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5 Title: Coaching Golf – How skilled are we in ‘skill’?

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22 of several books, published papers and popular articles.

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Coaching Golf – How skilled are we in ‘skill’?

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45 **Abstract**

46 There is much debate on how best to develop skilled performers in sport and which practices are most
47 effective in achieving this aim. This paper's interest is in the coaching of high-level golfers and how
48 coaches utilise their knowledge base to select the methods they employ to develop skilled performance.
49 With such a varied and sometimes dichotomous range of theories, concepts, ideas and practices, the
50 coaching industry needs support to navigate through this vast field of work. Here, the major theories of
51 skill learning and development are presented and explored in relation to the game of golf. Due to the
52 importance of skill acquisition, retention and transfer decisions, coaching action needs to be carefully
53 grounded in the environment and context in which it occurs. To support this, two models are presented
54 for consideration that can guide coaches' skill acquisition reflections and future skill development
55 decisions. Golf specific examples are provided to bring these models to life but the utility of both
56 frameworks has value to sports coaching in its many varied contexts. (176 words)

57 *Key terms: Motor Learning, Learning Chains, Coaching, Professional Judgement Decision Making.*

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59

60 **Introduction**

61 *Golf Coaching Knowledge – an industry in itself*

62 The knowledge of expert coaches gains great interest in the golf industry and media through a
63 burgeoning body of published instructional books, magazine articles, coaching videos, social media feeds,
64 and testimonials from famous and successful golfers. There is even a Top 50 (Golf Digest, 2017) and
65 Top100 leader board of golf instructors. Many studies have therefore been conducted into high level golf
66 to investigate the expert golf coaches' knowledge base (Grecic & Collins, 2012; Carson, Collins &
67 MacNamara, 2013; Schempp, Templeton, & Clark, 1998), the rationale that drives these expert golf
68 coaches' actions (Grecic, MacNamara & Collins, 2013; Schempp & McCullick, 2010; Schempp et al.,
69 2006), the self-monitoring of coaching knowledge and behaviour (Schempp, McCullick, Busch, Webster,
70 & Mason, 2006) as well as the fundamental knowledge areas required for effective golf coaching (Grant
71 et al., 2012; Smith et al., 2015).

72 Coaching is ultimately about helping the performer get better – critical to this is the ability to
73 facilitate an athlete's skill acquisition, retention and transfer to performance. Carson and Collins (2014)
74 note that in golf like many other sports there is an 'accepted wisdom' of the 'correct' model or technique
75 and the knowledge base required. Various studies have sought to illuminate how golf science can support
76 coaches' professional practice to achieve such skilled performance. In relatively recent times these
77 empirical studies have been collated and promoted by organisations, books and journals including the
78 Golf Journal, the Annual Review of Golf Coaching, and most recently the International Journal of Golf
79 Science (IJGS) to name but a few. Here research into golf instruction (Samson, 1993a; 1993b) motor
80 learning (Lee & Schmidt, 2014), motor control (Carson, Collins & MacNamara, 2013) imagery and skill
81 learning (Forlenza, Weinburg & Horn, 2013), swing dynamics (Jenkins, 2007) practice schedules
82 (Guadagnoli & Bertram, 2014) and many more golf research topics are all collated for consideration.

83 Although these insightful resources are publicly available this is not to say that golf coaching practitioners
84 will necessarily access, analyse, assimilate or value the knowledge such research contains.

85 In many related domains such as physical education and the coaching of other sports researchers have
86 identified a research gap and a knowledge lag between empirical research in skill development and
87 application by its practitioners (Partington & Cushion, 2011; Ford et al 2010; Renshaw et al., 2010;
88 Williams and Hodges, 2005). Indeed, specifically in golf Jenkins and many other respected golf officials
89 and researchers have recognised a similar void in the industry’s underpinning declarative and procedural
90 knowledge and have promoted the need for a more evidence based and professionalised qualification
91 which embeds coaching science into the continued training of its practitioners (Jenkins, 2014). It is for
92 this reason that the paper aims to explore the golf coaching knowledge base in relation to skill
93 development and how this is applied by its practitioners on the practice ground and golf course.

94 **Key Concepts**

95 *But what is ‘skill learning’ and what should golf coaches know?*

96 Skill in any field is seen as the ability to do something well with success. McMorris defines
97 skilled action as “the consistent production of goal orientated movements which are learned and specific
98 to the task” (McMorris, 2014, p.2)., whilst Schmidt and Lee note that skill is the ability to produce
99 organized muscular activity that achieve such a goal (Schmidt & Lee, 2014, p.8) As such researchers have
100 been extremely interested in how this successful execution of action occurs. Initial studies focussed on a
101 simple stimulus – reaction response to explain action, but as studies evolved other more complex ideas
102 and theories evolved to answer the question of how coordinated, fluid and successful movements occur.
103 An impetus for much of this research stemmed from the observations of Bernstein and his Six Degrees of
104 Freedom concept of motor movement (Bernstein 1967). Here Bernstein recognised that novice
105 performers of any skill, when looking ungainly, would freeze certain joints to overcome a motor control
106 problem. Later, as the performer became more experienced however, some of these joints were

107 gradually released, thus engaging additional muscles and joint angles in order to achieve what appeared to
108 be a much more coordinated and fluent movement pattern.

