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Coaches' self-perceptions on how they

influence collective behaviour in team sports

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Abstract

Introduction: Team invasion games (e.g., football, basketball, rugby) all rely on cohesive and synchronous efforts for successful outcomes. Without this key fundamental, teams can appear disorganised and in turn perform poorly in competition. It becomes the coach's responsibility to create shared understanding within the team . This can be done through planning engaging and diverse training situations and the interactions between coach and athlete seen during training sessions. This research project focused on two main theories, Ecological Dynamics (ED; Bennie & O'Connor, 2010) and the Constraint Led Approach (CLA; Newcombe *et al.* 2019). Both tools suitably equip coaches to plan and build training environments that can challenge and progress the learning of their athletes. **Methods:** Semi-structured interviews were conducted with 6 team sports coaches (5 football, 1 hockey). Interviews took place online (via Zoom or Google Hangouts). All interviews were transcribed into scripts, which then were thematically analysed as per the guidelines outlined by Braun and Clarke (2021). Appropriate measures were taken to maintain the anonymity of participants. **Result:** The thematic analysis resulted in the development of 3 higher-order themes; a) Practice Design (Small Sided Conditioned Games, Session Intention, Representative Learning Design), Learning Environment (Goal Setting, Scaffolded Learning), and Coaching Behaviour that highlights how coaches perceived their contribution towards the development of a more synergistic team. **Conclusion:** In conclusion, coaches perceived themselves as environment builders that created environments promoting the problem-solving capabilities of the athletes. They reported various methods of task constraint manipulations (e.g., creating over/underloads in team numbers and changing pitch dimensions). Furthermore, coaches reported that they applied a "hand-off approach when coaching to allow the athletes to develop autonomy and discover the answers to the practice tasks, instead of simply prescribing actions. They also reported to avoid the use of

instruction unless completely necessary and preferred the use of questioning as their

behaviour of choice to help guide the perception of affordances in the learners.

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Introduction

In the past decades, academic literature has attempted to observe behavioural patterns in many different contexts that are defined as complex systems (i.e., schools of fish, ant colonies, human communities; Riley *et al.,* 2012). Recently, team sports has been included and conceptualized as complex dynamic systems as they rely on various interacting components (i.e., player to player, player to ball, player to environment) to self-organize around varying degrees of freedoms. Due to the complex nature of team sports, contemporary pedagogic literature has provided theoretical explanations towards the behavioural patterns evidenced in such systems. A dynamical systems approach has described how coordinated movement patterns can emerge, continue, and adjust within competition (Davids *et al.,* 2005). Furthermore, the research surrounding synergies primarily are investigated through the lens of Performance Analysis, to evidence the physical characteristics of synergies (i.e., dimensional compression, reciprocal compensation, interpersonal linkages, degeneracy; discussed later; Araujo & Davis, 2016). Building on the dynamical systems approach commonly used to investigate synergies, this paper will adopt an ecological framework, which views human behaviour and movement occurs through an individual's perception of affordances (opportunities for action; Gibson, 1979) and action on relevant information that satisfies the task (Araujo *et al.,* 2013).

Success in invasion-based team sport (i.e., football, basketball, rugby, netball etc.…) is based on the ability of a team to score more points than the other. This provides an incentive for members on each team to score (attacking; in-possession) and preventing the opponents from scoring (defending; out of possession), however, to avoid oversimplification, there are cases where teams can be defending while in possession (i.e., keeping possession to defend a lead), and where teams can be attacking out of possession (i.e., implementing a high-press to pressure the ball carrier; Araujo & Davis, 2016). This poses an interesting predicament as each team will try and implement their performance plan (i.e., tactics,

formations) while trying to disrupt/hinder the plans of the opposition (Davids *et al.,* 2005). The need to be cohesive and synchronous within the efforts of teams can dictate successful outcomes in competition, and a lack of this fundamental can result in sporting teams to appear disorganized and prone to costly mistakes.

