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

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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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Introduction

Golf Coaching Knowledge – an industry in itself

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

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

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

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

Key Concepts

But what is 'skill learning' and what should golf coaches know?

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

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

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

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

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

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

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

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

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

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

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

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

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

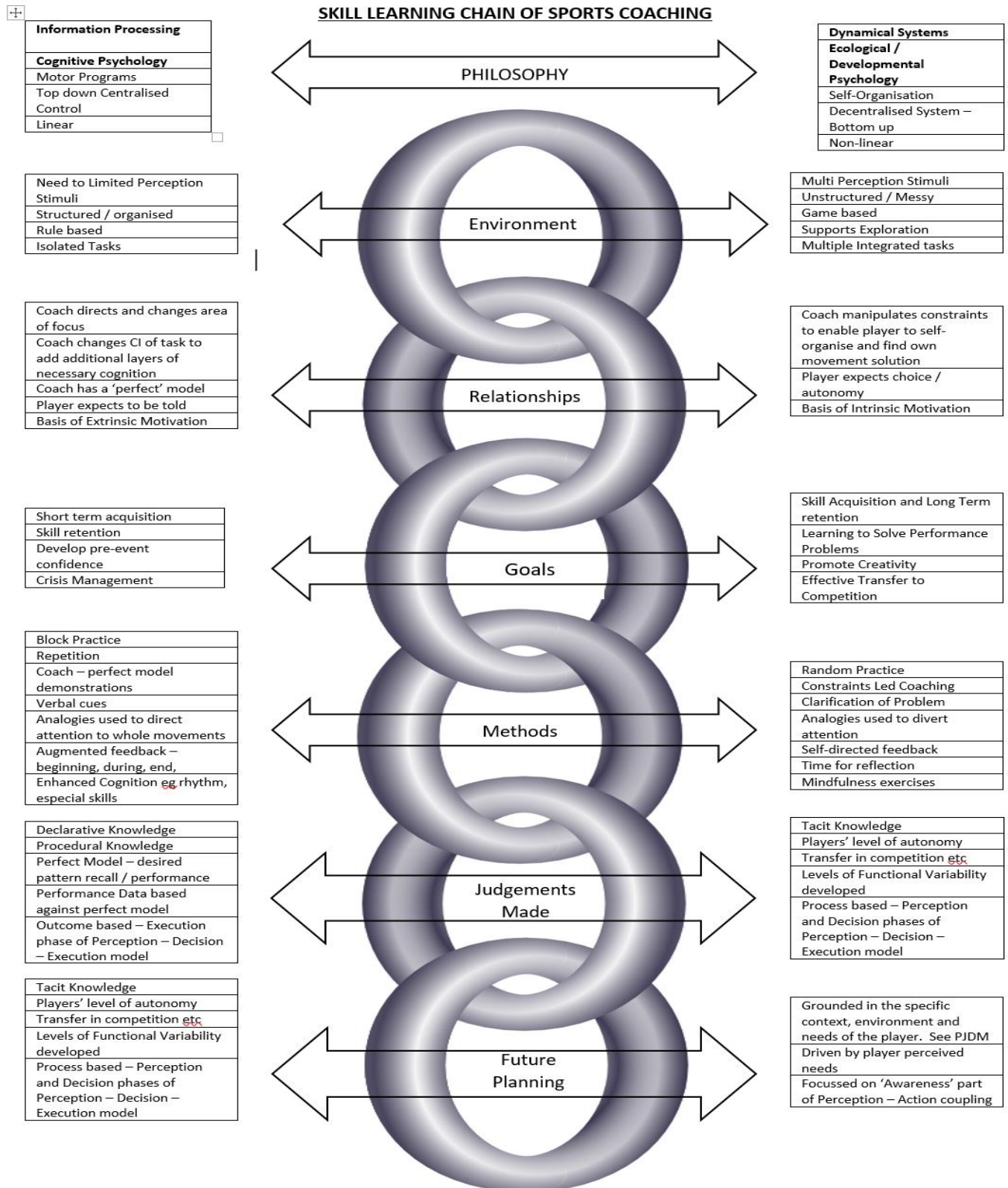
Most recently however additional information about how the brain works has become available through neuroscience. Researchers have started to explore how this body of work can support the coaching profession in creating a neurological perspective on skill learning (Bezzola et al., 2011;

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

What now?

