Applying an ecological approach to practice design in American football: Some case examples on best practice

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Abstract

In this paper, we outline an ecological approach to practice design in American football to support coaches in helping players to coordinate skilled movement behaviours in dynamic performance environments. This approach may require moving away from some long-held practice approaches traditionally employed by some coaches across all performance levels. To guide this progression, we present two novel case examples to support coaches interested in moving towards more contemporary pedagogical frameworks that support the notion of their role as a practice *designer*, placing athlete-environment interactions at the centre of performance preparation. Distinctively, through the utilisation of a constraints-led methodology, coaches could design practice tasks to offer opportunities for players to interact with challenging performance problems that vary in complexity levels. Our two case examples range from high school players to National Football League standouts to support the implementation of alternative approaches to practice design, exploring what an ecological dynamics rationale could *look, feel and sound* like in the context of American football.

Keywords: American football; ecological dynamics; affordances; non-linear pedagogy; constraints-led approach; representative design

Introduction

American football is a dynamic sport, presenting a confluence of challenges for players, coaches, and other support practitioners interested in understanding *what* skilled movement behaviour is and *how* it emerges during gameplay. More explicitly, and regardless of developmental level, it is a team sport that is inherently complex and challenging, offering highly variable movement problems for players to solve. The goal for coaches in American football, then, is to support players in developing skilled movements, helping them in navigating dynamic competitive environments through the design of performance preparation frameworks that function at separate but integrated timescales of performance, learning, and development (Button et al., 2020).

Contemporary developments in motor learning and skill acquisition have encouraged coaches and support practitioners to re-align their role toward being a *designer* of practice tasks that are replete with various opportunities for (inter)actions (see Button et al., 2020; Chow et al., 2016; Woods et al., 2020). This re-alignment is grounded in the theory of ecological dynamics (Araújo & Davids, 2011), which integrates ecological psychology and dynamical systems theory to consider athletes and sports teams as complex adaptive systems. An ecological dynamics rationale places *athlete-environment interactions* at the core of practice task designs to promote the development and enrichment of reciprocal functional relationships between performer and performance contexts (Chow et al., 2016). By appreciating the athlete-environment relationship (Araújo & Davids, 2011), we reject the prevailing belief that with increasing expertise, human interactions with a performance environment can become 'automatically regulated' through internally stored mental representations of the world (Segundo-Ortin & Heras Escribano, 2021).

An ecological dynamics rationale encourages players to search for means of solving performance problems in a myriad of ways through the perception and actualisation of an environment's *opportunities for action* (referred to as *affordances* in ecological psychology; Gibson, 1979; for an update, see Chong & Proctor, 2020). In ecological dynamics, the information perceived by an athlete during performance specifies affordances. Gradually, a relationship is progressively formed between the athlete and their performance environment, giving rise to further opportunities for action that can achieve intended goals. It is important to note that affordances are athlete and frame-dependent (meaning, they are contextualised, changing from moment to moment). Thus, affordances may invite different behaviours for different athletes, depending on their attunement to surrounding information and the skills and capacities they can draw upon to solve performance problems they face in context (Withagen et al., 2012).

While key tenets of ecological dynamics have been empirically-verified (see Button et al., 2020), there is a need for more applied research on how to apply key concepts in designing practice environments in different sports (for some examples, see McKay et al., 2021; Woods et al., 2020; McCosker et al., 2021; Rudd et al., 2021). More specifically, concerning the current paper, there is limited research (to the authors' knowledge) that explores what an ecological dynamics rationale could specifically look, feel and sound like in American football.

For some context to what is to follow, the two lead authors of this paper have served as coaches working in American football across levels ranging from high school to the professional level for nearly 40 years collectively. One of the lead authors has served as both a position coach (across several different positions in Division II NCAA college football) and as a football-specific strength and conditioning coach in the Big Ten Conference in Division I NCAA football, where over a dozen athletes he worked with were drafted into the National Football League (NFL). He now operates as an individual sport movement specialist working with athletes from high school to the professional level. The other lead author has worked exclusively with individual NFL players for the last 14 seasons, serving as their movement skill acquisition coach. In this role, he has partnered with over 100 players, including eight players who have achieved All-Pro distinction and one who has been awarded the NFL Most Valuable Player.

In this theory-practice paper, we present some case examples regarding what an ecological dynamics rationale could encapsulate for coaching within American football. Specifically, this paper aims to present a refined way of capturing how players may utilise their physical characteristics and express them in context-specific, problem-solving scenarios, based on the typical demands of their respective playing positions. Before this, though, we explore *why* an ecological dynamics rationale presents a different way of understanding performance preparation in sport, contrasted to some of the more traditional ways in which practitioners typically prepare players for the demands of competition in American football.