Diverting away from traditional pedagogies in sport that predominantly focus on developing good technical athletes, the role of the coach has slightly shifted to creating synchronous teams. It becomes the responsibility of the coach to create shared understanding within the team, and this can be done through planning engaging and diverse training situations, but also through the interactions between coach and athlete seen during training sessions. Current academic literature already explores the various methods in session planning, with theories and frameworks guiding coaches, however, fewer academics focus on the actions of the coach and the role they play to enforce the change. This research project will focus on two main theories, Ecological Dynamics (ED; Bennie & O'Connor, 2010) and the Constraint Led Approach (CLA; Newcombe *et al.* 2019). Both tools that suitably equip coaches to plan and build training environments that can challenge and progress the learning of their athletes.

Research in this study will be conducted qualitatively, to understand the self-perceptions of coaches, and understand their real-world experiences when trying to build synergies within a team. In doing so, the aims of this project are: a) to explore the way in which coaches plan their training sessions, b) to evaluate the various principles of practice design implemented by coaches to potentially develop athletes, and c) to understand the role of coaching behaviour (coach-athlete interactions).

Complex Adaptive Systems

The study of complex adaptive systems (CAS) has been ongoing for decades, with researchers contributing to the understanding of how large population of living organisms go on to interact and adapt their actions to achieve a collective goal (Deneuborg & Goss, 1989). Primary investigations into biological systems have revealed that various species all exhibit spontaneous (i.e., non-externally controlled) emergent collective behaviour (i.e., schools of fish, Couzin *et al.,* 2002; swarms of honeybees, Visscher & Camazine, 1999; & ant colonies, Mallom, Pratt & Franks, 2001). Notions from these studies have also been applied to human social contexts such as; behaviour of crowds in a stadium (Farkas & Vicsek, 2005), or the flow of pedestrian or vehicular traffic (Yuan, Wang, Xu & Li, 2005). In line with the previous findings, academics have posited that sports teams can also be considered as a complex, adaptive systems (Davids, Araújo, & Shuttleworth, 2005; Gréheagne, Bouthier, & David, 1997; McGarry, 2005).

Research surrounding CAS has spanned over the past two decades and have tried to expand the consideration of complex adaptive system to include competitive teams (Arrow *et al.,* 2000). Arrow *et al.,*(2000) further postulates that the organisation of CAS systems can be affected through three levels of casual dynamics: (A) local dynamics (i.e., how members within a team develop influence within a social network; Klein, Lim, Saltz, & Mayer, 2004), (B) global dynamics (i.e., how global processes such as team coordination and movement is constructed), and (C) contextual dynamics. A myriad of research since has elaborated on each dynamic.

These concepts all tie in the ability for CAS systems to operate synergistically, it is imperative to understand how they influence the emergence of collective behaviour. Collective behaviour is usually observed as a global dynamic but is typically framed

as the terms team cohesion and movement (Bourbousson *et al.,* 2015; Correa *et al.,* 2012).

In CAS, collective behaviour emerges from the patterns of interpersonal coordination of agents within a system (i.e., teammates & opposition; Bar-Yam, 2004) and information from the environment (i.e., the performing context that constrains behaviour; Beek, Peper, & Stegeman, 1995). However, within CAS Davids *et al,.,* (2008) theorizes that interpersonal coordination is underpinned by the individual (limb control; Kelso, 1984) or the collective (i.e., attacker and defender interactions in a team sport; McGarry, Anderson, Wallace, Hughes, & Franks, 2002) degrees of freedom which allows for the variety of interactions between system components. The CAS approach focuses on the interactions the develop between players from both teams in relation to the playing context (McGarry, 2009; Passos *et al.,* 2009). Collective behaviour is ever present in any social neurobiological system and in team sports the need for positive collective behaviour is vital to successful performance. To create such behaviour, it is important to understand the effects of self-organization. Kauffman (1993) posits that the interactions between many individuals governs the self-organization tendencies within any given system. In the context of team sports, Araújo & Davids (2016) define collective behaviour the organization of individuals with varying DOF's that is dictated by a task specific goal (i.e., keeping possession to defend a lead, covering teammates and space and dribbling). Thus, academics (Araújo *et al.,* 2006; Duarte *et al.,* 2010) argue that the behaviour exhibited in these systems should be examined through ecological variables or context-based measures.

