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Coaching Golf – How skilled are we in 'skill'?

Abstract

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

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

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 though 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;

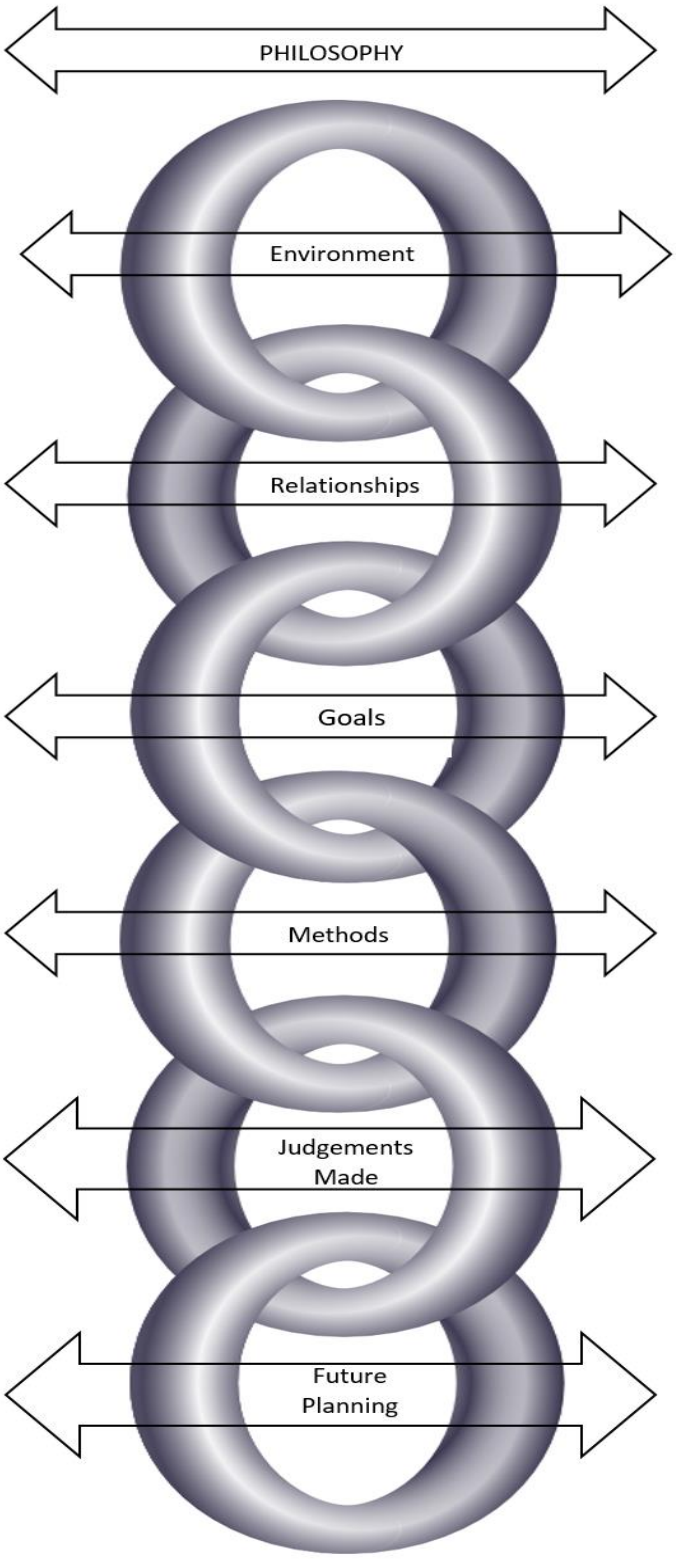
205 Kawashima et al., 2012; Schlaffke et al., 2014). For this paper however, the focus is the skill learning
206 concepts that are most widely accepted and implemented in golf and the related sports coaching fields.

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

SKILL LEARNING CHAIN OF SPORTS COACHING



Information Processing
Cognitive Psychology
Motor Programs
Top down Centralised Control
Linear

Dynamical Systems
Ecological / Developmental Psychology
Self-Organisation
Decentralised System – Bottom up
Non-linear

Need to Limited Perception Stimuli
Structured / organised
Rule based
Isolated Tasks

Multi Perception Stimuli
Unstructured / Messy
Game based
Supports Exploration
Multiple Integrated tasks

Coach directs and changes area of focus
Coach changes CI of task to add additional layers of necessary cognition
Coach has a 'perfect' model
Player expects to be told
Basis of Extrinsic Motivation

Coach manipulates constraints to enable player to self-organise and find own movement solution
Player expects choice / autonomy
Basis of Intrinsic Motivation

Short term acquisition
Skill retention
Develop pre-event confidence
Crisis Management

Skill Acquisition and Long Term retention
Learning to Solve Performance Problems
Promote Creativity
Effective Transfer to Competition

Block Practice
Repetition
Coach – perfect model demonstrations
Verbal cues
Analogies used to direct attention to whole movements
Augmented feedback – beginning, during, end,
Enhanced Cognition eg rhythm, especial skills

Random Practice
Constraints Led Coaching
Clarification of Problem
Analogies used to divert attention
Self-directed feedback
Time for reflection
Mindfulness exercises

Declarative Knowledge
Procedural Knowledge
Perfect Model – desired pattern recall / performance
Performance Data based against perfect model
Outcome based – Execution phase of Perception – Decision – Execution model