Re-conceptualising the movement skill paradigm

Where we are and where we have been in American football

Within American football, there has been a traditional reliance on what could be deemed a "coach-centred approach" (Hendry & Hodges, 2013). These approaches centralise the coach as the principal facet of an athlete's learning, often through practice tasks that encourage players to rehearse movements that conform to a prescribed way of being and doing, often captured in playbooks. This coaching approach typically manifests in the design of practice environments that promote the accumulation of rote repetitions and automations, captured with unopposed drills (e.g., footwork and cone drills), practising a movement component in isolation (e.g., striking a blocking apparatus, cutting at a bag, running routes on air), and/or attempting to perfect "technique" (e.g., the performer adopting an internal focus and executing movements following highly explicit verbal instructions). Part practice (e.g., training components of skill in isolation) is heavily relied upon in traditional training tasks, specifically during "individual" periods. The rationale underpinning such an approach is to *automate* movement responses, in which athletes perform actions in accord with an internally stored representation or motor program, implying how to execute the "right" movement at the "right" time (Araújo & Davids, 2011; Segundo-Ortin & Heras Escribano, 2021). This focus on coaching to automate movements is an implication of what is known as the "automaticity principle" in cognitive psychology (Montero, 2013) – the prevailing idea that humans can automatise movements or components of actions to prevent cognitive overload during performance.

Our observations suggest that such a coach-centred approach risks detaching athlete behaviour from the context in which it emerges, constraining an athlete's capability to play the game. That is, to solve problems, make decisions and adapt actions to the dynamic demands of competitive performance. For example, there is a difference between rehearsing unopposed plays with defined, predictable start and endpoints, and knowing how to skilfully achieve a defined task goal by interacting with dynamic features of the environment, such as the continuous co-positioning of opponents and teammates, in relation to field locations and markings. Thus, these ideas encourage coaches in American football to acknowledge that the competitive environment often looks, feels, acts and sounds very different to practise environments traditionally observed in training sessions of professional, collegiate, and high school football teams. This is because, we contend, that when a performer steps out onto the field on game day, they are instantly required to solve *alive* movement problems. This emphasised term refers to the contexts of performance that have varying complexity and intensity, occurring within a given play or across plays during the course of a game(s). Further, the opportunities for action a game provides (e.g., its affordances, such as the co-positioning of teammates, gaps between defenders, or the location of the ball) are often unpredictable. Moreover, what shapes the emergence of affordances are *constraints*, which Guerin and Kunkle (2004) proposed as emerging and decaying from properties of surrounding information sources (e.g., visual, haptic, auditory, proprioceptive) available in a performance environment, which a performer must detect and couple their movement behaviours to. Within dynamic environments – like sport – the nature of a *more alive* problem being presented to an athlete would be uncertain, thereby allowing for emergent decision-making and flexibility within the coordinated movement solution (in contrast to a *more passive* problem where the movement strategy or action being employed may be predetermined and/or rehearsed).

Rather than trying to automate a technique or specific play, it is our contention that coaches in American football could shift their focus from coach-centric practices to facilitating athlete-environment interactions, encouraging players to learn how to functionally adapt their movements under constraints representative of those experienced within competition. Take running speed, for example – a metric within American football traditionally measured in a linear, de-contextualised manner. Such de-contextualisation fails to capture the adaptive nature of a skilled player's problem-solving processes during movement. Some of the most successful professional coaches and players in the history of the sport have acknowledged and alluded to the need to view American football in this renewed fashion. For example, in 2016, the Head Coach with the most Super Bowl appearances and victories, Bill Belichick, has stated:

> "The time-speed is always a tricky thing because time-speed isn't *football speed*… So, a player's running the ball or running full speed covering a kick and there is people in front of

> him and people trying to tackle him, it's a little different speed than running a sprint on the stopwatch (Florio, 2016)" (emphasis added)

Additionally, one of the most prolific receivers of all time, Jerry Rice, routinely talked about the differences for him between being fast and actually possessing *football speed*. Though he reportedly ran relatively slow times in the 40-yard dash (the most utilised measure of linear speed in the sport) coming out of college, very few could play the game as skilfully as Rice. He stated: "you've got to separate yourself from the DB (defensive back). That's all it is. And I don't really know where the extra speed comes from that makes me do it (Oates, 1987)." Teammate and fellow Hall of Fame player, Ronnie Lott, said about Rice: "(He) has deceptive speed. He may be 4.6 [seconds over 40-yards] on Tuesday and Wednesday, but he's 4.2 on Sundays." These types of anecdotes suggest that many well-meaning coaches and analysts may have been slightly misguided in how they seek to identify and develop prospective players.

Drawing upon experiential knowledge and supported by the ideas that form ecological dynamics, the notion of speed could thus be re-conceptualized as *gamespeed*, or, in this case and following Belichick, *football speed*. Football speed transcends the traditional way of viewing speed, embracing the athlete-environment mutuality and a player's *knowledge of* (Gibson, 1966) the game. James Gibson (1966) proposed that functional performance is based on *knowledge of* the environment, which is perceptual in nature, and different from the more abstract symbolism of *knowledge about* the environment. Specifically, the former is unmediated or *direct*, whereas the latter is *indirect*, often mediated through pictures, words, symbols (Gibson, 1966) – or given the focus and context of our paper, through the verbal instructions offered by a coach. Thus, enriching one's knowledge of the environment is an integral part of learning designs in sport, framed through an ecological dynamics rationale. This distinctive conceptualisation of knowledge would imply that the game's fastest players are those who can operate at "optimal" speeds while interacting with problems of the performance environment, and not always those who can register the fastest times recorded on a stopwatch while running a set distance outside of game contexts (e.g., like as seen within the NFL Combine – a scouting camp conducted to 'identify talent' via the use of decontextualized tests and drills).