Ecological perspectives advocate that organism are complex CAS which means that there is inherent variability within any system which affects ones' ability to discover 'ideal' movement solutions (Woods *et al.,* 2020). With each viable path of action, there are consequences towards the outcome, this is better described as the degrees of freedom (DOF) available to

an individual (Bernstein, 1967). This introduces the idea of self-organization, a concept frequently used by ecological psychologists when describing human movement. Self-organization often describes how multiple parts of the body can coordinate to execute the simplest of motions (i.e., throwing a ball) and the more complex (i.e., doing a backflip; McMorris, 2014). According to Newell's (1986) model of interacting constraints and self-organisation processes, the study of coordination and motor control understood how motor system DOFs were utilized in the process of learning football skills. Prior research from Bernstein (1967) postulated that the formation of specific functional muscle-joint linkages (coordinative structures) regulated the DOFs in the human movement system. Further studies by Anderson & Sidaway (1994) supported the same ideas, through a 10 week period of exploratory practice that evidenced the novice footballers were adapting joint range of motions at the knee and hip to increase linear foot velocity at ball contact. Environments that present multiple DOF's can be viewed as both a 'curse' as individuals will have to process information from a numerous number of sources, making their decision-making process longer (i.e., a tennis swing; Wells, 1976), however, it can also encourage individuals to exploit their self-organizational tendencies to form coordinating movement patterns which will help achieve expertise in sport (Handford *et al.,* 1997; Davids *et al.,* 2008).

Degrees of freedom, however, do not only affect athletes at an individual level (i.e., limb coordination) but also in a larger scale when regarding team sports. When understanding team sports such as basketball, football, rugby, each player on the pitch acts as a node within the system that and their relative positing in relation to many different interacting parts (i.e., ball, goal, teammates, opposition, referees) affects the decision-making during performance (Torrents *et al.,* 2020). Macroscopic patterns of behaviour in such systems tend to spontaneously emerge as a result of interaction at a more microscopic level of organization (Araújo *et al.,* 2003). Using football as the primary example in this project, the game rhythm can be defined by the exchanges of possession at an unequal measure, where the objective of the game is to "coordinate with your team to recapture, conserve and move

the ball so that it can be within the scoring zones and to score a goal" (Gréhaigne *et al.,* 1997, p.137). An understanding of this concept helped advance the study of player movement patterns on the football field, as the 'perturbations' (a key event or aspect of skill that disrupts the normal flow of the game; McGarry *et al.,* 2002) of individuals within a team could destabilize or (re)stabilize the system accordingly. Through this viewpoint the macroscopic game of football (11 v 11) can be broken down into various microscopic sub-phases of play such as attacking & defending movements in certain contexts (e.g. 1 v 1, 1 v 2, 2 v 2, etc…).

Collective self-organizational tendencies has been observed in many different natural phenomena with a study from Couzin *et al.,* (2002) modelling the formation of schools of fish and analysing the behaviour exhibited to three principles/rules; i) afford space to neighbours, ii) adopt the same direction to those nearby, and iii) move at the same velocity to neighbours to avoid isolation. Similar organizational pattern has also been noticed in humans and within a sporting context study by Passos (2011) looked at the interpersonal distances within attacking phases of play in union rugby. The study discovered that the interpersonal distances between the ball carrier and adjacent players is context dependent, with shorter offensive interpersonal distances being shown before breaking the first line of defence. Furthermore, the attacking subunit would spread out once passing the first line of defence to spread the defenders, asking them to cover more of the playing surface to prevent a score. Such findings show that in team sport the act of self-organization can help create complex and effective patterns to achieve goal-directed behaviour.

Ecological Dynamics vs. Shared Mental Models
This section will introduce both information processing theories (shared mental models; Eccles & Tran, 2012) and will be compared to a more ecological approach to understand how teams can act cooperatively.

