonseca, 2007). In a sample of 186 young male football players, Marques and Samulski (2009) found that 80.6% had played futsal. Rosa, et al. (2009) reported that, in a sample of 93 elite woman football players, 97.85% had played futsal. Thus, *pelada* is a broad description for the diversification of football practice task constraints. To better illustrate the *pelada*'s context, Table 2 summarizes the descriptions found in Freire (2006), Scaglia (1999, 2005), Silva and Chaveiro (2007), as well as Cabral and Neves (2007).

As observed in Table 2, *pelada* contrasts with traditional practice through unique constraints like: (i) its irregular surfaces (e.g., changing size, changing type, changing slopes), (ii) its competitive balance where players change from one team to another independent of the number of players in each team, their gender and their age to provide equitable competitive conditions, and (iii) its unplanned time schedule, and unpredictable

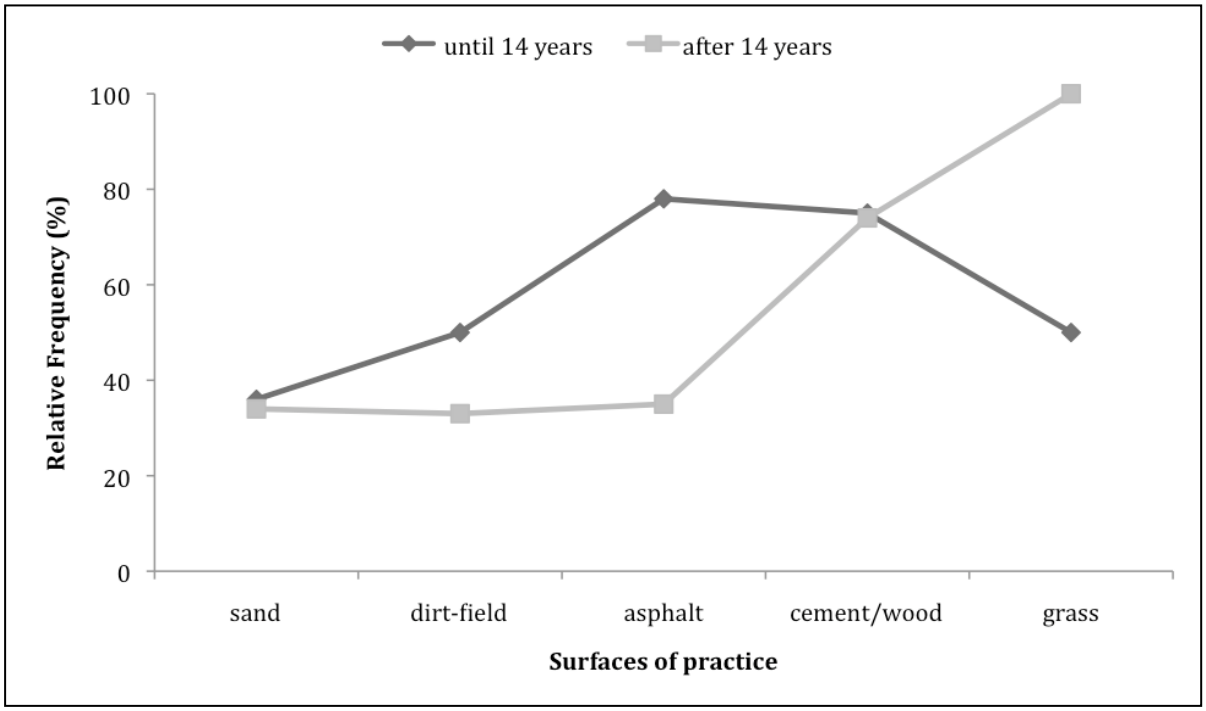

Figure 2. Surfaces used for football practice in Brazil before and after players reach 14 years of age (Rosa et al., 2009).