The athlete-environment mutuality

A key component of an ecological dynamics rationale is to appreciate the interactions between an individual and their environment (Gibson, 1979). At this individual-environment scale of analysis, we can begin to understand the mutual, reciprocal nature of these two components, becoming one connected system regulated by informational exchanges or transactions. This characteristic of interactions is captured by the insight from Gibson (1979), who argued that "we must perceive in order to move, but we must also move in order to perceive" (p. 223). In this athlete-environment interaction, we can conceptualise behaviour as emerging from a complex, adaptive system of intertwined perceptions, intentions, and actions that underpin the problem-solving of athletes. This appreciation is why Araújo and Davids (2011, p. 7, emphasis added) suggested that:

> "…skill acquisition may not refer to an entity but rather to the emergence of an *adaptive*, *functional relationship* between an organism and its environment."

Additionally, an ecological dynamics rationale holds that the expression and acquisition of expertise in specific domains (e.g., in the coordination and control of sport movement skill), through a more functional relationship between a player and their environment, will be characterised by *attunement* (e.g., increasing sensitivity) to relevant perceptual variables and the concomitant calibration of their actions (Araújo & Davids, 2011; Jacobs & Michaels, 2007).

These perspectives encourage coaches to move past many of the traditional biases ingrained in American football, which typically adopt an individual scale of analysis to view behaviour removed from context. Instead, by adopting an ecological approach, a coach would study the interactive processes involved in movement problem-solving in sport. Namely, understanding how players coordinate their behaviours in dynamic performance environments through the continuous and interwoven processes of perception (e.g., information detection of affordances), cognition (e.g., intentions and decision-making), and action (e.g., adjusting and adapting motor system degrees of freedom) to functionally fit the needs, opportunities, and challenges of the problems encountered in competition. As discussed in the case examples later, this re-conceptualisation of practice design will have implications for the learning environments coaches design.

Analysing movement behaviours in context

The performance of any movement skill is contextually situated; meaning, it is embedded within a specific environment, shaped under varying constraints. Moreover, it is the context (of a sport movement problem) that will channel the content (of the coordinated movement solution), allowing practitioners and athletes to determine its functionality (e.g., how practical and useful it is in achieving the task goal). In assessing the level of functionality of movement skills, Bernstein (1996) presented the idea of dexterity, “the ability to find a motor solution for any external situation, that is, to adequately solve any emerging motor problem” (p. 228). More than that, though:

> “Dexterity is not confined within the movements or actions themselves but is revealed in how these movements behave in their interaction with the environment, with its unexpectedness and surprises” (ibid., p. 232).

Applied to American football, these ideas emphasise that from game-to-game, and even snap-to-snap (within a game), the task and environmental constraints acting upon the player can differ quite significantly. This means that because every problem differs, so will every performance solution. Thus, whether as a coach, applied scientist, or performance analyst, it is important to understand movement skills from the perspective of the player who is problem-solving within a dynamic, unpredictable environment which provides affordances and challenges (Zelaznik, 2014). So, what does this mean for the design of practice tasks in American football? More specifically, *how can coaches work with players and other practitioners to design information-rich practice tasks that centralise athlete-environment interactions?*

Utilising representative learning design

Araújo and Davids (2009, p. 6) eloquently stated, “In human behaviour, the act of ‘doing’ never occurs in a vacuum. To do is always to do something somewhere.” In other words: context is everything! Speaking to position coaches and coordinators, applied sport scientists, and strength and conditioning coaches, have you ever noticed differences in what you have practised (perhaps over and over again) and what (does/does not) transfer into the competition? In games, for example, do athletes struggle to adjust their routes, make tackles from disadvantageous positions, or make throws from unbalanced stances? If so, perhaps next consider what information is missing in training compared to the competition – e.g., *are there similar numbers of opponents and teammates on the field as would be experienced in competition? Are "messy" plays encouraged to be "played out", or are they stopped because of a missed block or tackle? Or is practice consumed by the sound of the coach’s voice? Meaning, is instruction overly prescriptive?* In reflecting on such questions, it is paramount for coaches to consider that the context shapes the content. Think about, for example, the number of moving bodies (both of teammates and opponents), the gaps between players emerging and rapidly closing, the weather conditions (e.g., wind direction and strength) – are these things we encourage players to directly experience and interact with during the practice or are they things we try to control – perhaps even avoid – given the ensuing messiness they could create? Thus, we argue that coaches could consider using practice tasks that encourage *exposure*, not removal from context. Practice should offer players opportunities to learn how to adapt movements to emergent problems likely encountered during gameplay, as in this messiness, dexterity comes to life.

Egon Brunswik's (1955) notion of *representative design* advocated the study of organism-environment relations in experimental psychology. Specifically, he recognised the need to study behaviour through designing key features of the environment into experiments, so contextual informational sources were available to the participant (Renshaw et al., 2019). Later, espoused through the framework of ecological dynamics, the notion of representative design was re-configured as *representative learning design* (RLD) in sport performance contexts by Pinder and colleagues (2011a; 2011b). Representative learning design advocates that practice design represents the constraints found in the competitive setting. It is imperative that the movement problem-solving process looks, feels, and acts like it would in the game, where athletes interact with contextual information used to self-regulate their behaviours.