Defining Shared Mental Models

Shared mental models (SMM) is a concept with its roots deeply planted within a social-cognitive framework (Eccles & Tenenbaum, 2007). The foundations of this framework rests on the tenet that the organization of individual and collective behaviour revolves around knowledge-based mental models (Rentsh & Davenport, 2006; Araújo & Bourbousson, 2016). Reviewing pertinent literature surrounding SMM evidences the fact that interpersonal coordination is built on the ability of individuals to regulate their contributions within a shared ground. 'Sharedness', a term that when paired within this line of research focuses on the idea that synergies can aggregate due to team members' mental functioning to create similarity and complementarity in movement solutions (Langan-Fox *et al.,* 2004; Cooke *et al.,* 2003; Stanton *et al.,* 2006; Ward & Eccles, 2006). The aim of these models is to enhance team performance by enabling nonverbal interactions and implicit coordination between agents in a team (Cannon-Bowers & Bowers, 2006; Rico *et al.,* 2008, Cooke *et al.,* 2013).

SMMs can be applied through two pillars. The first pillar associates itself by how behavioural instructions can be fed forward to athletes so they know the desired movement patterns in identified game situations (Eccles, 2010). This takes forms in the 'plan' (Schank & Abelson, 1977). Plans can operate at both a macro and micro level. Macro-level planning refers to the overall team plan and favoured strategies (Eccles & Tenenbaum, 2007). Micro-level plans refers to the information that individuals may use to confine behaviour in certain game situations (Macquet & Kragha, 2015). For example, offensive and defensive plays in American Football the use of microlevel plans identify the specific routes that offensive players might run, or the areas defensive players are meant to cover/ the players they need to mark. Furthermore, SMMs can be viewed as "top-down" models as the shared knowledge is forwarded and filtered information so that interpersonal coordination can emerge (Steiner *et al.,* 2017). Giske *et al.,* (2015) conducted a questionnaire-based study which understood how shared mental models were used in ice hockey and handball teams. The study posits that in these sports there is evidence of common attacking shapes specific to certain game

states and formations. However, the use of shared mental models has been rarely supported in outside literature (Gershgoren *et al.,* 2013).

For teams plans to be effectively utilized they must be planned before player involvement to create movement solutions to various specific game situations. However, since the game context is very situational, dynamic and often in a unique configuration, the reliance on pre-existing plans may not always be the most effective (Araujo *et al.,* 2006; Silva *et al.,* 2013). However, the application of SMMs can also be seen more dynamic and implicit methods when there are overlaps between multiple team members' mental models in any given situation (Blickensderfer *et al.,* 2010; Eccles & Tran, 2012). Shared information from the environment during real time events can be perceived by multiple agents (i.e., team mates), and as the task changes, the probabilities of certain decision routes changes, thus confining and conditioning the action and reaction of both individual but also team dynamics (Ward & Williams, 2003). When multiple athletes can perceive the environment and movements of their peers in anticipation and followed by complementary actions has been a key factor in sporting success (Reimer *et al.* 2006). Blickensderfer *et al.* (2010) has provided empirical evidence for the role shared knowledge can play in the implicit coordination in team sports. The project observed the different degrees in positioning between partners in Doubles Tennis as an indicator towards implicit coordination.

Defining Ecological Dynamics

Branching from two different theories; ecological psychology (understanding the demands of the environment; Seifert & Davids, 2017), and dynamical systems (understanding the organism; Seifert & Davids, 2017).