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

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

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

Environmental

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

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

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

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

Relationships

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

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

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

Goals

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

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

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

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

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

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

Methods

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

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

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

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

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

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

Judgements Made

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

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

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

Future Planning

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

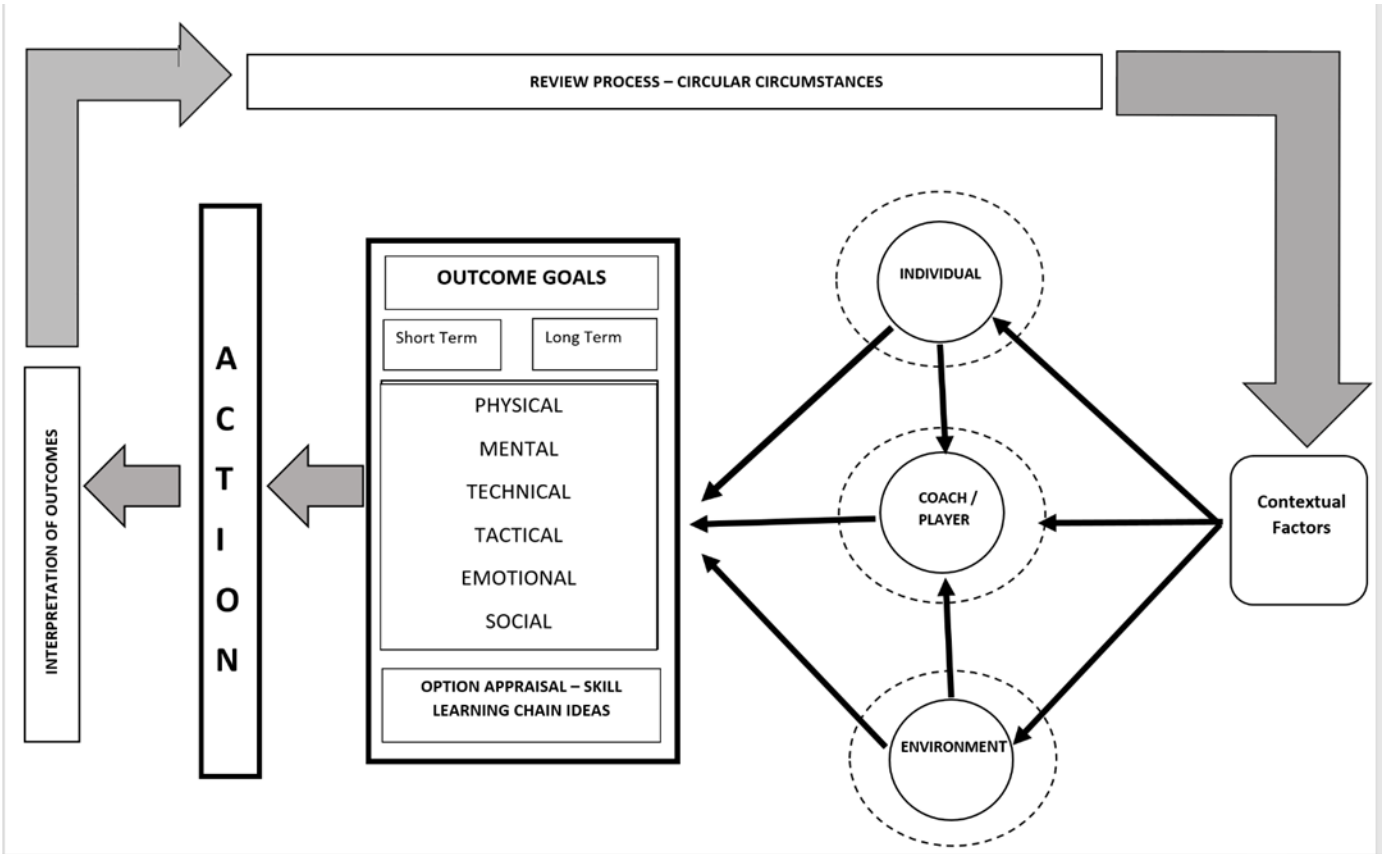
Discussion

It is too simplistic to presume that coaches fit discretely into one of these two categories (IP v EA). Instead we propose that coaches operate upon a skill learning spectrum moving from left to right and back again as and when required. Here coaches adopt the principles from either approach to varying extents depending on their deep held views of coaching and their philosophy of skill learning. An example of where we have found this most prevalent is amongst the topic of transference training. Here we see in practice how initial training methods aligned to IP lead onto tasks which embed the core concepts of the EA; constraints, contextual interference and random practice. At the foundation of each of these ideas is helping the student take their skills from the range to the golf course. To illustrate the concepts, we will use the example of an elite golfer who is preparing for a tournament on a longer golf course. The golfer is aware that they will have many approach shots from 175-200 yards. Previous stats show deficiencies in this area for this player. With feedback from an instructor, the player will work to improve his pattern with a goal of producing consistent shots on the range. Once the player feels proficient, they will move to the next step random practice; isolating the skill by playing every hole as a 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 eg25 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.