Applied to American football, RLD would see players performing under constraints likely experienced during competition, leading to greater action-fidelity (Stoffregen et al., 2003). For this reason, a learning designer should look to design alive movement problems that emerge in the game, faithfully capturing the dynamic nature of American football, where athletes solve football problems that vary in complexity. As many experienced coaches are aware, no two problems, or solutions, are the same. Thus, to help design diverse problems that could be experienced during competition, coaches could work with athletes to *co-design* activities (Woods et al., 2020): an approach centralises athlete-environment interactions by capturing their rich experiences. In our case examples, we illustrate how practice designs can shift towards athletes going through the process of solving alive movement problems, where they interact with contextual information and are given ample opportunities to become progressively attuned to information about emerging and decaying affordances provided by gaps, the relative speed of oncoming players, line markings, environmental conditions, and so on.

Emphasising affordances when facilitating athlete-environment interactions

Affordances – opportunities for action – can be exploited by American Football coaches in their practice designs. For example, an opening in a defensive formation may be perceived differently based on the ball carrier's action capabilities. As *football speed* develops, an athlete's knowledge of their environment can help them perceive and actualize relevant affordances – which gaps afford *run-through-ability*, which opponents afford *tackle-ability*, or which teammates afford *pass-ability*. For this reason, during practice, athletes need many opportunities to search, discover, and exploit soliciting affordances in their environment, developing functional information-movement couplings. Additionally, practice task designs of coaches may help affordances in team sports to be shared between athletes (Silva et al., 2013). Silva et al. (2013) elaborated on the notion of *shared affordances*, which they viewed as opportunities *of* and *for* teammates and opponents. They discussed how shared affordances could form a communication platform for teams that can emerge and be refined between members during practice and performance. Though, it should be noted that further empirical work is needed to unpack the notion of shared affordances in more detail. Nonetheless, these ideas imply that coaches could design practice tasks (especially during full team and half-line activities) that help athletes seek and exploit key affordances to help solve problems in competition.

The perception and utilisation of affordances is an important characteristic of skilled behaviour in team sports. Learning to perceive affordances, for example, can help athletes develop 'game intelligence' as they become better attuned to information about their performance environments (Button et al., 2020). Using relevant affordances is part of becoming more skilful, as, in team games, players learn to couple their movements to relevant information sources in the environment. These couplings become stronger with practice and experience (e.g., more stable, and resistant to perturbations in the performance environment) and are formed through decision-making and affordance utilisation that (Araújo et al., 2009, p. 160) defined as a "functional and emergent process in which a selection is made among converging paths of actions for an intended goal," or tantamount to movement problem-solving in dynamic performance environments. These ideas confirm that dexterous movers are not developed simply by performing repetition by rote. Instead, dexterity emerges from the process of solving movement problems through *repetition without repetition* (Bernstein, 1967), where athletes are challenged to adapt their behaviours and perceive affordances as they meet the ever-changing nuances of the performance problems faced in competition.

In summary, the first part of this paper explored some key concepts of an ecological dynamics rationale to support performance preparation. By no means does this intend to offer all the answers to know such a framework, but it should offer a point from which to orient oneself when setting out to explore what it could look, feel and sound like when applying the ideas in practice.

Offering a way forward on best practice

How a constraints-led approach can be implemented in American football

Nonlinear pedagogy is a framework based on the theory of ecological dynamics that provides principles for practitioners to use in a learner-environment-centred approach to teaching and coaching, especially related to constraints manipulation. The original constraints model proposed by Newell (1986) emphasised that movement is an emergent property of three interacting constraints, classified into the organism, environment, and task categories. Applied to sports through the constraints-led approach (CLA), Davids et al. (2008) suggested that *task constraints* are reflective of important variables like game rules, equipment, playing area dimensions, boundaries, opponents, and teammates; *environmental constraints* reflect physical properties like ambient light, humidity, temperature, and social expectations; and *organismic (performer) constraints* reflect personal properties like height, body weight, limb segment lengths, emotions, psychological states, and fatigue levels. Newell (1986) emphasised that the *interaction* of constraints from these categories shape behaviours. Next, we expand on what these ideas may imply through the presentation of two practical case examples from different levels of performance in American football. The purpose of these examples is not to provide practitioners with a detailed "book of drills" but to exemplify what these ideas may mean for them when exploring an ecological dynamics approach.

Developing dexterous movers: part 1

Case example #1 – facilitating attunement & adaptation for an NFL all-pro

Many may think that because a player has reached the upper echelons in the sport (e.g., the National Football League), that they have already "acquired" all the skills necessary to solve movement problems in the most efficacious ways. Therefore, once an individual is at this phase in their development, these skills must simply be "maintained" to continue playing at this level. However, as difficult as it is to "get there," it may be an equally challenging endeavour to remain "there," and continue to perform at the highest level. For this reason, ecological dynamics emphasises the nature of *skill adaptation*, rather than *skill acquisition*. The latter term infers a rather static conceptualisation of motor learning, when a more dynamic and ever-changing understanding might be needed (Araújo & Davids, 2011). Not only is there a constant influx of new athletes entering the NFL each year, hungry to prove themselves and carve out a role, but also when a player achieves a certain amount of success, their opponents begin to analyse their performance behaviours closely, picking apart their skill set to find any weaknesses, so they can "game plan" and "scheme" against them. To combat these demands, the player, and their coaches must be honest about the current gaps which exist within the player's individual movement repertoire. Furthermore, they must use that awareness to design a learning environment containing highly representative task problems which frequently stretch the player to further explore refined or novel movement solutions (Renshaw et al., 2019).

