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

This is the Accepted version of the following publication

Yearby, Tyler, Myszka, Shawn, Roberts, William M, Woods, Carl and Davids, Keith (2022) Applying an ecological approach to practice design in American football: some case examples on best practice. *Sports Coaching Review*. ISSN 2164-0629

The publisher's official version can be found at
<https://www.tandfonline.com/doi/full/10.1080/21640629.2022.2057698?scroll=top&needAccess=true>

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1 **Applying an Ecological Approach to Practice Design in American Football: Some Case**
2 **Examples on Best Practice**

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18 Abstract

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

32

33

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

36

37

38 Introduction

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

47 Contemporary developments in motor learning and skill acquisition have encouraged coaches and
48 support practitioners to re-align their role toward being a *designer* of practice tasks that are replete
49 with various opportunities for (inter)actions (see Button et al., 2020; Chow et al., 2016; Woods et
50 al., 2020). This re-alignment is grounded in the theory of ecological dynamics (Araújo & Davids,
51 2011), which integrates ecological psychology and dynamical systems theory to consider athletes
52 and sports teams as complex adaptive systems. An ecological dynamics rationale places *athlete-*
53 *environment interactions* at the core of practice task designs to promote the development and
54 enrichment of reciprocal functional relationships between performer and performance contexts
55 (Chow et al., 2016). By appreciating the athlete-environment relationship (Araújo & Davids,
56 2011), we reject the prevailing belief that with increasing expertise, human interactions with a
57 performance environment can become ‘automatically regulated’ through internally stored mental
58 representations of the world (Segundo-Ortin & Heras Escribano, 2019).

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

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

76 For some context to what is to follow, the two lead authors of this paper have served as coaches
77 working in American football across levels ranging from high school to the professional level for
78 nearly 40 years collectively. One of the lead authors has served as both a position coach (across
79 several different positions in Division II NCAA college football) and as a football-specific strength
80 and conditioning coach in the Big Ten Conference in Division I NCAA football, where over a
81 dozen athletes he worked with were drafted into the National Football League (NFL). He now

82 operates as an individual sport movement specialist working with athletes from high school to the
83 professional level. The other lead author has worked exclusively with individual NFL players for
84 the last 14 seasons, serving as their movement skill acquisition coach. In this role, he has partnered
85 with over 100 players, including eight players who have achieved All-Pro distinction and one who
86 has been awarded the NFL Most Valuable Player.

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

95 **Re-conceptualising the Movement Skill Paradigm**

96 *Where We Are and Where We Have Been in American Football*

97 Within American football, there has been a traditional reliance on what could be deemed a “coach-
98 centred approach” (Hendry & Hodges, 2013). These approaches centralise the coach as the
99 principal facet of an athlete’s learning, often through practice tasks that encourage players to
100 rehearse movements that conform to a prescribed way of being and doing, often captured in
101 playbooks. This coaching approach typically manifests in the design of practice environments that
102 promote the accumulation of rote repetitions and automations, captured with unopposed drills
103 (e.g., footwork and cone drills), practising a movement component in isolation (e.g., striking a
104 blocking apparatus, cutting at a bag, running routes on air), and/or attempting to perfect

105 “technique” (e.g., the performer adopting an internal focus and executing movements following
106 highly explicit verbal instructions). Part practice (e.g., training components of skill in isolation) is
107 heavily relied upon in traditional training tasks, specifically during "individual" periods. The
108 rationale underpinning such an approach is to *automate* movement responses, in which athletes
109 perform actions in accord with an internally stored representation or motor program, implying how
110 to execute the “right” movement at the “right” time (Araújo & Davids, 2011; Segundo-Ortin &
111 Heras Escribano, 2019). This focus on coaching to automate movements is an implication of what
112 is known as the “automaticity principle” in cognitive psychology (Montero, 2013) – the prevailing
113 idea that humans can automatise movements or components of actions to prevent cognitive
114 overload during performance.