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



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

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

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

Concluding Remarks

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

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

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

References

- Adams, J.A. (1971). A closed-loop theory of motor learning. *Journal of Motor Behavior*, 3, 111–150.
doi:10.1080/002 22895.1971.10734898
- Battig, W.F. (1972). Intratask interference as a source of facilitation in transfer and retention. In R.F. Thompson & J.F. Voss (Eds.), *Topics in learning and performance* (pp. 131–159). New York, NY: Academic Press.
- Bezzola, L., Mérillat, S., Gaser, C., Jäncke, L. (2011). Training-induced neural plasticity in golf novices *Journal of Neuroscience*, 31 (35), pp. 12444-12448. DOI: 10.1523/JNEUROSCI.1996-11.2011
- Bernstein, N.A. (1967). *The coordination and regulation of movements*. Oxford: Pergamon Press
- Bowes, I. & Jones, R.L. (2006). ‘Working at the edge of chaos: understanding coaching as a complex, interpersonal system’, *The Sport Psychologist*, 20(2): 235–245.
- Broadbent, D. (1958). *Perception and communication*. London: Pergamon Press.
- Carson, H., & Collins, D. (2011). Refining and regaining skills in fixation/diversification stage performers: The Five-A Model. *International Review of Sport and Exercise Psychology*, 4, 146–167. doi:10.1080/1750984X.2011.613682
- Carson, H., & Collins, D. (2014). Effective Skill Refinement: Focussing on Process to Ensure Outcome, *Central European Journal of Sport Sciences and Medicine* | Vol. 7, No. 3/2014: 5–21
- Carson, H., Collins, D., & MacNamara, Á. (2013). Systems for technical refinement in experienced performers: The case from expert-level golf. *International Journal of Golf Science*, 2, 65–85.
- Collins, D., Morriss, C., & Trower, J. (1999). Getting it back: A case study of skill recovery in an elite athlete. *The Sport Psychologist*, 13, 288–298.

521 Collins, L., Collins, D., & Grecic, D. (2014). The epistemological chain in high-level adventure sports
 522 coaches. *Journal of Adventure Education & Outdoor Learning*, 1-15.

523 Davids, K., Araújo, D., Hristovski, R., Passos, P., & Chow, J. Y. (2012). Ecological dynamics and motor
 524 learning design in sport. In N. J. Hodges & A. M. Williams (Eds.), *Skill Acquisition in Sport:
 525 Research, Theory and Practice* (2nd ed., pp. 112-130). London: Routledge.

526 Davids, K., Button, C., & Bennett., S. (2008). *Dynamics of skill acquisition: a constraints-led approach*.
 527 London: Human Kinetics.

528 Davies, T., Collins, D., & Cruickshank, A. (2014). So what do we do with the rest of the day? Going
 529 beyond the pre-shot routine in professional golf. *International Journal of Golf Science*, 2, 163-
 530 175. doi: [10.1123/ijgs.2014-0008](https://doi.org/10.1123/ijgs.2014-0008).