109 How this precise outcome occurred has been explained by two contrasting theories. The first of
110 these was that the body engages a centralised control of movement through the brain and movement
111 patterns that had been stored there (Broadbent, 1958; Sternberg, 1969). This Information Processing (IP)
112 theory (Welford, 1968), proposed that for coordinated movement to occur the body's computer, the brain,
113 needed to be able to retrieve specific motor programmes that had been experienced and stored in its
114 memory and then activate the relevant muscle to make the desired movement happen (Shiffrin &
115 Schneider, 1977). This 'top-down' approach was predicated upon the exact motor programmes having
116 been practiced sufficiently to embed them deep down in long term memory where they could be retrieved
117 as necessary. This theory therefore spawned practice designs built upon repetition, the achievement of a
118 pre-designed movement pattern or model, and copious feedback to ensure maximum repetitions of the
119 desired model, so it could become 'grooved' in memory.

120 Fitts and Posner (1967) proposed that this 'embedding' process which eventually would lead to
121 instinctive reactions to facilitate successful movement, followed a 3-stage learning process. Initially the
122 novice performer required a great deal of cognition to understand and be aware of the required
123 movements, break the movement down into its constituent parts (isolating parts of the body thus limiting
124 the degrees of freedom available), and repeatedly practice these movements until motor programmes were
125 created in short term memory. An Associative phase would follow whereby the skill was built back up
126 from its various parts, creating associations between them and freeing up additional degrees of freedom.
127 Eventually after many more successful practices this motor pattern would become stored in long term
128 memory and require minimal conscious effort thus freeing the brain to work on secondary tasks and
129 allowing all the degrees of freedom to be released allowing coordinated, effective and efficient movement
130 outcomes to occur.

131 One important distinction was also made when considering this process, that of whether the skill /
132 motor movement being learned required feedback on progress towards the intended goal, which could be
133 used to re-compute future movement attempts and develop a more effective motor programme. Adams
134 (1971) classified this process as either being an Open or Closed Loop design. Here the Open category
135 operated via simple task stimulus, then motor program operation for a successful outcome. A Closed
136 Loop design by contrast required feedback about the initial motor program outcome to be utilised to re-
137 calibrate the selection of the subsequent motor program in order to achieve the desired goal.

138 Researchers from a more developmental or ecological psychology perspective however argued
139 that even with a 'Schema' to guide action, the sheer volume, speed and complexity of motor patterns
140 required in the 'real world environment' (e.g. Fast-moving team-based sports where there are countless
141 possible combinations of stimuli and potential decisions for players to make) could not possibly account
142 for athletes' high level performances. An alternative view had already been proposed that motor learning
143 was not a centralised process (Gibson, 1966) and that the body's many systems could interact themselves
144 in response to various stimuli and self-organise to achieve a successful movement (Kelso, 1995). This
145 Ecological Approach (EA) (Gibson, 1977) promotes practice design based upon creativity to solve
146 perceived movement problems, varied, chaotic environments, minimal coach input and the need for
147 additional time for the body to reorganise and embed following successful outcomes.

148 A key concept for coaches to appreciate in respect to either of the alternative philosophical view
149 of motor learning is that of Contextual Interference (Battig, 1972). This is the process whereby changes
150 in the precise context of the skill will cause the brain or system to re-compute or re-organise to gain a
151 successful movement solution. Battig's research showed motor programmes were modified in response
152 to create new novel and effective solutions to the tasks encountered. Following an information processing
153 / motor learning paradigm the theory proposes two possible explanations 1) that changes in context
154 facilitate greater cognitive effort as the brain strives to compare the edited or modified requirements with
155 its existing programmes available. This process of comparison then stimulates and magnifies the thought

156 process thus strengthening the ‘new’ motor programme which evolves. 2) The change of context
157 enforces the existing motor programme to be disregarded and a new motor programme to be created and
158 then stored in memory. For those proponents of the EA such changes in context result in a reorganisation
159 of the relationship between the various systems within an organism e.g. muscular, emotional, endocrine,
160 mental, etc. which eventually results in new movement responses being created. Newell (1986) in his
161 book chapter exploring how children developed coordinated movements proposed that by manipulating
162 the constraints on the system one could encourage the body’s self-organisation to solve the degrees of
163 freedom issue and develop fluid, successful movements. Here he described such constraints as being
164 anything which limited the practical solutions to a movement problem. Specifically, he categorised these
165 as either Performer, Environment, or Task constraints and depicted these as a triangle each acting upon
166 each other to various extents.

167 Sport domain researchers have been quick to utilise this theory and explore constraint led practice
168 design for coaching and teaching (Davids et al., 2008; Davids et al., 2012). Here practitioners recognise
169 and/or manipulate the constraints or practice conditions via the Environmental (altitude, weather -wind,
170 rain, light, temperature, playing surface, noise, gravity, etc) Individual (physical or psychological
171 characteristics – height, weight, fitness – strength /speed / endurance, anxiety, fatigue, attentional control,
172 motivation / goals, social role, culture / expectations etc) or Task (rules, number of players, equipment,
173 scoring system etc). The premise being that with any contextual interference the perceptual information
174 available to the player will be altered resulting in the systems re-organising to solve the movement
175 problem and creating successful action – ie. a Perception / Action coupling effect without the need for
176 conscious thought or a so-called Perception – Cognition – Action process.