To illustrate how these theoretical concepts may be able to inform and guide practical application out on the field, let's take a real-life example of a veteran NFL defensive end who has achieved Pro Bowl recognition several times throughout his career. During his time starting on his respective team, he had become widely known for his pass-rushing prowess (e.g., attempting to pressure, disrupt, or sack the opposing team's quarterback), typically facing and beating the immediate opponent (e.g., usually the opposing team's offensive tackle) predominantly through employing a speed rush move on the edge to go around the lineman, or via executing a bull rush in an attempt to go through the opponent, en route to the quarterback. Knowing that these were his two "go-to moves", which he relied upon heavily up to that point, and respecting the notion that NFL players will compensate and adapt rapidly to frequently faced problems, this player and his personal Movement Skill Acquisition Coach set out to expand his movement behavioural repertoire. This was undertaken to offer him a wider movement toolbox of potential solutions which could be coordinated, controlled, and organised in a variety of ways to solve frequently occurring problems (e.g., invoking Bernstein's 1967 notion of practice as repetition without repetition). The player and coach also observed, from detailed analysis of past emergent interactions on the field within the competitive setting, when the player was tasked with pursuing a more mobile quarterback, as opposed to those who would stay "in the pocket" and/or only manoeuvre within the pocket in more restricted or limited fashions, he would have a relatively difficult time accurately detecting information regarding the quarterback's movement behaviours, as well as subsequently expressing the coupled movement skills to adequately pursue the quarterback.

Certainly, some teams across various levels of skill (e.g., developmental to professional) may focus significant time and energy on setting 'more alive' problems within their practice structure. However, within this particular professional NFL team, it was found that less representative problems were utilised across the different periods of practice. For example, during 'individual periods' (e.g., indy periods, positional periods), many of the activities being employed were seemingly devoid of the information sources which one would actually need to couple their movements to the competitive task. Thus, it was not uncommon to see the defensive end spending the majority of their individual periods in the midst of drills being conducted in completely unopposed fashions (e.g., on air or against a sled, dummy, or other stationary objects) and/or while attempting to repeat a specific technique (e.g., such as take-off from one's stance). Even during most 1-versus-1 periods, where the defensive ends would line up in opposition against an offensive lineman, the various constraints utilised here usually included task manipulations like a coach standing stationary in the pocket to simulate the quarterback location (e.g., behind the lineman) or the ball snap being simulated while attached to a stick (e.g., as opposed to being directly snapped from a centre to a quarterback (QB). Even during half-line type of work, the QB would typically move in highly unrealistic and stereotyped fashions, often with very little movement in the pocket, and sometimes without an objective to throw. As such, we felt these types of activities did not look, feel, and unfold like they will within the game. They simply do not offer the appropriate information that skilful players must utilise to coordinate and regulate their movement skills through. It should be noted that these types of aforementioned activities are actually similar to some of those which are traditionally advocated for by various expert organisations, such as USA Football[1].

Within this particular team, the majority of truly alive problems being presented to players was limited, almost exclusively, to those found during full team periods (e.g., 11 versus 11). In this type of competitive and challenging environment, players may end up resorting to the utilisation of movement strategies and skill execution that they are already familiar with, that are already stable, and/or they feel comfortable with. Additionally, we also found that, though the problems here could be deemed more representative, the number of repetitions and associated exposure to these types of problems in the practice environment with the team, was actually rather limited, especially for players who are already on the starting unit and/or those who may be considered 'star' players. Now, we are not suggesting that all practice activities must be fully representative. The key point is that the specifying information that a player should become more attuned (more

[1] For examples of this – see: https://www.youtube.com/watch?v=Wq9dLnolo8g, https://www.youtube.com/watch?v=p9mic-sF7D4, and https://www.youtube.com/watch?v=tOJUteySASQ), and the NFL (see: https://www.youtube.com/watch?v=OcXlM4kiq1A and https://www.youtube.com/watch?v=kKSkNnUnWg0).

sensitive) to, make decisions around, and coordinate their movement behaviours in relation to, should be present to support interactions whenever possible. It is here where players will be given the opportunity to become more attuned, intentional, and adaptable in context, as long as they are given the adequate exposure (e.g., experiencing constantly changing problems through repetition without repetition) in facing constantly changing problems (e.g., through repetition without repetition), and are able to search for ways of organising an intertwined movement solution (e.g., through adapting processes of perception, cognitions, and actions).

To accomplish each of these goals, the player first had to be willing to explore the problem-solution dynamics in practice settings to search the perceptual-motor workspace to discover opportunities for organising movement system degrees of freedom in adapted, novel, and creative fashions (Orth et al., 2017). Additionally, it was imperative that throughout this process, the player remained vulnerable as he was pushed into "stretching his grip" over (effectively utilising) a range of affordances (Renshaw et al., 2019). As part of this exploration process, it meant that he was likely to lose a moderate number of repetitions versus the opposing players in practice – sometimes even players that he could easily beat if he would simply resort to the employment of his existing movement skills (e.g., the former "go-to" moves). Though challenging, if he could endure this factor, it was hypothesised that he could come out of this highly nonlinear process as a more attuned and adaptive player with an evolved, dexterous movement skill set (Araújo & Davids, 2011).