Table 2. Environmental and Task Constraints That Characterize Brazilian *Pelada* (See Text for References)

Local of practice	Street, beach, court, dirt-fields, formal fields, backyards or any available space. Different surfaces and conditions can generate different variations of football games.
Field dimension	Tacit, undefined and variable. The pitch can be constantly adjusted through implicit agreement amongst players, based on player's suggestions or to adjust to the particularities of the task, or of the local (e.g., before the building).
Facilities	Stones, shoes or bags are used as posts, and goal sizes can be modified according to the game. Game can be played with any kind of ball or something able to be kicked. Uniform can be t-shirts versus shirtless. Players also often are playing barefoot.
Team conditions	Adaptive and versatile. The number of players is adjusted to keep ongoing challenge, fun and well-balanced levels of competition. It can happen with different age-groups and gender playing together, with numerical disparity and different levels of ability.
Intervention	No coach or instructors intervention. Learning happens among players, who usually try to replicate skills performed by elite players or skilful friends.
Functions and tactical positions	There are no fixed positions or tactical arrangements. A player can change position or function many times during the game. And the actual game might help players arrange themselves in defensive and attack movements and positions.
Targets	Replicate the same technical movement or skill performed by a famous player. Try to execute something new or in a new way. Have fun with friends. Maintaining high levels of competition and challenges as criteria for the continuity of the game, besides winning.
Training sessions	The game happens until a number of goals have been scored, reach a set time or even players get tired or lose fun and enjoyment. During a whole day, the game might be stopped many times and restarted in an old or new configuration.

break times. From these findings it can be noted that Brazilian football players experience a range of games, contexts, surfaces, and cultural situations. Also it is evident that, when compared with experiences of higher social classes in other developed countries, the development of expertise occurs in apparently aversive contexts and follows different "norms" in local contexts. In Brazilian culture, it is clear that early specialization in football, developed through unstructured practice, without coaching interventions and full of fun and enjoyment, is possible.

At Bronfenbrenner's microsystem level, some of the secondary influences on behaviour (Baker & Horton, 2004) should also be considered at this level, such as coaching (Davids & Baker, 2007), interaction with peers and relative age effects (Musch & Grondin, 2001).

Bronfenbrenner's Mesosystem

Beyond the microsystem, the mesosystem is defined as comprising the relationships existing between two or more settings (i.e., microsystems). This level constitutes the family environment, or activities in the wider sport club beyond just training. (e.g., social and community activities). Importantly, parents play a critical role in promoting the athletic development of their children. Côté (1999) noted that athletes undergo stages of development and that resources provided by parents shift as athletes mature. Pelé, considered the best footballer ever, once observed that:

> My first experiences with the ball were promoted by my father. Since I was a boy he taught me some tricks and motivated me to perfect my natural talent. It was him who encouraged me to improve the heading skills and to kick with the left leg. If you don't work hard you will get nothing, said my father. (Manual do Atleta Inteligente, 2008, p. 46, our translation)

Bronfenbrenner's Exosystem

The next level of Bronfenbrenner's framework is the exosystem which comprises the linkages and processes between two or more settings. In these settings events occur that indirectly influence processes within the immediate setting (i.e., the microsystem) of the developing individual. A good example in sport involves certain aspects of the

demographics of expertise, such as birth location of the athlete. Consider the existence of locations without available places for practice. This may happen due to urban and geographical constraints. In these cases, if children want to practice they either have to travel to other locations with appropriate facilities or they have to use local unconventional facilities/surfaces to acquire skill, for example, when playing football on the slope of a hill, or in a middle of a street where cars and people are constantly passing. Locally, learners can engage in this type of practice whenever they want. In other regions, the saturation of practice locations, such as the fields of the local professional team, promotes the discovery of other surfaces for other players to practice (e.g., a tennis court or a small garden). In fact, evidence suggests that the size of the city in which an athlete develops may influence their likelihood of attaining elite level performance (Carlson, 1988). Individuals growing up in rural areas and smaller towns and cities have a higher probability of becoming professional athletes than those growing up in large cities, even though the latter may have access to superior sport facilities and more highly organized junior sport competitions. Côté, MacDonald, Baker, and Abernethy (2006) found that the optimal city size for athletic development appears to be between 1,000 and 500,000 people. This effect may be due to the possibility of developing athletes in smaller communities receiving more social support, and having available a greater amount of safe recreational space (Davids & Baker, 2007).