177 Depending on which of the two opposing ‘camps’ coaches support and whose theory they adopt
178 has major implications for their coaching practice and design (Schmidt, 2003). An IP approach promotes
179 repetition, expert models, copious extrinsic feedback and testing. An EA viewpoint however supports task
180 variability, intrinsic feedback, exploration and chaotic practice design.

181 A final key concept when considering such motor learning theories is that of Functional
182 Variability and the view that practice as ‘repetition without repetition’ (Bernstein, 1967) provides
183 movement variability which is a positive outcome. Functional Variability proposes that there are
184 numerous workable solutions to a movement problem which is a good thing, and in fact that no two
185 seemingly identical movement patterns will be identical in every facet (Newell & Corcos, 1993). If a
186 coach subscribes to this approach then the desire to provide a ‘perfect model’ or solution which can be
187 learnt, copied and repeated and again will not be considered. Instead a general guide or a self-organising
188 approach would be more appropriate within the coach’s practice design.

189 An additional debate that coaches should be aware of is presented below, that is, the role of
190 conscious thought to facilitate the coupling of an event’s perception and the movement action needed to
191 respond. The ecological psychologists’ position which builds upon the self-organizing concept within the
192 EA is that no conscious thought is required and that by manipulating the stimulus coaches can facilitate
193 skill learning without direct intervention.

194 Theories such as Implicit Learning (Masters, 1992) and External Attentional Control (Wulf,
195 2007) propose that skills develop best when conscious thoughts are not allowed to reinvest attention
196 internally onto the movement component parts. By contrast cognitive psychologists argue that conscious
197 thought is required to link perception and action in an athlete’s mind in order to establish the mental
198 model required for successful completion of a task and concepts and models such as Especial Skills
199 (Keetch et al., 2005) and the 5 A model of skill refinement (Carson and Collins, 2011) are predicated on
200 the conscious unpicking of the skill being developed in order to identify what makes a skill highly
201 specialised or able to be refined and then re-embedded in memory.

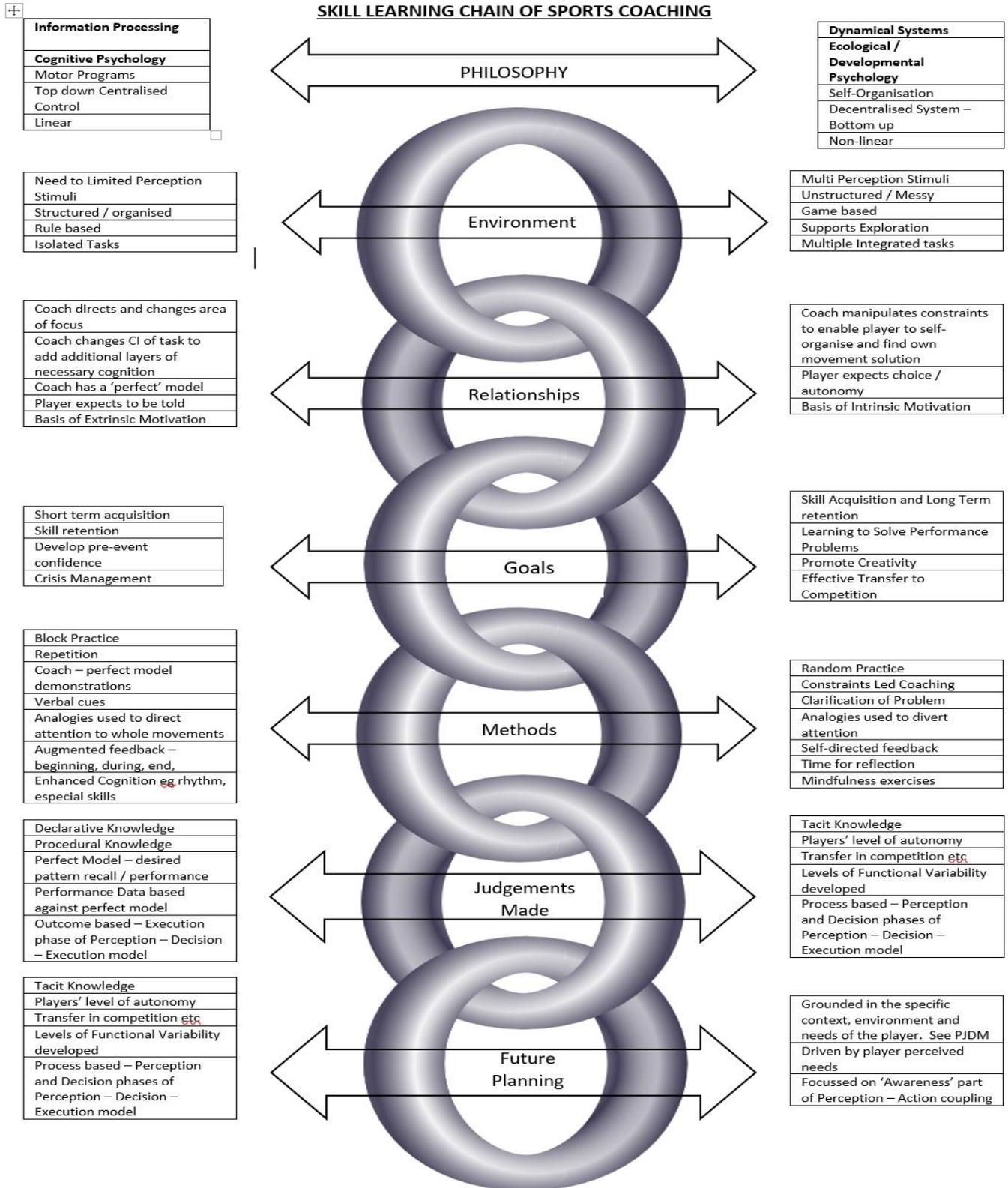
202 Most recently however additional information about how the brain works has become available
203 through neuroscience. Researchers have started to explore how this body of work can support the
204 coaching profession in creating a neurological perspective on skill learning (Bezzola et al., 2011;