The first constituent, ecological psychology primarily understands the relationship between perception and action in humans to generate coordinative actions (Gibson, 1979). To create

functional movement, performance is underpinned by the intentions of the individual which can shape the perceptual information, which can influence the emergence of further movements. For example, the information perceived by a footballer on a pitch is dictated by specific actions/ phase of performance (e.g., in possession, out of possession, set pieces, etc…) as well as their intention (e.g., playing conservatively or taking risks) (Cordovial *et al.,* 2009). Dynamical systems theory (DST) further focuses on understanding movement solutions through mathematical analysis and the use of physics (Davids *et al.,* 2015). For example, the coordination of a player's movements and the changes in a team's attacking/defending structure can be understood through the changes in space and time. DST further models the biomechanical system of the performer as a complex, dynamical system that will exhibit fundamental attributes (Williams *et al.,*1999). These attributes are 1) many independent degrees of freedom, 2) non-linear behavioural output, stable and unstable patterned relationships between parts of the system and 4) the ability of sub-system components to constrain the behaviour of other sub-systems (Yates, 1979; Kugler and Turvey, 1987; Kauffmann 1993; Kelso, 1995)

Gibson (1979) further explores the idea of the performer-environment relationship, by explaining that humans are surrounded by banks of information (i.,e optical, acoustic, proprioceptive) to constrain the coordination of the actions to an environment, with critical information shaping the intentions of the performer, enhancing decision making during goal-directed activity (Davids *et al.,* 2013). Data from studies which examined dribbling a football (Headrick *et al.,* 2012), dribbling a basketball (Cordovil *et al*., 2009), receiving a cross in football (Orth *et al.,* 2012) and running with a ball in rugby union (Correia *et al.,* 2012) have all posited how decision making and the coordination of action in sport are influenced by changing task constraints as critical information can be provided through knowledge on various spatial relationships (i.e., relative positioning of defenders, pitch parameters) and the role of instructional constraints on performer intent. This allows human behaviour to be a

result of the entwined relationship seen between an organism and its environment (Handford *et al.,* 1997).

Combined Perspectives

Academics have called for an integrated perspective between the shared mental model approach and the ecological approach. McNeese *et al.,* (2016) states that by taking the positives of the shared mental model approach and the ecological perspective makes sense as it can create a holistic approach to movement coordination research. The authors argue that both individual and collective shared mental models are necessary because not all actions in open-ended and interdependent team sports are led by the environment. Furthermore, Gorman (2014) also states that a generalized theory on interpersonal coordination should highlight the ways intention and knowledge of team members can affect interpersonal coordination as well as how the environmental constraints may manipulate them.

To further exemplify the need for an integrated approach within coaching practice is due to the nature of strategy in team sport (Gershgoren *et al.,* 2013). The frequency at which strategy/tactics are discussed in practice sessions evidence how the nature of pre-processed coordination can build shared mental models within members of a team (Eccles & Tenenbaum, 2007). However, it is also important for coaches to allow their athletes to be flexible and adaptable in their movement solutions, as the nature of team sports can be unpredictable, so training skills/techniques that can be applied to various contexts are equally as beneficial (Steiner *et al.,* 2017). A sporting example of this could be how football players emphasize the importance of a triangular alignment, as it allows for larger possibilities and affords the ball carrier a greater change for possession of the ball (Giske *et al.,* 2015).

Ecological Dynamics & Skill Acquisition

An ecological perspective allows practitioners to divert from the norms of skill acquisition, where currently traditional theories of skill acquisition overvalue repetition of 'ideal' movement patterns (Ericsson *et.,* 1997). However, through the development of research, the notion that there are 'general optimal movement patterns' has been challenged (see Schöllhorn *et al.,* 2006), and there has been a considerable push to dissuade from the idea that expert performance can be rehearsed and duplicated at will (Seifert *et al.,* 2013). This is most seen in sports such as golf, where this is a precedent that through hours of practice at the driving range will aid in the perfection of the golf swing.