115 Our observations suggest that such a coach-centred approach risks detaching athlete behaviour
116 from the context in which it emerges, constraining an athlete’s capability to play the game. That
117 is, to solve problems, make decisions and adapt actions to the dynamic demands of competitive
118 performance. For example, there is a difference between rehearsing unopposed plays with defined,
119 predictable start and endpoints, and knowing how to skilfully achieve a defined task goal by
120 interacting with dynamic features of the environment, such as the continuous co-positioning of
121 opponents and teammates, in relation to field locations and markings. Thus, these ideas encourage
122 coaches in American football to acknowledge that the competitive environment often looks, feels,
123 acts and sounds very different to practise environments traditionally observed in training sessions
124 of professional, collegiate, and high school football teams. This is because, we contend, that when
125 a performer steps out onto the field on game day, they are instantly required to solve *alive*
126 movement problems. This emphasised term refers to the contexts of performance that have varying
127 complexity and intensity, occurring within a given play or across plays during the course of a

128 game(s). Further, the opportunities for action a game provides (e.g., its affordances, such as the
129 co-positioning of teammates, gaps between defenders, or the location of the ball) are often
130 unpredictable. Moreover, what shapes the emergence of affordances are *constraints*, which Guerin
131 and Kunkle (2004) proposed as emerging and decaying from properties of surrounding information
132 sources (e.g., visual, haptic, auditory, proprioceptive) available in a performance environment,
133 which a performer must detect and couple their movement behaviours to. Within dynamic
134 environments – like sport – the nature of a *more alive* problem being presented to an athlete would
135 be uncertain, thereby allowing for emergent decision-making and flexibility within the coordinated
136 movement solution (in contrast to a *more passive* problem where the movement strategy or action
137 being employed may be predetermined and/or rehearsed).

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

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

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

152 Additionally, one of the most prolific receivers of all time, Jerry Rice, routinely talked about the
153 differences for him between being fast and actually possessing *football speed*. Though he
154 reportedly ran relatively slow times in the 40-yard dash (the most utilised measure of linear speed
155 in the sport) coming out of college, very few could play the game as skilfully as Rice. He stated in
156 1987 that: "you've got to separate yourself from the DB (defensive back). That's all it is. And I
157 don't really know where the extra speed comes from that makes me do it." Teammate and fellow
158 Hall of Fame player, Ronnie Lott, said about Rice: "(He) has deceptive speed. He may be 4.6
159 [seconds over 40-yards] on Tuesday and Wednesday, but he's 4.2 on Sundays." These types of
160 anecdotes suggest that many well-meaning coaches and analysts may have been slightly misguided
161 in how they seek to identify and develop prospective players.

162 Drawing upon experiential knowledge and supported by the ideas that form ecological dynamics,
163 the notion of speed could thus be re-conceptualized as *gamespeed*, or, in this case and following
164 Belichick, *football speed*. Football speed transcends the traditional way of viewing speed,
165 embracing the athlete-environment mutuality and a player's *knowledge of* (Gibson, 1966) the
166 game. James Gibson (1966) proposed that functional performance is based on *knowledge of* the
167 environment, which is perceptual in nature, and different from the more abstract symbolism of
168 *knowledge about* the environment. Specifically, the former is unmediated or *direct*, whereas the
169 latter is *indirect*, often mediated through pictures, words, symbols (Gibson, 1966) – or given the
170 focus and context of our paper, through the verbal instructions offered by a coach. Thus, enriching
171 one's knowledge of the environment is an integral part of learning designs in sport, framed through
172 an ecological dynamics rationale. This distinctive conceptualisation of knowledge would imply

173 that the game's fastest players are those who can operate at "optimal" speeds while interacting
174 with problems of the performance environment, and not always those who can register the fastest
175 times recorded on a stopwatch while running a set distance outside of game contexts (e.g., like as
176 seen within the NFL Combine – a scouting camp conducted to 'identify talent' via the use of
177 decontextualized tests and drills).

178 **The Athlete-Environment Mutuality**

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

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

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

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

205 *Analysing Movement Behaviours in Context*

206 The performance of any movement skill is contextually situated; meaning, it is embedded within
207 a specific environment, shaped under varying constraints. Moreover, it is the context (of a sport
208 movement problem) that will channel the content (of the coordinated movement solution),
209 allowing practitioners and athletes to determine its functionality (e.g., how practical and useful it
210 is in achieving the task goal). In assessing the level of functionality of movement skills, Bernstein
211 (1996) presented the idea of dexterity, “the ability to find a motor solution for any external
212 situation, that is, to adequately solve any emerging motor problem” (p. 228). More than that,
213 though:

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

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

226 **Utilising Representative Learning Design**

227 Araújo and Davids (2009, p. 6) eloquently stated, “In human behaviour, the act of ‘doing’ never
228 occurs in a vacuum. To do is always to do something somewhere.” In other words: context is
229 everything! Speaking to position coaches and coordinators, applied sport scientists, and strength
230 and conditioning coaches, have you ever noticed differences in what you have practised (perhaps
231 over and over again) and what (does/does not) transfer into the competition? In games, for
232 example, do athletes struggle to adjust their routes, make tackles from disadvantageous positions,
233 or make throws from unbalanced stances? If so, perhaps next consider what information is missing
234 in training compared to the competition – e.g., *are there similar numbers of opponents and*
235 *teammates on the field as would be experienced in competition? Are "messy" plays encouraged to*
236 *be "played out", or are they stopped because of a missed block or tackle? Or is practice consumed*
237 *by the sound of the coach's voice? Meaning, is instruction overly prescriptive?* In reflecting on
238 such questions, it is paramount for coaches to consider that the context shapes the content. Think
239 about, for example, the number of moving bodies (both of teammates and opponents), the gaps

240 between players emerging and rapidly closing, the weather conditions (e.g., wind direction and
241 strength) – are these things we encourage players to directly experience and interact with during
242 the practice or are they things we try to control – perhaps even avoid – given the ensuing messiness
243 they could create? Thus, we argue that coaches could consider using practice tasks that encourage
244 *exposure*, not removal from context. Practice should offer players opportunities to learn how to
245 adapt movements to emergent problems likely encountered during gameplay, as in this messiness,
246 dexterity comes to life.

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

257 Applied to American football, RLD would see players performing under constraints likely
258 experienced during competition, leading to greater action-fidelity (Stoffregen et al., 2013). For this
259 reason, a learning designer should look to design alive movement problems that emerge in the
260 game, faithfully capturing the dynamic nature of American football, where athletes solve football
261 problems that vary in complexity. As many experienced coaches are aware, no two problems, or
262 solutions, are the same. Thus, to help design diverse problems that could be experienced during

263 competition, coaches could work with athletes to *co-design* activities (Woods et al., 2020): an
264 approach centralises athlete-environment interactions by capturing their rich experiences. In our
265 case examples, we illustrate how practice designs can shift towards athletes going through the
266 process of solving alive movement problems, where they interact with contextual information and
267 are given ample opportunities to become progressively attuned to information about emerging and
268 decaying affordances provided by gaps, the relative speed of oncoming players, line markings,
269 environmental conditions, and so on.

270 **Emphasising affordances when facilitating athlete-environment interactions**

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

285 and half-line activities) that help athletes seek and exploit key affordances to help solve problems
286 in competition.

287 The perception and utilisation of affordances is an important characteristic of skilled behaviour in
288 team sports. Learning to perceive affordances, for example, can help athletes develop ‘game
289 intelligence’ as they become better attuned to information about their performance environments
290 (Button et al., 2020). Using relevant affordances is part of becoming more skilful, as, in team
291 games, players learn to couple their movements to relevant information sources in the
292 environment. These couplings become stronger with practice and experience (e.g., more stable,
293 and resistant to perturbations in the performance environment) and are formed through decision-
294 making and affordance utilisation that Araújo and Davids (2009, p. 4) defined as a “functional and
295 emergent process in which a selection is made among converging paths of actions for an intended
296 goal,” or tantamount to movement problem-solving in dynamic performance environments. These
297 ideas confirm that dexterous movers are not developed simply by performing repetition by rote.
298 Instead, dexterity emerges from the process of solving movement problems through *repetition*
299 *without repetition* (Bernstein, 1967), where athletes are challenged to adapt their behaviours and
300 perceive affordances as they meet the ever-changing nuances of the performance problems faced
301 in competition.