205 Kawashima et al., 2012; Schlaffke et al., 2014). For this paper however, the focus is the skill learning
206 concepts that are most widely accepted and implemented in golf and the related sports coaching fields.

207 *What now?*

208 So far various research, theories and opinions on skill learning that coaches need to be aware of
209 have been outlined. This list is not exhaustive but represents the major debates within the area. The
210 overview presents coaches with a plethora of ideas and concepts that can be considered and utilised in
211 their professional practice. How though can a golf coach make sense of such an overwhelming array of
212 information and place it in their own working context? One framework that the first author has used to
213 ‘make sense of skill’ is the Epistemological Chain (Grecic and Collins, 2013) which has been adapted to
214 focus on the knowledge and learning chain related to skill development provided below (Grecic, 2017).
215 This model intends to clearly break down the coaching act into its own constituent parts identify the
216 associations between the links in the chain, and then stimulate thought and personal reflection on how
217 various motor learning practices can be engaged at each stage of learning.

218 This *knowledge and learning chain* is a template that has value for all coaches. It allows them to
219 simply organise their thinking and knowledge they have acquired and reflect upon what strategies they
220 currently apply. As an example, the first author’s Knowledge and Learning Chain in relation to Skill
221 Learning in Sports Coaching is presented for consideration and development by fellow practitioners. This
222 framework below is then followed by golf specific examples of how elements of the chain have been
223 applied by the authors in practice. This is intended to provoke critical thought and encourage each coach
224 to consider the various approaches available, to reflect on their own professional practice and attempt to
225 make their own sense of skill learning in golf. ig 1. A Skill Learning Chain of Sports Coaching



227 *Philosophy*

228 At the centre of debate within the golf coaching community are various views about what is
229 needed for an effective and efficient golf swing. These fundamental knowledge areas (e.g. see Hogan's 5
230 lessons- Hogan & Wind, 1957) are interpreted and disseminated by coaches depending on their own
231 coaching philosophy and knowledge of skill learning. Popular examples include pre-swing fundamentals -
232 GASP; Grip, Stance, Alignment and Posture, maximal club head speed and the X factor, the ball flight
233 laws and the D-Plane, and how best to create a 'pure' strike.

234 To achieve these outcomes coaches will adopt a range of practice designs, instructional strategies
235 and lesson structures with elements taken from either the IP or EA philosophical stances. At the extreme
236 positions of these views however we encounter some extremely successful golf coaches. In the US Hank
237 Haney has his established 'Blueprint' for golfers to follow to copy his techniques and learn his Parallel
238 Swing Plan system, whilst David Leadbetter promotes his 'A Swing' through step by step chapters in his book
239 and an on line A Swing training course. At the other end of the continuum Kendal McWade and his
240 Instinctive Golf programme promote long term exploration, manipulating the task constraints to allow the
241 golfer to find their own solutions with minimal technical guidance.

242 In the US coaches have often been placed in categories partially aligned to the IP model and
243 referred to as method, system and non-system teachers (taken from Jim Mclean's book "The Eight Step
244 Swing"). Method teachers most closely match the IP approach. They have a specific model with the goal
245 of every student matching this model. Examples of golf methods would include Stack and Tilt, Square to
246 Square and Natural Golf. Each has a set of fundamentals and students are encouraged to adopt each
247 pattern to perfect the model. For example, in stack and tilt, players are encouraged to keep weight forward
248 during the pivot, staying centred. Although players may feel weight forward, testing using technologies
249 such as pressure mats demonstrate that that this is not the case.

250 System teachers follow a similar vein but have preferences among patterns and positions rather
251 than demanding a perfect match. Instead they would like people to demonstrate competency within set
252 parameters determined by themselves and develop their own functional variability of the swing. Non-
253 system teachers in the US context however have no philosophy at all, simply promoting the latest golfing
254 fad or ‘tip of the week’ promoted in popular media channels. Golf coaches with an EA are much harder
255 to source within a golfing industry that forces its Golf Professionals to remember and recite a single golf
256 instructional manual (PGA Instructional Manual) and assesses their competencies against such a
257 benchmark.