531 Davies, T., Collins, D., & Cruickshank, A. (2017a). This is what we do with the rest of the day! Exploring
 532 the macro and meso levels of elite golf performance. *The Sport Psychologist*, 31, 117-128. doi:
 533 [10.1123/tsp.2016-0049](https://doi.org/10.1123/tsp.2016-0049).

534 Davies, T., Collins, D., & Cruickshank, A. (2017b). This really is what we do with the rest of the day!
 535 Checking and clarifying what high-level golfers do during the meso-level of performance.
 536 *The Sport Psychologist*. doi: [10.1123/tsp.2017-0033](https://doi.org/10.1123/tsp.2017-0033).

537 Farrow, D. & Robertson, S. (2017). Development of a Skill Acquisition Periodisation Framework for
 538 High-Performance Sport, *Sports Medicine*, 47, 1043–1054 DOI 10.1007/s40279-016-0646-2

539 Fitts, P.M., & Posner, M.I. (1967). *Human performance*. California: Brooks/Cole Publishing Company

540 Ford, P.R., Yates, I., & Williams, M.A. (2010) An analysis of practice activities and instructional
 541 behaviours used by youth soccer coaches during practice: Exploring the link between science and
 542 application. *Journal of Sports Sciences*, 28, 483–495.

543 Forlenza, S., Weinberg, R. & Horn, T. (2013). Imagery Speed and Self-Efficacy:How Fast (or Slow) To
 544 Go? *International Journal of Golf Science*, 2, 126-141.doi.org/10.1123/ijgs.2013-0012

545 Gibson, J. (1966). The senses considered as perceptual systems. Boston: Houghton-Mifflin.

546 Gibson, J. (1977). An ecological approach to visual perception. Boston, MA: Houghton-Mifflin.

547 The 50 Best Teachers in America. (2017, October 19). *Golf Digest*.
 548 doi:<https://www.golfdigest.com/story/the-50-best-teachers-in-america>

549 Grant, M., McCullick, B., Schempp, P. & Tobin Grant, J. (2012). Experts' Content Knowledge of
 550 Fundamentals, *International Journal of Sports Science and Coaching*, Vol 7 (2), 398-410.

551 Grecic, D. (2017). Making Sense of Skill: A Personal Narrative of a Coaching and Teaching Journey,
 552 *Journal of Qualitative Research in Sport Studies*, 11, 30-48.

553 Grecic, D., & Collins, D. (2012). A qualitative investigation of elite golf coaches' knowledge and the
 554 epistemological chain. *Journal of Qualitative Research in Sport*, 6(1). 49-71.

555 Grecic, D., & Collins, D. (2013). The Epistemological Chain: practical applications in sports. *QUEST*,
 556 65(2), 151-168. Doi.10.1080/00336297.2013.773525

557 Guadagnoli, M. & Bertram, C. (2014). Optimising Practice for Performance Under Pressure International
 558 Journal of Golf Science, 2014, 2, 119-127. doi.org/10.1123/ijgs.2014-0021

559 Hogan, B., & Wind, H.(1957). *The Modern Fundamentals of Golf*. Kaye and Ward, London

560 Hill, D. M., Hanton, S., Matthews, N., & Fleming, S. (2011). Alleviation of choking under pressure in
 561 elite golf: an action research study. *The Sport Psychologist*, 25, 465-488.
 562 *International Journal of Sports Science and Coaching*, 4, 247-253.

563 Jenkins, S. (2007) Golf Coaching and Swing Plane Theories. *International Journal of Sports Science &*
 564 *Coaching*, 2, 1-24.

565 Jenkins, S. (2014)..Professionalism, golf coaching and a Master of Science degree. *International Journal*
 566 *of Sports Science & Coaching*, 9(4), 693-715.doi.10.1260/1747-9531.9.4.693

567 Jowett, S., & Nezlek, J. (2012). Relationship interdependence and satisfaction with important outcomes in
568 coach–athlete dyads. *Journal of Social and Personal Relationships*, 29(3), 287-301.