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

306

307 **Offering a Way Forward on Best Practice**

308 *How a Constraints-Led Approach Can Be Implemented in American Football*

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

325 **Developing Dexterous Movers: Part 1**

326 *Case Example #1 – Facilitating Attunement & Adaptation for an NFL All-Pro*

327 Many may think that because a player has reached the upper echelons in the sport (e.g., the
328 National Football League), that they have already “acquired” all the skills necessary to solve
329 movement problems in the most efficacious ways. Therefore, once an individual is at this phase in

330 their development, these skills must simply be “maintained” to continue playing at this level.
331 However, as difficult as it is to “get there,” it may be an equally challenging endeavour to remain
332 “there,” and continue to perform at the highest level. For this reason, ecological dynamics
333 emphasises the nature of *skill adaptation*, rather than *skill acquisition*. The latter term infers a
334 rather static conceptualisation of motor learning, when a more dynamic and ever-changing
335 understanding might be needed (Araújo & Davids, 2011). Not only is there a constant influx of
336 new athletes entering the NFL each year, hungry to prove themselves and carve out a role, but also
337 when a player achieves a certain amount of success, their opponents begin to analyse their
338 performance behaviours closely, picking apart their skill set to find any weaknesses, so they can
339 “game plan” and “scheme” against them. To combat these demands, the player, and their coaches
340 must be honest about the current gaps which exist within the player’s individual movement
341 repertoire. Furthermore, they must use that awareness to design a learning environment containing
342 highly representative task problems which frequently stretch the player to further explore refined
343 or novel movement solutions (Renshaw et al., 2019).

344 To illustrate how these theoretical concepts may be able to inform and guide practical application
345 out on the field, let’s take a real-life example of a veteran NFL defensive end who has achieved
346 Pro Bowl recognition several times throughout his career. During his time starting on his respective
347 team, he had become widely known for his pass-rushing prowess (e.g., attempting to pressure,
348 disrupt, or sack the opposing team’s quarterback), typically facing and beating the immediate
349 opponent (e.g., usually the opposing team’s offensive tackle) predominantly through employing a
350 speed rush move on the edge to go around the lineman, or via executing a bull rush in an attempt
351 to go through the opponent, en route to the quarterback. Knowing that these were his two “go-to
352 moves”, which he relied upon heavily up to that point, and respecting the notion that NFL players

353 will compensate and adapt rapidly to frequently faced problems, this player and his personal
354 Movement Skill Acquisition Coach set out to expand his movement behavioural repertoire. This
355 was undertaken to offer him a wider movement toolbox of potential solutions which could be
356 coordinated, controlled, and organised in a variety of ways to solve frequently occurring problems
357 (e.g., invoking Bernstein's 1967 notion of practice as repetition without repetition). The player and
358 coach also observed, from detailed analysis of past emergent interactions on the field within the
359 competitive setting, when the player was tasked with pursuing a more mobile quarterback, as
360 opposed to those who would stay "in the pocket" and/or only manoeuvre within the pocket in more
361 restricted or limited fashions, he would have a relatively difficult time accurately detecting
362 information regarding the quarterback's movement behaviours, as well as subsequently expressing
363 the coupled movement skills to adequately pursue the quarterback.

364 Certainly, some teams across various levels of skill (e.g., developmental to professional) may focus
365 significant time and energy on setting 'more alive' problems within their practice structure.
366 However, within this particular professional NFL team, it was found that less representative
367 problems were utilised across the different periods of practice. For example, during 'individual
368 periods' (e.g., indy periods, positional periods), many of the activities being employed were
369 seemingly devoid of the information sources which one would actually need to couple their
370 movements to the competitive task. Thus, it was not uncommon to see the defensive end spending
371 the majority of their individual periods in the midst of drills being conducted in completely
372 unopposed fashions (e.g., on air or against a sled, dummy, or other stationary objects) and/or while
373 attempting to repeat a specific technique (e.g., such as take-off from one's stance). Even during
374 most 1-versus-1 periods, where the defensive ends would line up in opposition against an offensive
375 lineman, the various constraints utilised here usually included task manipulations like a coach

376 standing stationary in the pocket to simulate the quarterback location (e.g., behind the lineman) or
377 the ball snap being simulated while attached to a stick (e.g., as opposed to being directly snapped
378 from a centre to a quarterback (QB)). Even during half-line type of work, the QB would typically
379 move in highly unrealistic and stereotyped fashions, often with very little movement in the pocket,
380 and sometimes without an objective to throw. As such, we felt these types of activities did not
381 look, feel, and unfold like they will within the game. They simply do not offer the appropriate
382 information that skilful players must utilise to coordinate and regulate their movement skills
383 through. It should be noted that these types of aforementioned activities are actually similar to
384 some of those which are traditionally advocated for by various expert organisations, such as USA
385 Football¹.