258 *Environmental*

259 Many golfers, particularly in North America, spend considerable time on a “driving range”. A
260 driving range is meant to allow golfers the opportunity to practice and prepare their ‘game’, however they
261 almost always characterized by flat tee decks and perfect lies. The limited natural stimuli, with players
262 protected from the environment, not approaching their ball from a realistic distance, nor in a realistic time
263 frame, reduces the pre-shot information gathering and decision-making process (Davies, Collins &
264 Cruikshank, 2014). Coupled to the variety of range target nets, posts, flags, novelty objects, distance
265 markers and club / hotel surroundings this environment may have a quantity but not the quality of
266 attentional cues that optimal motor learning requires depending on your coaching philosophy. Indeed, it
267 may be this lack of appropriate contextual interference that prevent golfers from engaging in proper
268 transference training; the ability to take successful skills from the range onto the golf course.

269 A typical scene witnessed in such an environment sees players arrive at a range or practice
270 ground and receive a basket or tray of golf balls. They then ‘use up’ their allocation one after another
271 focussing on a specific swing thought or movement, often one forcing attention upon elements of the
272 takeaway or backswing, before collecting their next allocation and going through the same process. The
273 problem is that golf requires multiple, unique and concurrent shots. The unique part is usually missed

274 within a range environment, making transference of skill to the golf course more difficult. The unique part
275 of shots can include practicing different distances, trajectories or curves, or any combination from
276 different lies. For example, the player may want to practice hitting distance wedges from divots to targets
277 between 40-75 yards away or maybe long irons / hybrids from downhill lies. Unfortunately, the lack of
278 contextual interference limits players' opportunities on the range to refine skills over a broad spectrum.
279 Then, when faced with a tricky situation on the course, many players don't know what to do.

280 An alternative on course or pseudo-course environment where coaches can set challenges in
281 match conditions (or on a specific series of holes) would much improve skill transference training. From
282 an EA standpoint would allow coaches to set games-based tasks which players must solve and complete
283 using the relevant perception-action couplings allowing the player to self-organize their behaviours in
284 response to the 'affordances' or opportunities for action they recognize (Davids, 2008). From an IP
285 perspective the coach could prompt the players' to explore their thinking and make explicit the
286 perception-cognition- action coupling in order to strengthen the executed motor pattern For example, on
287 any given golf shot, most elite professionals would go through a pre-pre shot routine i.e. process of
288 checking the lie, weather conditions, shot options, yardages to different green segments including pin,
289 good or bad miss options, and consider their current performance level before picking a target and starting
290 their mental processes of the pre-shot routine (Davies, Collins and Cruickshank, 2017a; 2017b). Many of
291 these perceptual cues are not available when practicing in a sterile, driving range environment but are
292 invaluable in developing skilled performance.

293 *Relationships*

294 A key difference between good and great instruction is the relationship between the instructor and
295 the student (Jowett & Nezelek, 2012). Good instruction in golf relies heavily on the pathos of the
296 relationship; the student makes progress and any required swing change because they trust and like the
297 coach. Such coach / player relationships are often based on closed feedback loops provided by the coach
298 and underpinned by the IP model. Here lots of verbal communication is provided for the coach to fully

299 communicate their idea, model, or construct to the player. Feedback is given frequently, there is lots of it
300 and external methods such as GPS radar data, or video capture demonstrations and comparisons may be
301 used to reinforce the desired outcome. For example, a coach working with a golfer who suffers from
302 excessive hooking of the ball, can gain Flight Scope or Trackman data instantly in order to differentiate
303 between horizontal swing plane, face to path and spin axis to provide their golfer with information to
304 understand the cause of the problem and then real time feedback on the modification being made.

305 Great coaches transcend the coach / player relationship by providing adjustments to swing
306 variables which impact d-plane and body mechanics, while making the student feel like they are making
307 little or no change and using little verbal communication. Here a more EA model may be being used
308 where small constraints are being manipulated such adding rules such as having to hold a high 'T'
309 finishing position, using modified equipment such as clubs with different swing weights, length of shaft,
310 grip width, etc., or by using analogies such as having to 'squash a tomato' with the outside of the lead
311 foot at impact, which facilitate the desired swing path and shot outcome but do so by allowing the players
312 to create their own movement solutions.

313 *Goals*

314 Depending on the coach / player goal the motor learning methods adopted should be different. At
315 a simple level the timeframe of the goal will have major implications. For example, Shea and Morgan's
316 research on motor learning established a key finding i.e. blocked or repetitive practice tends to lead to
317 better short-term performance during practice, but Random practice, where different tasks are varied
318 during practice, leads to greater long-term learning (Shea & Morgan, 1979). Here blocked practice would
319 align more to an IP approach in learning precise movement patterns whilst random practice would seem
320 more game like if it presented players a more ecologically valid task to solve.

321 An IP focus may also be adopted in cases of pre-tournament training to allow players to practice
322 their favourite shots and build confidence in the specific shots that have been included in the game

323 strategy for that round. Especial skills i.e. those which are grooved most often (Keetch et al., 2005) and
324 will be used most regularly may also be the focus of this practice. E.g. Layup distance approach shots,
325 hole out putting drills etc.

326 IP may also be the focus if the goal is to overcome a previous catastrophic event (major choke in
327 pressured competition). Here IP is used to break down the stroke and allow the player to focus on a
328 single segment cue to provide an anchor to redevelop confidence by concentrating on a simple motor
329 movement and redirecting attention away from external pressures (Hill et al., 2011).