Since the 1970s' motor skill acquisition has been led by cognitive scientists and their use of the information processing theory (Gardener, 1985). The general assumption surrounding this approach is that individuals interact with the environment to acquire specific information, which they will then compare to information that may already be stored in their memory to 'calculate' the best possible action (Hinsz *et al.,* 1997). Massaro & Cowan (1993) breaks down the process into multiple phases (refer to Figure 1) ; a) the attention phase, b) the selection phase, c) anticipation phase and d) the decision phase. The attention phase relates itself to the areas performers direct their attention towards in performance to perceive relevant cues (Tenenbaum, 2003). With a failure from the player to attend to the relevant cues inhibits processing of information. The selection phase, information is further filtered down to construct a mental model of the critical features within the environment. This follows into the anticipation phase, where all processed information will be compared to existing knowledge structures found in the short-term memory (STM), or long-term memory (LTM; Welford, 1986) to find movement solutions, and through using newly acquired information to create a careful assessment of the various outcomes and alternative courses of action (Reimer *et al.,* 2005). Lastly, the decision phase focuses on the execution of the desired route of action, which can be followed by feedback received through various sources; i) successful or unsuccessful outcome, ii) instructional feedback, and iii) informational changes

in the environment as a result of performer interaction (Reimer *et al.,* 2005). The approach

tries to draw similarities between the human brain and the function of a computer, where

each computation follows a strict process of rules and/or programs (Casey & Moran, 1989).
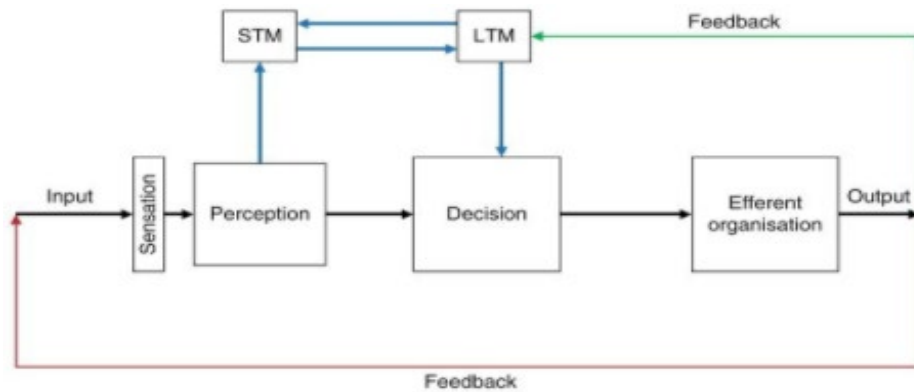
Figure 1: Model of Information Processing (Welford, 1989).

However, when trying to operate the human brain as a computer, cognitive psychologists

forget that by relying on STM and LTM stores it prolongs the reactionary times of athletes in

sport. Studies have shown that in sports where the speed of the game is faster than the

information processing approach can account for. For example, a study conducted by

Williams & Ford (2008) posited that cricket batsmen and tennis players try to identify early

signals from the body positioning of the bowler/opponent in tennis to try and predict ball

speed, ball trajectory and final placement of the ball (Müller *et al.,* 2009) instead of 'ball

watching' (Moran, 2012).

Information processing theorists believe that perception precedes action, whereas ecologists

believe that perception and action is coupled, with neither working independently (McMorris,

2014). This has ramifications when learning skills in training and/or reproducing movement

patterns in performance as cognitive theories believe that there are motor programmes

stored in the brain. Motor programmes are better defined as 'a set of muscle commands that

allow movement to be performed without peripheral feedback' (Keele, 1968). This leads to a

few problems, the first one being that when a motor programme is formed, the individual