386 Within this particular team, the majority of truly alive problems being presented to players was
387 limited, almost exclusively, to those found during full team periods (e.g., 11 versus 11). In this
388 type of competitive and challenging environment, players may end up resorting to the utilisation
389 of movement strategies and skill execution that they are already familiar with, that are already
390 stable, and/or they feel comfortable with. Additionally, we also found that, though the problems
391 here could be deemed more representative, the number of repetitions and associated exposure to
392 these types of problems in the practice environment with the team, was actually rather limited,
393 especially for players who are already on the starting unit and/or those who may be considered
394 'star' players. Now, we are not suggesting that all practice activities must be fully representative.
395 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=OcXIM4kiq1A> and
<https://www.youtube.com/watch?v=kKSkNnUnWg0>).

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

403 To accomplish each of these goals, the player first had to be willing to explore the problem-solution
404 dynamics in practice settings to search the perceptual-motor workspace to discover opportunities
405 for organising movement system degrees of freedom in adapted, novel, and creative fashions (Orth
406 et al., 2017). Additionally, it was imperative that throughout this process, the player remained
407 vulnerable as he was pushed into “stretching his grip” over (effectively utilising) a range of
408 affordances (Renshaw et al., 2019). As part of this exploration process, it meant that he was likely
409 to lose a moderate number of repetitions versus the opposing players in practice – sometimes even
410 players that he could easily beat if he would simply resort to the employment of his existing
411 movement skills (e.g., the former “go-to” moves). Though challenging, if he could endure this
412 factor, it was hypothesised that he could come out of this highly nonlinear process as a more
413 attuned and adaptive player with an evolved, dexterous movement skill set (Araújo & Davids,
414 2011).

415 To facilitate the emergence of this enhanced movement behavioural repertoire, a representative
416 task design was utilised by manipulating specifically relevant constraints, thereby allowing alive
417 movement problems to become the norm in the training environment – providing many
418 opportunities for athletes to couple actions and perceptions, find and use available affordances for

419 relevant actions, and to adapt their movements by exploring repetition without repetition (Button
420 et al., 2020). These endeavours were undertaken while maintaining a learner-centred focus
421 throughout the practice process, where ownership and autonomy, as well as authenticity and
422 creativity, were prioritised whenever possible (Hendry & Hodges, 2013). Finally, an additional
423 benefit emerged to help combat the apparent gaps within his movement skill set mentioned above
424 regarding his previous lack of functionality when facing more mobile quarterbacks. It should first
425 be noted that the trends and current realities of the dynamic performance landscape in the NFL
426 indicate that quarterbacks are becoming more athletic and using this all-around athleticism as an
427 integral part of their movement performance. Meaning, the current “Form of Life” (Wittgenstein,
428 1953; Rothwell et al., 2020) used for preparing athletes for competition in the NFL is changing to
429 accept and expect a more agile and skilful mover at the quarterback position. Thus, a defensive
430 end who is tasked with pursuing and attempting to tackle (e.g., sack) the opposing team’s
431 quarterback, must have the capacity to be able to adapt accordingly to respond to these challenging
432 demands.

433 Though this particular movement skill refinement process took place primarily in adapted, non-
434 team settings, it was still possible to set problems that were representative of the full-team scenario,
435 as long as key component parts of the athlete-environment system formed the interacting relations
436 between the player and his opponent(s). Each day while practising out on the field, it was ensured
437 that an opposing quarterback, an offensive lineman in the form of an offensive tackle, and another
438 additional player to act as the centre who would snap the ball, would all be present to serve as
439 interacting component parts of the problem. We found that this latter individual was vital to the
440 information-movement coupling for the defensive end – the ball being snapped in relation to the
441 quarterback’s audible snap count (e.g., both the count itself, as well as the inflection of the voice,