To facilitate the emergence of this enhanced movement behavioural repertoire, a representative task design was utilised by manipulating specifically relevant constraints, thereby allowing alive movement problems to become the norm in the training environment – providing many opportunities for athletes to couple actions and perceptions, find and use available affordances for relevant actions, and to adapt their movements by exploring repetition without repetition (Button et al., 2020). These endeavours were undertaken while maintaining a learner-centred focus throughout the practice process, where ownership and autonomy, as well as authenticity and creativity, were prioritised whenever possible (Hendry & Hodges, 2013). Finally, an additional benefit emerged to help combat the apparent gaps within his movement skill set mentioned above regarding his previous lack of functionality when facing more mobile quarterbacks. It should first be noted that the trends and current realities of the dynamic performance landscape in the NFL indicate that quarterbacks are becoming more athletic and using this all-around athleticism as an integral part of their movement performance. Meaning, the current "Form of Life" (Wittgenstein, 1953; Rothwell et al., 2020) used for preparing athletes for competition in the NFL is changing to accept and expect a more agile and skilful mover at the quarterback position. Thus, a defensive end who is tasked with pursuing and attempting to tackle (e.g., sack) the opposing team's quarterback, must have the capacity to be able to adapt accordingly to respond to these challenging demands.

Though this particular movement skill refinement process took place primarily in adapted, non-team settings, it was still possible to set problems that were representative of the full-team scenario, as long as key component parts of the athlete-environment system formed the interacting relations between the player and his opponent(s). Each day while practising out on the field, it was ensured that an opposing quarterback, an offensive lineman in the form of an offensive tackle, and another additional player to act as the centre who would snap the ball, would all be present to serve as interacting component parts of the problem. We found that this latter individual was vital to the information-movement coupling for the defensive end – the ball being snapped in relation to the quarterback's audible snap count (e.g., both the count itself, as well as the inflection of the voice, are often deliberately manipulated by a quarterback to be highly unpredictable), represented essential specifying information which the defender must become attuned to. If the player became too reliant on detecting just the quarterback's voice, he could be easily deceived into jumping off-sides (e.g., incurring a penalty). Thus, still being sensitive to the quarterback's voice, while also simultaneously detecting small nuances of the movement of the ball in the centre's hand prior to the snap, allowed the defensive end to explode with intention in executing his first-step action out of his stance at the appropriate time. This aspect of the movement problem-solving process is vital as it enables the defensive end to put earlier pressure on the movement behaviours of the offensive tackle (e.g., the opponent then would "kick" harder in attempts to cover more distance to keep up with the defensive end). This interactive design feature would create more space to the left and right of the tackle (e.g., opening a two-way go for the defensive player's path, based on additional space afforded between this unfolding dyadic relationship, and in relation to other moving players on the field; see Figure 1: A snapshot illustration of the unfolding movement problem-solution dynamics between a defensive end (DE) and an offensive tackle, while the DE simultaneously detects the information about the emerging movement behaviours of the quarterback).

******INSERT FIGURE 1 ABOUT HERE*******

This scenario would also give the defensive end more options for the pass rush move he would subsequently attempt to execute (e.g., he no longer had to rely on one of the two options for interacting with the movement problem being presented by the tackle). Additionally, though still remaining highly connected, perceptually, to the detection of subtle nuances of the tackle's movement behaviours (using information from interpersonal distance and relative velocity relationships between the competing players (see Passos et al., 2008), these modifications in movement performance now allowed the defensive end to simultaneously perceive information about the unfolding intentions and movement actions of the quarterback. This multi-layered, and simultaneous, information detection represented successive nested affordances for the defensive end to perceive and act upon (Button et al., 2020). This idea implies that the functional movement solution continuously regulated by the player was no longer simply about solving the immediate movement problem being presented by the offensive tackle. It was also about how the quarterback was simultaneously behaving – thereby allowing the behaviours of both of these key opponents to channel the resultant movement behaviour of the defensive end.

Within this particular activity design, the task intentions of the offensive players were typically driven through a co-adaptive relationship between the quarterback and the Movement Skill Acquisition Coach, in order to select tactical strategies (e.g., the play call as a pass or a run, the required depth of the quarterback's drop, potential QB movement within the pocket), which would create ample opportunities (e.g., affordances) for the defensive end to solve representative problems and bring appropriate challenges for his skill set. To continue to stretch the grip of the defensive end, in attempting to pursue amplified attunement to his unique affordances for action and ultimately striving towards enhanced dexterity in his movement skill, modifications to the problems set were made frequently through constraint manipulations such as, but not limited to:

- Having the defensive end face different opposing players (e.g., a change in the quarterback, offensive tackle, and/or centre): since behaviour affords behaviour, this alteration would require the defensive end to face a wider variety of opponents and become more sensitive to the key specifying information commonly present in the representative tasks he interacts with.

- Changing the down and distance on each repetition of the simulated task: modifying these circumstances would influence the intentional aims of players on both sides of the ball while increasing upon the game-like nature of the practice tasks.
- Including additional players for the problem, such as a tight end and/or running back who may have the responsibility of executing a “chip block” on the defensive end: this would present more 1-versus-2 scenarios and represent an increase in the complexity of the movement problem to be solved. Additionally, the defender would be required to remain highly flexible in the movement solution organised as strategies that worked when he was 1-versus-1 with an offensive tackle, were no longer feasible if a double-team was executed against him.
- Requiring the defensive end to begin the task from the opposite side of the defensive formation: because he primarily plays on the right side of the defence, by moving him to the other side, where he has very little experience and less information-movement couplings established, put his movement skills to the test in staying in a constant state of learning and adaptability.
- Moving to different fields so a variety of surfaces were being practised on: this would change the behavioural dynamics of the movement solutions being organised (e.g., how a movement is executed on a turf surface will differ from that being carried out on the grass).
- Performing these tasks under the influence of key performance inhibitors such as fatigue (e.g., through the accumulation of game-like workloads), and/or anxiety (e.g., such as having various spectators present watching the sessions): including these *inhibitors* in the practice environment required the player to manage his associated physical and

psychological states while still attempting to coordinate the most functional movement solutions possible (Glazier, 2017).