Bronfenbrenner's Macrosystem

This is the highest level in Bronfenbrenner's systemic approach and can be described as the broad socio-cultural context for the developing individual (e.g., national sport culture). The bioecological model indicates that the analysis of expertise acquisition is based on an intricate network of influences, which is somehow missed if we simply assume them as primary and secondary influences on sport expertise (Baker & Horton, 2004).

Contrasting with data from studies conducted in the US, Canada, Australia, and parts of Europe, Salmela and Moraes (2003) suggested different roles of coaching, families and cultural contexts for the development of expertise in countries with emergent economies and extensive lower socioeconomic classes, such as Brazil. Despite attempts to identify and organize the constraints for adequate long-term expertise development in young athletes, we know little about the role of macro environmental constraints. In a series of papers, Salmela and colleagues (e.g., Marques & Salmulski, 2009; Salmela, Marques, Machado, & Durand-Bush, 2006; Moraes, Rabelo, & Salmela, 2004; Moraes, Salmela, Rabelo, & Vianna, 2004; Salmela & Moraes, 2003) analysed experiences of Brazilian football players showing that, at junior level, the developmental pathways of squad Brazilian footballers (U18) differed from those of National squad footballers of other countries (Visscher, Elferink-Gemser, & Lemmink, 2009). The main differences were the more typical absence of familial support, specialized coaching, and adequate facilities in Brazil. Moreover, these players dedicated childhood time practicing football to the detriment of other activities, and they saw sport rewards as a possible path to improve their social standing and support their families. According to the Brazilian footballer Didi, one of the best midfielders of the world, "the boy who has an easy life doesn't have a chance in football because he doesn't know the value of a plate of food" (Manual do Atleta Inteligente, 2008, p. 47, our translation). Pelé also commented:

> My father was a football champion in 1946, but three, four years later he broke his knee and we started to have difficulties at home. My father was always my great idol, and I was observing his decline. At 13 years of age I had to work to help my family. I went to sell newspapers, to polish shoes and I thought that I wanted to be the same as my father; therefore, I was too much devoted to this work. When I worked in a boot factory I thought about abandoning the dream of being a player but all those difficulties helped me a lot to understand life and to value it. We were "hungry for playing"; I always put my heart into my football boots. (Manual do Atleta Inteligente, 2008, p. 47, our translation)

The narratives of Brazilian sportswriter Rodrigues Filho (2003) have highlighted that, since the introduction of football in the 1930s, Brazil has experienced two antagonistic

contexts of learning and practice. He described the experiences of higher social classes who played on manicured grass fields with many facilities and specialized instruction involving British coaches and Brazilian students recently graduated in Europe. Rodrigues Filho (2003) contrasted those experiences with that of the lower social classes, without access to football academies, coach education, and adequate material facilities. Consequently, they were compelled to produce their own footballs (e.g., sock balls) and play on the streets or fields of mud and stone, trying to express what they had seen at the professional games, changing the movements into new movement forms. Players from these lower social classes began to be accepted at small football clubs of higher classes, performing more skilfully than players from the football academies.

Bronfenbrenner's Interactive Dimensions

For Bronfenbrenner (2005), the power of developmental forces operating at any one system level of the environment depends on the nature of structures existing at the same or higher levels of the system. Bronfenbrenner (e.g., Bronfenbrenner & Morris, 2006) considers the joint interaction (i.e., the process) of the person with the environment over different timescales. This aspect helps, not only in organizing extant knowledge about sport expertise, but also in the search for environmental variables at different levels of analysis (micro, meso, exo and macrosystem). It considers different time scales (micro, meso and macrotime, both from a personal and from a broader historical perspective), the characteristics of the person, and the interactive nature of development (i.e., the process, Bronfenbrenner & Morris, 2006). Importantly, this model is more a framework for organizing knowledge than a theory of sport expertise. To this end, a joint perspective of Gibsonian ecological psychology and dynamical systems theory, the ecological dynamics perspective, is promising with respect to *explaining* the interaction of constraints at an ecological scale (Araújo, Davids, & Serpa, 2005; Araújo, Davids, & Hristovski, 2006; Davids & Baker, 2007, Phillips et al., 2010).