442 are often deliberately manipulated by a quarterback to be highly unpredictable), represented
443 essential specifying information which the defender must become attuned to. If the player became
444 too reliant on detecting just the quarterback's voice, he could be easily deceived into jumping off-
445 sides (e.g., incurring a penalty). Thus, still being sensitive to the quarterback's voice, while also
446 simultaneously detecting small nuances of the movement of the ball in the centre's hand prior to
447 the snap, allowed the defensive end to explode with intention in executing his first-step action out
448 of his stance at the appropriate time. This aspect of the movement problem-solving process is vital
449 as it enables the defensive end to put earlier pressure on the movement behaviours of the offensive
450 tackle (e.g., the opponent then would "kick" harder in attempts to cover more distance to keep up
451 with the defensive end). This interactive design feature would create more space to the left and
452 right of the tackle (e.g., opening a two-way go for the defensive player's path, based on additional
453 space afforded between this unfolding dyadic relationship, and in relation to other moving players
454 on the field; see Figure 1: A snapshot illustration of the unfolding movement problem-solution
455 dynamics between a defensive end (DE) and an offensive tackle, while the DE simultaneously
456 detects the information about the emerging movement behaviours of the quarterback).

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

458 This scenario would also give the defensive end more options for the pass rush move he would
459 subsequently attempt to execute (e.g., he no longer had to rely on one of the two options for
460 interacting with the movement problem being presented by the tackle). Additionally, though still
461 remaining highly connected, perceptually, to the detection of subtle nuances of the tackle's
462 movement behaviours (using information from interpersonal distance and relative velocity
463 relationships between the competing players (see Passos et al., 2008), these modifications in
464 movement performance now allowed the defensive end to simultaneously perceive information

465 about the unfolding intentions and movement actions of the quarterback. This multi-layered, and
466 simultaneous, information detection represented successive nested affordances for the defensive
467 end to perceive and act upon (Button et al., 2020). This idea implies that the functional movement
468 solution continuously regulated by the player was no longer simply about solving the immediate
469 movement problem being presented by the offensive tackle. It was also about how the quarterback
470 was simultaneously behaving – thereby allowing the behaviours of both of these key opponents to
471 channel the resultant movement behaviour of the defensive end.

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

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

- 486 • Changing the down and distance on each repetition of the simulated task: modifying these
487 circumstances would influence the intentional aims of players on both sides of the ball
488 while increasing upon the game-like nature of the practice tasks.
- 489 • Including additional players for the problem, such as a tight end and/or running back who
490 may have the responsibility of executing a “chip block” on the defensive end: this would
491 present more 1-versus-2 scenarios and represent an increase in the complexity of the
492 movement problem to be solved. Additionally, the defender would be required to remain
493 highly flexible in the movement solution organised as strategies that worked when he was
494 1-versus-1 with an offensive tackle, were no longer feasible if a double-team was executed
495 against him.
- 496 • Requiring the defensive end to begin the task from the opposite side of the defensive
497 formation: because he primarily plays on the right side of the defence, by moving him to
498 the other side, where he has very little experience and less information-movement
499 couplings established, put his movement skills to the test in staying in a constant state of
500 learning and adaptability.
- 501 • Moving to different fields so a variety of surfaces were being practised on: this would
502 change the behavioural dynamics of the movement solutions being organised (e.g., how a
503 movement is executed on a turf surface will differ from that being carried out on the grass).
- 504 • Performing these tasks under the influence of key performance inhibitors such as fatigue
505 (e.g., through the accumulation of game-like workloads), and/or anxiety (e.g., such as
506 having various spectators present watching the sessions): including these *inhibitors* in the
507 practice environment required the player to manage his associated physical and

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

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

522 **Developing Dexterous Movers: Part 2**

523 *Utilising an Ecological Approach with High School Football Players to Expand Their Football*

524 *Speed*

525 Regardless of the athlete's age or skill level, utilising a nonlinear pedagogy with an ecological
526 dynamics rationale is crucial in helping athletes adapt their skills over time. In this way,
527 development is viewed as 'learning to learn to move' as athletes become more skilfully attuned to
528 information such as the surface of play, current environmental conditions, tactical strategies of the
529 opposition, emerging interpersonal distances between teammates, and opponents as plays unfold,
530 and so on. Karen Adolph and Justine Hoch, who study infant motor development, eloquently stated

531 that when children are discovering new ways of moving as they use perceptual information during
532 tasks, they are *learning to learn to move*. They argued that adaptive action requires that movements
533 be constructed, selected, and modified that are congruent with situational constraints and
534 opportunities provided by the environment. The notion of learning to learn to move (Adolph &
535 Hoch, 2019) transcends infant development. In American football, learning to learn to move is
536 analogous to athletes adapting their movement solutions to create a functional fit with the problems
537 they face in sports. Essentially, learning is about adaptive behaviour rather than acquiring fixed
538 technical solutions (Araújo & Davids, 2011).