These ideas represent several ways in which we (re)designed the learning environment, and the problems within it, for this particular player leading up to his team's training camp (e.g., which marks the start of that respective NFL season). After an offseason of employing this representative, challenging, and nonlinear approach, several alternative movement strategies emerged for interacting with opposing team's offensive lineman. These included an inside spin move and accompanying fake, a jab step and acceleration manoeuvre to both the inside and the outside, as well as several chop variations with his hands (to further assist in manipulating the offensive lineman in numerous ways). Additionally, because of the constant need for layered problem-solving within this type of practice environment, the player began to demonstrate the ability to become more attuned (to information sources stemming from the movement of the ball, the offensive tackle, and the quarterback) and adaptable (e.g., tailoring the movement solution to match the contextual problem at-hand) (Araújo & Davids, 2011).

Developing Dexterous Movers: Part 2

Utilising an ecological approach with high school football players to expand their football speed

Regardless of the athlete's age or skill level, utilising a nonlinear pedagogy with an ecological dynamics rationale is crucial in helping athletes adapt their skills over time. In this way, development is viewed as 'learning to learn to move' as athletes become more skilfully attuned to information such as the surface of play, current environmental conditions, tactical strategies of the opposition, emerging interpersonal distances between teammates, and opponents as plays unfold, and so on. Karen Adolph and Justine Hoch, who study infant motor development, eloquently stated that when children are discovering new ways of moving as they use perceptual information during tasks, they are *learning to learn to move*. They argued that adaptive action requires that movements be constructed, selected, and modified that are congruent with situational constraints and opportunities provided by the environment. The notion of learning to learn to move (Adolph & Hoch, 2019) transcends infant development. In American football, learning to learn to move is analogous to athletes adapting their movement solutions to create a functional fit with the problems they face in sports. Essentially, learning is about adaptive behaviour rather than acquiring fixed technical solutions (Araújo & Davids, 2011).

In the following example, which focuses on high school level players ranging from 16-18 years of age, we will take a deeper look into the application of the constraints-led approach, along with *representative co-design* where the athletes are actively engaged in the practice design process (Woods et al., 2020). Designing representative learning environments for a specific individual or group of athletes requires the coach to watch their movement behaviours within the context of their sport (both practices and games) to identify strengths and weaknesses (or opportunities). Watching players move in context offers coaches a better understanding of how the human movement system *softly assembles* the degrees of freedom (e.g., temporarily re-organises body components such as muscles, joints, limb segments) to satisfy changing performance constraints. The process of soft assembly is available in complex adaptive systems which can exploit tendencies to *self-organise* components into an emergent coordination solution to meet the nuances of performance challenges (Kugler & Turvey, 1987). Analogous to a softly assembled movement solution, the coach-athlete system can work together to “softly assemble” practice activities that promote search, where athletes look to solve game-like movement problems. Instead of forcing drills and technique repetitions, likely written far in advance (generalised for groups of athletes, not for specific individuals), the softly assembled practice activities allow the coach-athlete system to manipulate constraints to challenge athletes to solve performance problems at that time.

Case example #2 – making tackles in open space

Problem-solving in football is dynamic, where the linebacker position is consistently required to take on blocks while making tackles in confined spaces where there are numerous moving bodies. Additionally, they must bring down elusive ball carriers in the open field, along with helping to protect the pass in man and zone coverage. In this specific example, through movement analysis, the coach and the athletes identified the need for work closing on the ball carrier in open space (getting in position to make a tackle). Collisions between players often occurred, but the ball carriers were not tackled during this activity. However, the activities were designed to faithfully represent the spatial-temporal dynamics of the interacting players occurring during games (replicating the way they co-positioned themselves when competing). Throughout certain times of the year, when the athletes are wearing full pads and the season is approaching, coaches should consider full-contact activities like these, so the representativeness continually increases. We started the activity between the 20-yd lines near the hash marks, with the problem-solving area extending to the sideline (task constraints). The design situates the athletes in an open space where the interactions likely occur with them moving at high speed, where information such as interpersonal distance values, body orientation, relative velocities, and angles between the offensive and defensive players specify what actions are possible (Passos et al., 2008). The running back or receiver can start the activity carrying the ball, or the quarterback can pitch or throw it to them.