330 IP and motor programming is also a crucial stage in the 5 A model of skill refinement where high
331 level players and their coaches are attempting to unlearn an existing skill pattern and replace it with new
332 one (see Carson & Collins, 2011, for a full description of this process).

333 A more Ecological approach may be adopted however if the coach's focus is in preparation for
334 new environments which will be encountered during future competition e.g. players on the USPGA Tour
335 preparing for the British Open on a Links course – skills required may be so different to the players'
336 existing repertoire that the coach needs to creatively reproduce specific challenges on course for players
337 to work out their own solutions to the upcoming challenge. These solutions can then form basis of the
338 players' future course strategy. Indeed, the coach may also modify the task or individual constraints to
339 create a more stressful and demanding challenge if their goal is based around how their player reacts
340 during pressure training or pressure testing.

341 *Methods*

342 As described above the teaching, coaching and instructional methods adopted by coaches may
343 revolve around their specific short or long-term goals but also, they will consider the season's timing (off-
344 season, early, mid, late), practice context (pre-competition, during, post) and player's developmental stage
345 (novice, developing, performance) when selecting their specific practices. For coaches implementing a
346 more IP approach typical methods employed will include blocked, constant, repeated practice,

347 demonstrations, and frequent external feedback benchmarked against coach directed expectations (coach
348 comments, video capture, launch monitor data, playing statistics), e.g. Club head and body segment
349 positions, Putts per round, greens in regulation, fairways hit, launch angle, swing to path data, spin rates
350 etc). Verbal cues may be used within this methodology to focus attention on specific body movements
351 and stages of the golf swing e.g. Fire the legs through to target, Feel the back ‘coil’, brace the back knee,
352 etc. Analogies or errorless learning (where players achieve success every time e.g. making a 1 foot putt on
353 a flat green) may also be used to support implicit learning of the motor program by reducing or removing
354 the declarative knowledge required during the first stage of learning thus limiting the brain’s ability to
355 reinvest attention to this area when put under pressure (Lam, Maxwell & Masters, 2009; Masters and
356 Maxwell, 2008; Maxwell, Masters, Kerr & Weedon, 2001). Coaches supporting this IP paradigm may
357 even experiment with the use of music and rhythm to match and train the precise timings of the desired
358 movement pattern, so it is embedded deeper into memory by engaging more of the senses in the IP
359 learning process (MacPherson, Collins & Obhi, 2009; Collins, Morris & Trower, 1999).

360 Coaches may also wish to reinforce and / or test the learning process by utilising a “Think Aloud
361 Protocol” (Someren, Barnbard & Sandberg, 1994). This system requires the individual to provide detailed
362 feedback on their thoughts and feelings before, during and after skill execution providing a unique insight
363 into their systems and their knowledge base for the coach to build future sessions upon. (see Whitehead,
364 Taylor & Polman, 2015 for an exploration of its use in golf)

365 Within the EA however coaches prioritise a more variable approach to skill learning utilizing
366 random and varied practice and manipulating the contextual interference available. Here constraints led
367 coaching strategies would be actioned whilst analogies may be used to divert attention away from internal
368 sources which could derail the player’s self-organization process. Examples of constraints employed may
369 include changing the club selected to play a particular shot e.g. the 100yd driver to work on the feel of the
370 swing’s rhythm and balance, changing the rules of the game e.g. putting ‘draw back’ on the greens, i.e. if
371 you miss a putt, you must draw the ball one putter length away for the hole, and continue to do so until

372 the putt is holed. You may also play a game where you only play with your odd or even number irons, or
373 maybe even 3 clubs and a putter. Examples of task constraints in golf may also include playing the rough
374 as out of bounds, playing off the red tees to achieve a target score, hitting two drivers off each tee and
375 playing the 'worst' ball, playing two balls and hitting one approach short and one long on each hole etc.
376 External attentional cues may include a focus on the hole itself when holing short putts, a point 6 inches
377 in front of the ball to encourage a square club face contact, pointing the belt buckle towards the target to
378 encourage full body rotation etc.

379 A key point of difference in design practice here is the source, level and timing of feedback.
380 Based on the EA and self-organization, feedback is owned by the players themselves. What, how and
381 when feedback takes place is decided by the player who will ask the coach for support as required. Time
382 for reflection is also considered which allows players to request delayed feedback after a sufficient period
383 of exploration and system re-organisation. Some coaches may also promote mindfulness exercises to
384 develop awareness. This can be used to heighten the players' cognitions or alternatively to divert
385 attention from any sources which may be causing them to look inside themselves and 'reinvest' attention
386 away from the task at hand (Masters & Maxwell, 2008)

387 *Judgements Made*

388 Coaches with an IP approach such as 'method' coaches and 'system' coaches would base their
389 player assessments on the extent to which the specific elements of their method or system have been
390 adopted, embedded and applied. Comparison data and the level of declarative and procedural knowledge
391 of the player would be crucial. E.g. how like the numbers, movement pattern, outcome data is the swing,
392 and how much knowledge of what the player has to do and how they must do it has been transmitted and
393 received.

394 Those coaches with more of an EA may base their judgements against very different success
395 criteria e.g. The tacit knowledge (seemingly thoughtless ability to apply the appropriate skill to solve the

396 movement problem) evidenced in competition, the variety of solutions available to the player for any
397 given shot, the increased recognition of perceptual cues and affordances available, and the level of
398 decision making autonomy developed in their players.