stores the sequencing of the action (technique), timing and range of movement. Consequentially, when asked to reproduce that action in a performance context, the player only has the memory of a specific situation, meaning that for every time we kick a ball there are changes in the environment such as the distance of the ball relative to the player, speed of the ball, weather conditions (i.e., wind) and the goal (short or long-distance pass/shot) the individual intends to achieve from the kick (Schmidt & Wrisberg, 2000). This calls for a modification in the whole motor programme thus inhibiting the adaptability of movement patterns. In sports such as snooker, this isn't a big issue as the player has time to survey the table, assess their options and pick the best available shot within this designated playing time, however in sports such as football, basketball and rugby, decisions need to be made quickly and if the performer does not have the motor programme it can inhibit his performance. Psychologists have coined this phenomenon as 'choking'. When in environments of pressure, performers may exhibit a sudden breakdown in movement patterns due to high levels of anxiety (Hill *et al.,* 2010). To battle this, athletes will "re-invest" to account for the effects that choking can have on performance (Masters & Maxwell, 2008). The theory of reinvestment, which was originally hypothesized by Masters (1992), explains that when athletes are anxious, they will default to a mode of consciousness that is associated with the early stages of motor development. Doing so can make the athlete freeze and produce slow and effortful movement instead of the usual sub-conscious processes that allow for elite performance (Masters & Maxwell, 2004). On the other hand, ecological psychology frames the mind as a goal setter. For example, a footballer receiving the ball understands the action needed is to 'control the ball', however, the way that can be executed is dependent on the conditions of the pass (i.e., in the air, proximity to the ball, speed of the pass, defensive pressure), through an ecological understanding the player can achieve a simple instruction such as controlling the ball in many ways.

<u>Performance Analysis of Invasion Sports</u>

In recent decades, there has been an increased interest in identifying the properties that allowed CAS to work collectively in sporting contexts (Eccles & Tenenbaum, 2004; Salas *et al.,* 1997). Academics such as Riley *et al.,* (2011) and Silva *et al.,* (2013) have both expressed the notion that collective team behaviour can be defined by the interactions of three of more players looking to coordinate their actions to achieve a common goal.

Traditional approaches that focus on understanding team effectiveness is analysed through the lens of group cognition. Group cognition is a concept based on the premise that all individuals within the sporting team share a mental model of performance, that internally informs action and behaviour (Cannon-Bowers *et al.,* 1993; Fiore & Salas, 2006; Salas *et al.,* 2008). Shared cognition refers to a state of group coordination where each player has a specific cognitive expectation and representation of the performance context is similar or identical to team members. However, the work of performance analysts has helped conceptualize the various means of group coordination using group-based measures. There are five different variables: i) team centre, ii) team dispersion (stretch index, team spread etc…), iii) team synchrony, iv) division of labour (heat maps) and v) communication networks.

<u>Team Centre</u>

The teams centre (i.e., centre of gravity or geometrical centre) can be obtained by computing the average of the lateral and longitudinal coordinates of each performer within the performance space, which means the actions of each individual will contribute equally into the measure (Araújo *et al.,* 2015). Studies have used this measure to examine and evaluate both the intra- (Gonçalves *et al.,* 2013) and the inter- (Frencken *et al.,* 2011) team coordination team processes. The team centres can represent the relative positioning of both teams in vertical (front and back) and horizontal (side to side) movement displacement. Studies by Frencken *et al.,* (2011) observed how the team centre of an attacking team would

often cross the centre of the defending during plays ending in a goal in small sided games, however due to the decrease in playing surface area, they concluded the centre only overlapped to increase the probabilities of scoring. Different results from a study conducted by Bartlett *et al.,* (2012) showed that in the full form of the game (11 v 11; football) there was no clear correlation between the team centre and goal conversion, and this was due to the fact that players adjacent to the ball contributed equally to the measure as opposed to players further away from the ball.

Team Dispersion

The need for tactics in invasion team sport is vital to performance success. These tactics are expressed by the expanding of attacking players as they aim to stretch the playing surface and the contracting and reducing of distance of defenders to protect their 'scoring area' (Araújo *et al.,* 2015). Studies have tried to understand how team dispersion aids in the ability of successful sporting outcomes, for example a study by Clemente, Courcerio, Martins, & Korgaokar (2012) investigated how the different distances of players to the weighted centroid affected the stretch index. In doing so, Clemente and colleagues observed a negative relationship in both teams' stretch indices when out of possession of the ball in u13's seven-a-side football game. They concluded that the expansion and contraction exhibited by teams was determined by the position of the ball and the proximity of acting agents to the ball. Following from this, the study introduced the concept of an "effective playing surface", which accounts the area covered by all players and how the available space was utilized by the opposing teams (Frenken & Lemmink, 2008). Gréhaigne & Godbout (2013) further investigated the relationship of how the stretch index could represent the overall positioning and balance of the whole game. They suggested that attacking teams tend to cover a larger surface area as their aim is to occupy majority of the playing surface to maximize their offensive options.