569 Kawashima, S., Ueki, Y., Kato, T., Matsukawa, N. & Mima, T. (2012). Changes in Striatal Dopamine
570 Release Associated with Human Motor-Skill Acquisition. *PLoS ONE* 7(2): e31728.
571 doi:10.1371/journal.pone.0031728

572 Keetch, K., Schmidt, R, Lee, T, & Young, D. (2005) Especial Skills: Their Emergence with Massive
573 Amounts of Practice, *Journal of Experimental Psychology: Human Perception and Performance*,
574 31(5), 970-978

575 Kelso, J.A.S. (1995). *Dynamic patterns: The self-organization of brain and behavior*. Cambridge, MA:
576 MIT Press.

577 Kelso, J.A.S., & Zanone, P.G. (2002). Coordination dynamics of learning and transfer across different
578 effector systems. *Journal of Experimental Psychology. Human Perception and Performance*, 28,
579 776–797. doi:10.1037/0096-1523.28.4.776

580 Lam, W., Maxwell, J. & Masters, R. (2009). Analogy Learning and the Performance of Motor Skills
581 under Pressure, *Journal of Sport and Exercise Psychology*, 31.(3),337-357, doi:
582 10.1123/jsep.31.3.337

583 Lang, P. (1979). A bio-informational theory of emotional imagery. *Psychophysiology*, 16, 495– 512.
584 doi:10.1111/j.1469-8986.1979.tb01511.x

585 Lee, T. & Schmidt, R. (2014). PaR (Plan-act-Review) Golf:Motor Learning Research and Improving
586 Golf Skills. *International Journal of Golf Science*, 3, 2-25. doi.org/10.1123/ijgs.2014-0004

587 Martindale, A., & Collins, D. (2005). Professional judgment and decision making: The role of intention
588 for impact. *Sport Psychologist*, 19(3), 303-317.

589 Martindale, R., & Collins, D. (2012). A Profession Judgement and Decision Making case study:
590 Reflection-in-action research. *The Sport Psychologist*, 28, 500-518.

591 McMorris, T. (2014). Acquisition and Performance Sport Skills, 2nd Edn, Wiley, London.

592 MacPherson, A.C., Collins, D., & Obhi, S. (2009). The importance of temporal structure and rhythm for
593 the optimum performance of motor skills: A new focus for practitioners of sport psychology.
594 *Journal of Applied Sport Psychology*, 21, 48–61. doi:10.1080/10413200802595930

595 Masters, R. S. W. (1992). Knowledge, nerves and know-how: the role of explicit versus implicit
596 knowledge in the breakdown of a complex motor skill under pressure. *British Journal of*
597 *Psychology*, 83, 343–358. doi:10.1111/j.2044-8295.1992.tb02446.x

598 Masters, R. & Maxwell, J. (2008). The Theory of Reinvestment, *International Review of Sport and*
599 *Exercise Psychology*, 1, 160-183.

600 Maxwell, J. P., Masters, R. S. W., Kerr, E., & Weedon, E. (2001). The implicit benefit of learning without
601 errors. *The Quarterly Journal Of Experimental Psychology. A, Human Experimental Psychology*,
602 54, 1049–1068. doi:10.1080/713756014

603 Newell, K. (1986). Constraints to the development of coordination. In M.G. Wade & H.T.A. Whiting
604 (Eds.), *Motor development in children: Aspects of coordination and control* (pp. 341–360).
605 Dordrecht, The Netherlands: Martinus Nijhoff.

606 Newell, K. & Corcos, D. (1993). *Variability and Motor Control*, Human Kinetics, Champaign, IL
607 (1993)

608 Partington, M., & Cushion, C. (2011). An investigation of the practice activities and coaching behaviours
609 of professional top-level youth soccer coaches. *Scandinavian Journal of Medicine and Science in*
610 *Sports*. 1-9. doi: 10.1111/j.1600-0838.2011.01383.x

611 Renshaw, I., Chow, J., Davids, K. & Hammond, J. (2010). A constraints-led perspective to
612 understanding skill acquisition and game play: a basis for integration of motor learning theory
613 and physical education praxis?, *Physical Education and Sport Pedagogy*, 15:2, 117-137, DOI:
614 10.1080/17408980902791586

615 Sampson,C.(1993a). The history of golf instruction. Part 1: Its only swinging a stick at a ball, isn't it. But
616 this simple act has spawned literally hundreds of thousands of pages of how-to over the centuries.
617 *Golf Journal*, 43(1), 10-13.