399 *Future Planning*

400 Following on from the player progress reviews made above, within the learning chain the coaches
401 then plan the follow-up actions, work-ons, and future plans. Within a pure IP approach coaches will use
402 the comparison of desired and actual movements to enable the 'gap' between actual and desired execution
403 to be reduced. Here they may focus on the 'thinking' part of Perception – Cognition – Action coupling to
404 make any fault fixing or refinement plans explicit for their players.

405 *Discussion*

406 It is too simplistic to presume that coaches fit discretely into one of these two categories (IP v
407 EA). Instead we propose that coaches operate upon a skill learning spectrum moving from left to right
408 and back again as and when required. Here coaches adopt the principles from either approach to varying
409 extents depending on their deep held views of coaching and their philosophy of skill learning. An
410 example of where we have found this most prevalent is amongst the topic of transference training. Here
411 we see in practice how initial training methods aligned to IP lead onto tasks which embed the core
412 concepts of the EA; constraints, contextual interference and random practice. At the foundation of each of
413 these ideas is helping the student take their skills from the range to the golf course. To illustrate the
414 concepts, we will use the example of an elite golfer who is preparing for a tournament on a longer golf
415 course. The golfer is aware that they will have many approach shots from 175-200 yards. Previous stats
416 show deficiencies in this area for this player. With feedback from an instructor, the player will work to
417 improve his pattern with a goal of producing consistent shots on the range. Once the player feels
418 proficient, they will move to the next step random practice; isolating the skill by playing every hole as a
419 par 3 from a predetermined yardage set between 175-200 yards with a goal of hitting 70% of greens and

420 having an aggregate score of even par. If they are not successful the first time, the player may have to
421 complete a forfeit to add an element of pressure eg 25 push-ups, sing a song in front of the coach and
422 fellow players, go without their mobile phone for 24 hours etc. and then re-do the game. After engaging
423 in random practice, they would then test their game in a tournament. The scores, along with data collected
424 by the player and coach / player reflections would be used to feedback into their practice plan.

425 However not every situation encountered by golf coaches can be fit into such a convenient
426 process model. Coaching by its nature is messy (Bowes & Jones, 2006) with a myriad of decisions to
427 make relating to the players that we coach. Although the Skill Learning Chain offers a useful reference
428 guide to many of the strategies at our disposal the decision of which one to select, within what time frame
429 and what the impact will be on everyone we support is an extremely difficult one. One framework which
430 we have found invaluable when encountered by such dilemmas is the Professional Judgement Decision
431 Making (PJDM) model (Martindale and Collins, 2005). Here what at first seem intuitive decisions by
432 experienced practitioners are considered as the result of a complex interplay between their ‘intention for
433 impact’, the myriad of performer and environmental variables, and the reflections in action, on action and
434 for action that feedback into the current and future decision-making process. The PJDM has been
435 applied within sports science support (Martindale & Collins, 2012) and a sports coaching context in the
436 outdoors (Collins, Collins & Grecic, 2014). Here a conceptual framework is presented of how PJDM
437 may be modified and considered within the specific context of skill development in golf coaching.

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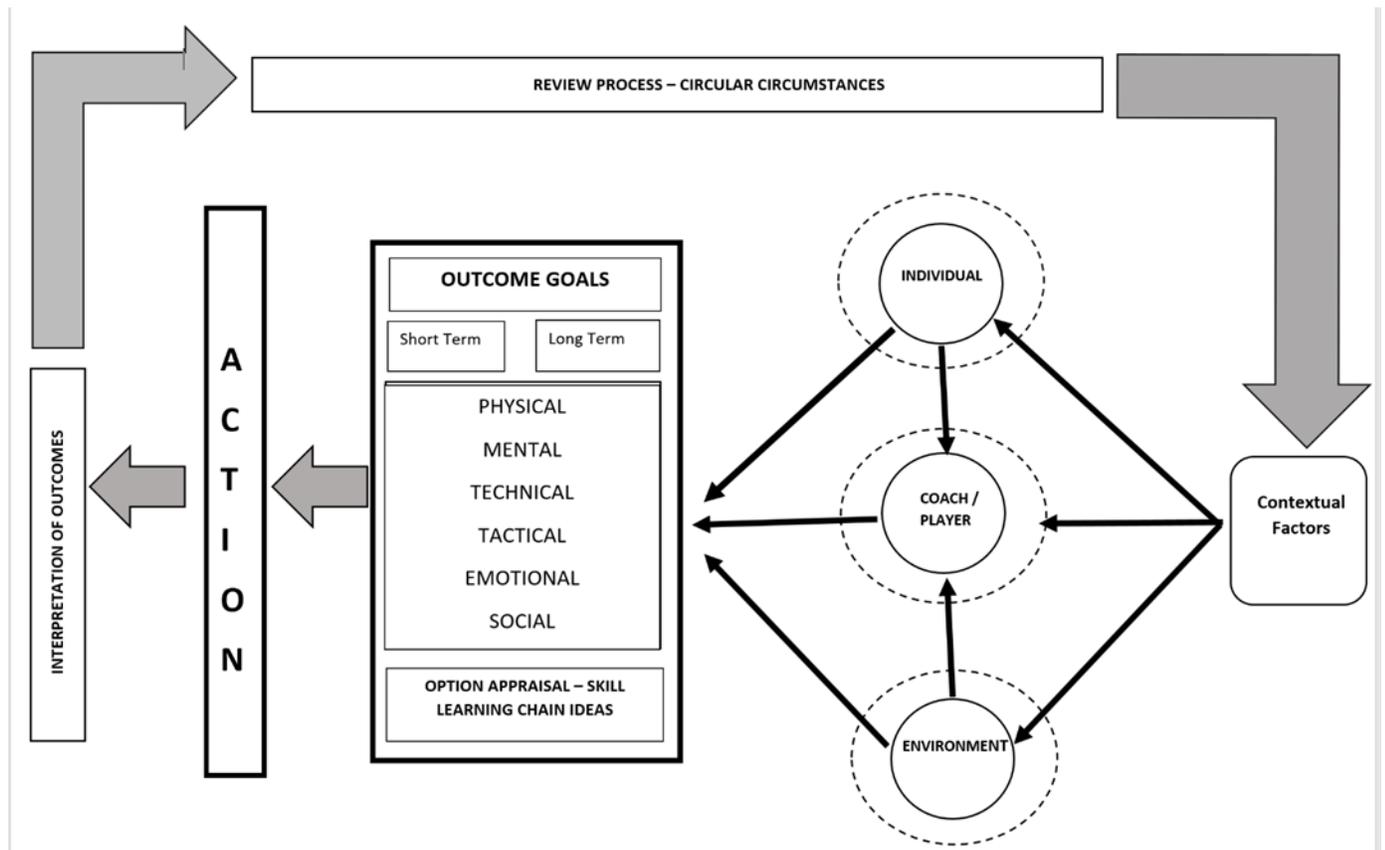
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443 Fig. 2. PJDM and its application for Skill Development in Golf