******INSERT FIGURE 2 ABOUT HERE*******

Initially, both the offensive and defensive players owned the way they chose to enter the workspace (stationary or moving, and the direction they were facing). The space between the two opponents started around 10 yards, and the athletes were rarely stacked. Instead, there was generally a stagger to begin the activity. In doing so, this might offer one player a better angle to beat the other to the sideline or exploit their speed in lateral pursuit and hit gaps (affordances) that emerge towards the middle of the field. The slightly disadvantageous positions the athletes find themselves in, which frequently occur in American football, challenge them to actively self-regulate their behaviour to the *alive* problems and find a functional fit as the constraints change. There are plenty of opportunities for the coach-athlete system to manipulate constraints that challenge the athlete's optimal grip over the field of affordances. Purposely manipulating constraints to invite relevant performance behaviours is encouraged to help athletes adapt their skills as task complexity increases. A few task manipulations were made for these linebackers based on their ability to solve problems, such as but not limited to the interpersonal distances between the two opponents and the direction they faced to start the activity. As we progressed, the linebackers expressed the need to reach the opposition in situations where the ball could be thrown to a receiver where they would need to cover more distance to get to them. By involving the athletes, coaches can capture their experience and design practice tasks that focus on areas they have acknowledged as opportunities. Following the engagement between the coach and athletes, a different activity was co-designed.

In the new co-designed activity, the athletes search to pick up whether it is a run or pass, which allows them to gain experience and adapt their behaviour to make the play as the complexity changes. We expanded the space (task manipulation) for the modified activity to include the middle of the field to the sideline, which allows for inside runs while still inviting multiple pass options. In addition to the linebacker and running back (or receiver) in the initial one versus one situation, the following positions were added to challenge the athlete's grip over the field of affordances.

- A centre to snap the ball to the quarterback.
- A quarterback to throw, run or hand off the ball.
- A receiver to catch passes or block for the ball carrier and an opposing cornerback.
- A defensive end to provide pressure on the quarterback and an offensive tackle opposing him.

Furthermore, what started as one versus one expanded in complexity to a five versus three activity affording the athletes to sample larger "slices" of the game. Through experiencing the game in "slices" where invitations emerge and decay rapidly, athletes are challenged to adapt their football speed and problem-solving capabilities. While the example highlighted the linebacker position, it is worth acknowledging that the offensive players also solved problems under representative learning design situations. Additionally, collisions that occur on and off the ball, which shape the intentions and attention of athletes, were designed into the activities (e.g., starting the activity with contact), so they gain experience in areas that influence their emergent behaviour during games. Finally, coaches can include equipment like football helmets and shoulder pads when available, which changes the way athletes connect to information through their perceptual systems to guide their emergent behaviour.

What can we take from this?

First, we would like to emphasise the importance of the opposition's presence in the practice design. Behaviour affords behaviour where movements emerge from the relations between system components, and athletes learn to perceive and use shared affordances for and of other players. Second, our focus centred around the linebacker position in the example above, but all the athletes solved representative problems where context-specific information helped guide their behaviour. The training sessions generally consisted of 5-12 offensive and defensive players from the same high school team. For team coaches, this is promising because they can maximise their numbers, and the athletes can interact with game-like information sources, which specify individual and frame-dependent affordances to expand their football speed.

The following individual, environmental, and task constraints were manipulated during the off-season to facilitate the skill adaptation process. They include but are not limited to:

- The playing area (e.g., widening, narrowing, lengthening, and shortening the playing space).
- Numerical relations (e.g., facing advantageous and disadvantageous situations for both sides of the ball).
- The rules (e.g., down & distance, time remaining on the play clock).
- The interpersonal distances of the starting positions.
- The equipment used (e.g., throwing and catching different footballs, which challenges the athlete's perceptual sensitivity and wearing different cleats, which shapes the way they interact with the surface).
- Practising at different times of the day, on different surfaces, and facing different directions concerning the sun, which influences the athlete's movement behaviour as they interact with problems across conditions.
- Performing tasks under the influence of key performance inhibitors such as fatigue (e.g., right after several plays on defence, the athletes perform tasks on special teams representing game-like situations) and anxiety (e.g., practising in the city limits of opposing teams and practising with players from the collegiate or professional level).

Our observations throughout the off-season suggest the athletes solved movement problems more efficiently than when they started, even as the problems increased in complexity. This perception may highlight the benefits of adopting a periodised approach to skill adaptation (Otte et al., 2019). The athletes commented that the game felt slower, and they seemed more relaxed, which we attribute to the expansion of their individual-specific football speed. From our perspective, these insights, and more importantly, their actions embody their attunement and emergent decision-making ability, which increased over the nearly six-month training period.

Conclusion

Traditionally, the sport of American football has taken an overly "coach-centred" approach to movement and sport skill acquisition. Typically, the coach is looked at as already being in possession of the answers, perhaps collated in a playbook, and practice resembles more of a rehearsed orchestration of motor patterns. Here, we sought to highlight how an ecological dynamics rationale may help alleviate these coach-centric practices. To use this framework, coaches are required to frame the scope of analysis from the individual to the individual-environment system. To help support coaches in exploring these ideas in practice, we included two case examples to illustrate where and how these concepts may live and breathe within the learning environments that football coaches and movement skill practitioners design. There is a need for more research to capture the coach perspective to elucidate how the ideas of ecological dynamics are being applied to practice design in American football at different performance levels.

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Figure Captions

Figure 1. A snapshot illustration of the unfolding movement problem-solution dynamics between a defensive end (DE) and an offensive tackle, while the DE simultaneously detects the information about the emerging movement behaviours of the quarterback.

Figure 2. A schematic of practice task design for developing dexterous movers.

Footnote: Please note that while the diagram in Figure 2 is presented statically, in practice, the movement problem is dynamic, or “alive” – replete with opportunities for interaction.