539 In the following example, which focuses on high school level players ranging from 16-18 years of
540 age, we will take a deeper look into the application of the constraints-led approach, along with
541 *representative co-design* where the athletes are actively engaged in the practice design process
542 (Woods et al., 2020). Designing representative learning environments for a specific individual or
543 group of athletes requires the coach to watch their movement behaviours within the context of
544 their sport (both practices and games) to identify strengths and weaknesses (or opportunities).
545 Watching players move in context offers coaches a better understanding of how the human
546 movement system *softly assembles* the degrees of freedom (e.g., temporarily re-organises body
547 components such as muscles, joints, limb segments) to satisfy changing performance constraints.
548 The process of soft assembly is available in complex adaptive systems which can exploit
549 tendencies to *self-organise* components into an emergent coordination solution to meet the nuances
550 of performance challenges (Kugler & Turvey, 1987). Analogous to a softly assembled movement
551 solution, the coach-athlete system can work together to “softly assemble” practice activities that
552 promote search, where athletes look to solve game-like movement problems. Instead of forcing
553 drills and technique repetitions, likely written far in advance (generalised for groups of athletes,

554 not for specific individuals), the softly assembled practice activities allow the coach-athlete system
555 to manipulate constraints to challenge athletes to solve performance problems at that time.

556 *Case Example #2 – Making Tackles in Open Space*

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

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

576 Initially, both the offensive and defensive players owned the way they chose to enter the workspace
577 (stationary or moving, and the direction they were facing). The space between the two opponents
578 started around 10 yards, and the athletes were rarely stacked. Instead, there was generally a stagger
579 to begin the activity. In doing so, this might offer one player a better angle to beat the other to the
580 sideline or exploit their speed in lateral pursuit and hit gaps (affordances) that emerge towards the
581 middle of the field. The slightly disadvantageous positions the athletes find themselves in, which
582 frequently occur in American football, challenge them to actively self-regulate their behaviour to
583 the *alive* problems and find a functional fit as the constraints change. There are plenty of
584 opportunities for the coach-athlete system to manipulate constraints that challenge the athlete's
585 optimal grip over the field of affordances. Purposely manipulating constraints to invite relevant
586 performance behaviours is encouraged to help athletes adapt their skills as task complexity
587 increases. A few task manipulations were made for these linebackers based on their ability to solve
588 problems, such as but not limited to the interpersonal distances between the two opponents and the
589 direction they faced to start the activity. As we progressed, the linebackers expressed the need to
590 reach the opposition in situations where the ball could be thrown to a receiver where they would
591 need to cover more distance to get to them. By involving the athletes, coaches can capture their
592 experience and design practice tasks that focus on areas they have acknowledged as opportunities.
593 Following the engagement between the coach and athletes, a different activity was co-designed.
594 In the new co-designed activity, the athletes search to pick up whether it is a run or pass, which
595 allows them to gain experience and adapt their behaviour to make the play as the complexity
596 changes. We expanded the space (task manipulation) for the modified activity to include the
597 middle of the field to the sideline, which allows for inside runs while still inviting multiple pass
598 options. In addition to the linebacker and running back (or receiver) in the initial one versus one

599 situation, the following positions were added to challenge the athlete's grip over the field of
600 affordances.

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

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

617 *What Can We Take from This?*

618 First, we would like to emphasise the importance of the opposition's presence in the practice
619 design. Behaviour affords behaviour where movements emerge from the relations between system
620 components, and athletes learn to perceive and use shared affordances for and of other players.

621 Second, our focus centred around the linebacker position in the example above, but all the athletes

622 solved representative problems where context-specific information helped guide their behaviour.
623 The training sessions generally consisted of 5-12 offensive and defensive players from the same
624 high school team. For team coaches, this is promising because they can maximise their numbers,
625 and the athletes can interact with game-like information sources, which specify individual and
626 frame-dependent affordances to expand their football speed.

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

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

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

652 **Conclusion**

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

664

665 **Declaration of Conflicting Interests**

666 No authors declare any potential conflicts of interest.

667 **Funding**

668 No funding was obtained or sought for the construction of this paper.

669 **Acknowledgments**

670

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781 **Figure Captions**

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

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

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