Tacit Knowledge
Players' level of autonomy
Transfer in competition etc
Levels of Functional Variability developed
Process based – Perception and Decision phases of Perception – Decision – Execution model

Tacit Knowledge
Players' level of autonomy
Transfer in competition etc
Levels of Functional Variability developed
Process based – Perception and Decision phases of Perception – Decision – Execution model

Grounded in the specific context, environment and needs of the player. See PJDM
Driven by player perceived needs
Focussed on 'Awareness' part of Perception – Action coupling

Philosophy

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

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

In the US coaches have often been placed in categories partially aligned to the IP model and referred to as method, system and non-system teachers (taken from Jim Mclean's book "The Eight Step Swing"). Method teachers most closely match the IP approach. They have a specific model with the goal of every student matching this model. Examples of golf methods would include Stack and Tilt, Square to Square and Natural Golf. Each has a set of fundamentals and students are encouraged to adopt each pattern to perfect the model. For example, in stack and tilt, players are encouraged to keep weight forward during the pivot, staying centred. Although players may feel weight forward, testing using technologies 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" (Someren, Barnbard & 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.

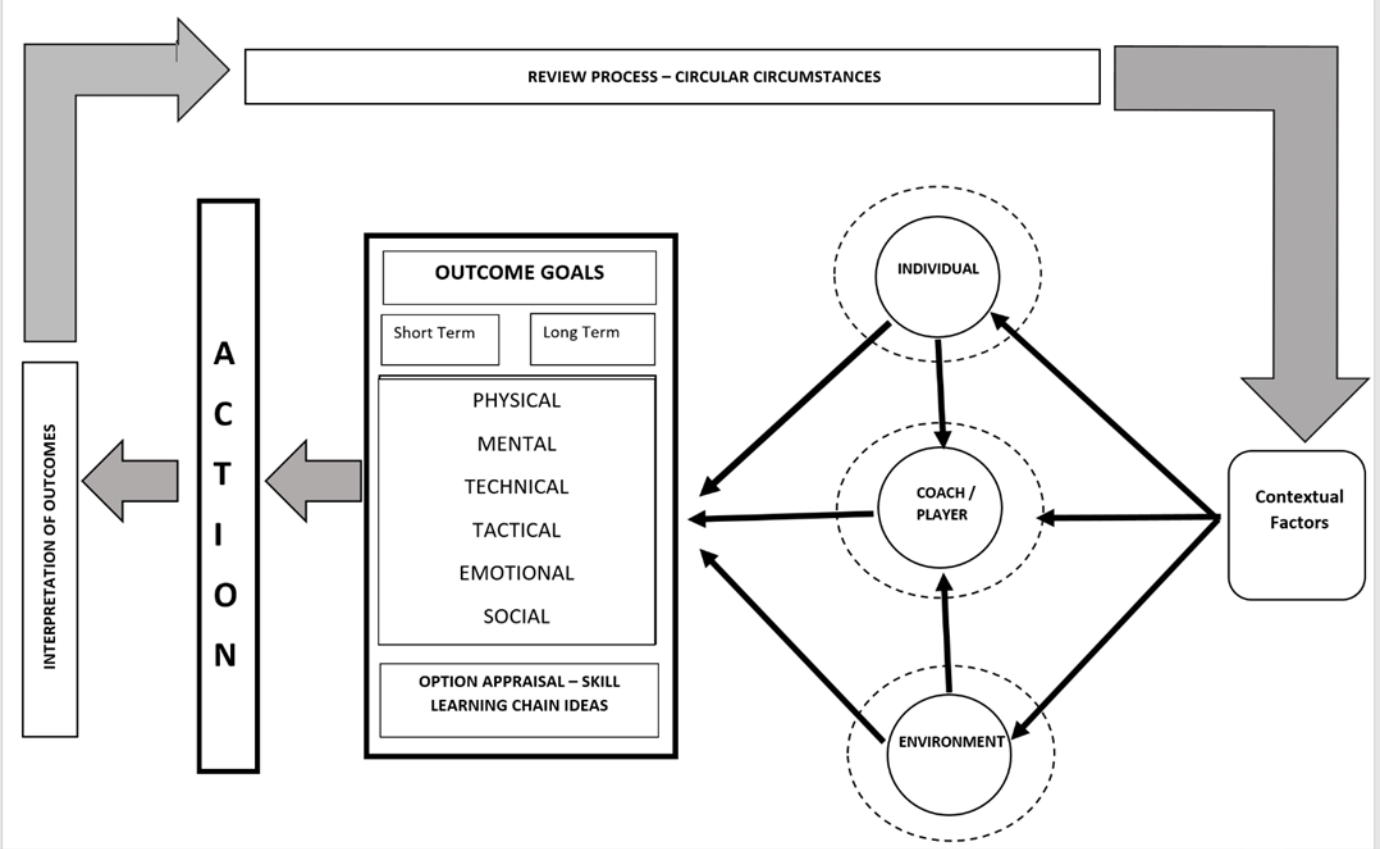
Discussion

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

having an aggregate score of even par. If they are not successful the first time, the player may have to complete a forfeit to add an element of pressure eg25 push-ups, sing a song in front of the coach and fellow players, go without their mobile phone for 24 hours etc. and then re-do the game. After engaging in random practice, they would then test their game in a tournament. The scores, along with data collected by the player and coach / player reflections would be used to feedback into their practice plan.

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

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



444

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 periordized
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

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!

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