The influence of environmental constraints on non-experts' development is not clear. This is a critical issue, since it is not clear whether there are some athletes experiencing similar environmental population constraints who may not achieve expertise. It may be possible that athletes from very different cultural backgrounds may achieve expertise in different sports and physical activities (Salmela & Moraes, 2003). An implication of Davids and Baker's (2007) review for understanding individual variations in sport performance is that there may be diverse pathways to achieve the same performance outcome levels (see also Phillips et al., 2010).

Conclusion

Recent research has begun to highlight the role of environmental constraints on the development of sport expertise. The importance of putative secondary influences is being investigated, by considering the influence of cultural importance, instructional resources, familial support, sport maturity, and depth of competition (Baker & Horton, 2004). However, more than intuitively exploring the environmental constraints that may have an influence on the development of expertise, Bronfenbrenner's bioecological model (e.g. Bronfenbrenner & Morris, 2006) guides and organizes this search for influences. In this case, we can observe evidence for the influence of not so intuitive constraints, such as those environmental constraints found in Brazilian football. This finding means that Brazilian football is not an exception that contradicts past findings, but that a broader theoretical view should be taken in order to contextualize past findings in their ecology. Intercultural programs of research are much needed in order to further address this issue, and it is firmly argued that without situating research findings in their ecology, an over-generalization of what "appropriate" training environments are may occur. In this paper, experiential knowledge of world-class footballers was examined showing how expertise can be achieved with little formal coaching, without material facilities, and with little parental support. Early specialization involving football type experiences and activities,

without a coach to structure training, played an important role in skill acquisition. In this paper we argued that a different kind of early specialization exists, not based on precise repetition of movement drills in structured practice tasks, but rather on a huge variability of constraints encountered during self-generated, non-guided discovery learning during play. In these practice environments, skill acquisition emerged from the athlete's continuous adaptation to uncertain constraints. In this way, a broad range of early specialization is developed. These findings contrast with perspectives on the development of expertise through deliberate practice by Ericsson and colleagues (Ericsson et al., 1993). In *pelada*, Brazilian players undertake a variety of different activities with the ball and feet, not just official, structured football. These observations cannot be considered deliberate play, either. They are not activities that resemble sports, they are real football experiences under changing ecological constraints. However, the qualitative data fit with findings from the studies of Côté and colleagues (e.g., Côté et al., 2007), who noted that players can specialize very early in 'feet-ball activities', but in the Brazilian case, the activities have a direct correspondence to organized football.

Finally, the important, constraining characteristics of learning environments like the *pelada* provide ideas on the design of practice constraints in modern sport development programs. Some key characteristics of learning design include: (i) not relying on formalised games and training drills all the time; (ii) designing fun and enjoyment (rather than work as in deliberate practice) into programmes; (iii) creating learning environments that encourage search, discovery and exploration in movements; (iv) enhancing adaptive behaviours by creating opportunities for learners to satisfy different constraints (playing in different weathers, against different age groups, gender, number of players, etc); (v) varying equipment and facilities for practice, sometimes keeping the environment very simple and uncluttered, varying surfaces, footwear, ball types; (vi) not conceptualising an idealised target movement pattern as 'the' way to perform a skill; (vii) making sure that skill practice is 'repetition without repetition'. But can talent development programs change their practice to harness principles of unstructured play to ensure that learners are open to the influence of informal environmental constraints? Family support, facilities access and other environmental constraints need to be considered as integral constraints on expert performance and development of expertise. An important part of exhibiting expert performance involves understanding how to act in a manner that reflects the socio-cultural context (Araújo, 2007). The performance of an expert should be conceived as being influenced by an interaction of individual, environmental and task constraints (Davids, Button, & Bennett, 2008). Ecological constraints such as quantity and quality of practice, significant others' influence, coaching, available facilities and so on, may exert a deliberate or an implicit influence, and both types of influences have a nonlinear impact on the development of expertise. Only through acknowledgement of the ecological nature of expertise development, guided by a theoretical framework such as Bronfenbrenner's bioecological model (e.g., Bronfenbrenner & Morris, 2006), can meaningful practice contexts be designed.

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