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445 The model presented above is cyclical in nature and an iterative process where each decision
 446 builds upon the previous and informs future practice. As our starting point for discussion the prime mover
 447 is the golf coach's Intention for Impact based upon the short term (sessional) and long-term development
 448 (periodized) plan. (See Farrow & Robertson, 2017 for the SPORT Skill Learning specific periodized
 449 plan) The Intention for Impact is grounded in the specific contextual factors of the coach/player
 450 relationship (aligned philosophy, skill learning approach preferences, level of player buy in, trust and
 451 respect, communication strategies employed etc.), as well as Individual variables such as the player's
 452 gender, age, experience, skill level, motivation, physical, mental and emotional characteristics as well as
 453 the specific Environmental context in which the coaching act is taking place with its associated pressures
 454 e.g. Talent pathway stage -School /College /Club /Academy/ National squad / Tour, physical resources -
 455 course/ range/ studio / lab, competition or season phase, level of parental input, etc. Each of these

456 variables therefore intertwine to shape the considerations (an Option Appraisal) which lead to the specific
457 coaching actions i.e. The Goals, Methods, Judgements made, and the overall coaching Plan selected.

458 Following the coaching act itself, a key element of the model is then the Interpretation of
459 Outcome. Here an honest review of progress towards the outcome goal must be undertaken. This
460 reflection then feeds back into the cycle to reinforce, re-establish or recalibrate the plan as required. Key
461 to this process however is the recognition again of the coach/ player relationship and their alignment to
462 the possible skill learning and coaching philosophies, and the individual and environmental context. The
463 coach must now consider if anything has changed within these contextual factors because of the previous
464 plan and action that now needs to be embedded within the subsequent PJDM cycle. In this way golf
465 coaches' decisions can be studied in action, measured on action, and contemplated for future action. Such
466 a model that can make explicit the coaching outcome goals grounded in the specific context of the
467 player's circumstances and the skill learning means by which they are attempting to achieve them should
468 be invaluable for coach learning on many levels not least by illuminating any gaps in knowledge upon
469 which their decisions need to be based.

470 **Concluding Remarks**

471 This paper initially acknowledged the knowledge to practice gap which has been identified in
472 various sports coaching domains. The area of motor learning / skill acquisition, retention and refinement
473 was highlighted. The paper therefore proceeded to describe some of the major theories and concepts golf
474 coaches should be aware of and their implications for sports coaching. This paper does not profess to
475 provide an exhaustive review of all possible viewpoints, designs, concepts and beliefs rather an
476 interpretation of how the two existing frameworks of information processing (IP) and the ecological
477 approach (EA) can be adapted and utilised within the specific golf coaching domain.

478 To 'make sense of skill' a Skill Learning Chain has been collated for coaches to use as a
479 reference tool to aid reflections and identify key ideas and initiatives that they may wish to learn more

480 about and experiment within their own professional practice. As the objective of the paper was to support
481 golf coaches' development, golf specific examples were provided to better relate the various concepts to
482 practice. Finally, recognising the daunting nature such a vast array of information for coaches the
483 decision-making model – the PJDM in Golf, was offered to support golf coaches' choices of the
484 appropriate methods to adopt with each individual player o maximise their skill development. The next
485 stage is for coaches to apply the models to their current and desired future professional practice to
486 hopefully help them become a little more skilled in skill!

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