618 Sampson,C.(1993b). The history of golf instruction. Part 2: The instruction business booms, replete with
619 contradictory theories, profit motives, and a touch of gold among the dross. *Golf Journal*, 46(2),
620 24-27.

621 Schlaffke, L, Lissek, S, Lenz, M, Brüne, M, Juckel, G, Hinrichs, T, Platen, P, Tegenthoff, M, Schmidt-
622 Wilcke, T. (2014). Sports and brain morphology - a voxel-based morphometry study with
623 endurance athletes and martial artists. *Neuroscience*, Vol: 259, Page: 35-42,
624 doi.org/10.1016/j.neuroscience.2013.11.046

625 Schempp, P.G., Templeton, C.L., & Clark, B. (1998). The knowledge acquisition of expert golf
626 instructors. In M. Farrally & A. J Cochran (Eds.), *Science and golf III: Proceedings of the world*
627 *scientific congress on golf*, (pp. 295-301),Leeds: Human Kinetics.

628 Schempp, P.G., McCullick, B.A., Busch, C.A., Webster, C., & Mason, I.S. (2006). The self-monitoring of
629 expert sport instructors. *International Journal of Sports Science and Coaching*, 1, 25-35.

630 Schempp, P., & McCullick, B. (2010). Coaches' expertise. In J. Lyle & C. J. Cushion (Eds.), *Sport*
631 *coaching: professionalisation and practice* (pp.221-323). London: Churchill Livingstone.

632 Schmidt, R.A. (2003). Motor Schema Theory after 27 Years: Reflections and Implications for a New
 633 Theory, *Research Quarterly for Exercise and Sport*, 74:4, 366-375, DOI:
 634 10.1080/02701367.2003.10609106

635 Schmidt, R. & Lee, T. (2014). *Motor learning and control: A behavioural emphasis*. 6th ed. Champaign,
 636 IL: Human Kinetics

637 Shea, J.B., & Morgan, R.L. (1979). Contextual interference effects on the acquisition, retention, and
 638 transfer of a motor skill. *Journal of Experimental Psychology. Human Learning and Memory*, 5,
 639 179–187. doi:10.1037/0278-7393.5.2.179

640 Shiffrin, R. M., & Schneider, W. (1977). Controlled and automatic human information processing: II.
 641 Perceptual learning, automatic attending and a general theory. *Psychological Review*, 84, 127–190.
 642 doi:10.1037/0033-295x.84.2.127

643 Smith, A., Roberts, J., Wallace, E., Wah Kong, P. & Forrester, S. (2015). Golf Coaches' Perceptions of
 644 Key Technical Swing Parameters Compared to Biomechanical Literature, *International Journal*
 645 *of Sports Science & Coaching*, Vol 10, (4), 739 - 755
 646 doi.org/10.1260/1747-9541.10.4.739

647 Someren, W., Barnard, F., & Sandberg, A. (1994). *The think aloud method. A practical guide to modeling*
 648 *cognitive process*. London: Harcourt Brace & Company.

649 Sternberg, S. (1969). The discovery of processing stages: Extensions of Donders' method. In W. G.
 650 Koster (Ed.), *Attention and performance II* (pp. 276–315). Amsterdam: North-Holland.

651 Welford, A., (1968). *Fundamentals of Skill*, Methuen, London.

- 652 Whitehead, A. E., Taylor, J. A., & Polman, R. C. J. (2015). Examination of the suitability of collecting in
653 event cognitive processes using Think Aloud protocol in golf. *Frontiers in Psychology*, 6, 1083.
654 <http://doi.org/10.3389/fpsyg.2015.01083>.
- 655 Williams. M., & Hodges, N. (2005). Practice, instruction and skill acquisition in soccer: Challenging
656 tradition. *Journal of Sports Sciences*. 23(6), 637-650.
- 657 Wulf, G. (2007). *Attention and motor skill learning*. Champaign, IL: Human Kinetics.
- 658