In many team-based invasion sports (i.e., basketball, football, hockey, etc..) the use and creation of 'triangles' by players has been vital to success. Clemente *et al.,* (2013) worked under the assumption that the area the attacking team can cover without interfering with the area covered by the opposing (defending) team would lead to greater tactical success.
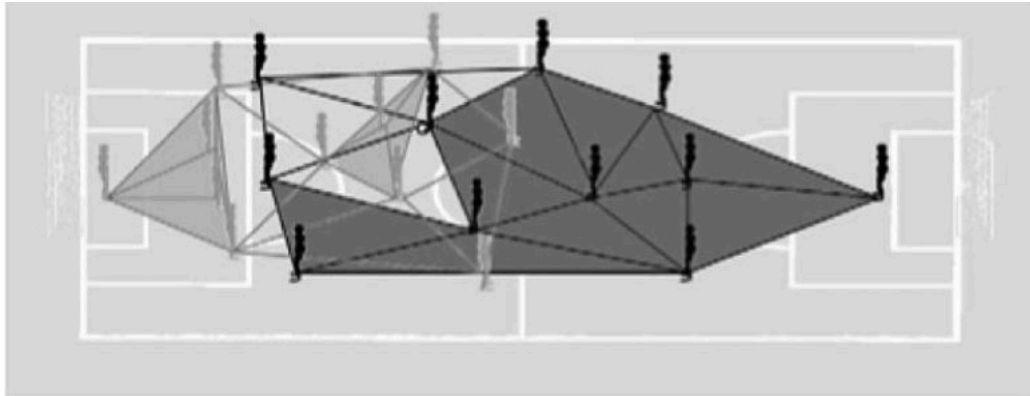
Figure 2 - Effective surface area with offensive (dark grey) and defensive (light grey) triangles (Clemente *et al.,* 2013)

In general teams with possession of the ball showed higher values of triangulations (Figure 2) as they were afforded more playing space to create more triangles without the risk of interaction with the opposing team.

Team Synchrony

The ability for individuals to coordinate their actions with other individual units is vital to any team-based sport and is a key feature in understanding team dynamics. Previous research tried to analyse team sports through relative phase analysis (Bourbousson *et al.,* 2010) and running correlations (Duarte *et al.,* 2012; Frencken *et al.,* 2013). Researchers have proposed the use of a cluster phase method (Frank & Richardson, 2010; Richardson *et al.,* 2012) to analyse the synchrony in systems with a small number of oscillatory units. Originally proposed outside the field of sport science, Duarte *et al.,* (2013) applied the same algorithm to the movements of 11 football players from two different teams during a English Premier

League fixture to further understand the team as a collective and player – team synchronous behaviour.

Division of Labour

Division of labour is a metric that understands how each individuals' actions contribute to the team's tactical outlook. By actions, it further understands how the performers spatial awareness (i.e., positioning on the pitch), phase of play (i.e., attacking or defending) and how the game rules can affect the emergent team behaviour (Duarte *et al.,* 2012; Eccles, 2010). First proposed by Gréhaigne (1988), division of labour was analysed through spatial observations of each player and their interaction within various 'zones' of the pitch. By dividing the pitch into 40 squares, performance analysts can map the movements of players and the zones they 'visited' every 30 seconds. More commonly known as heat maps, coaches could understand the tactical contribution/characteristics of each player by seeing which zones were more frequently visited (warmer in colour; Lames, 2008). Using this concept, Silva *et al.,* (2014) produced heat maps comparing the spatial distribution between players in different competitive levels (i.e., regional player vs national player) and discovered that the national player exhibited a wider range of moment variability within a 4-a-sde football game, meaning they had the ability to apply themselves across the playing surface, when compared to their domestic counterpart. However, studies have yet to show the differences in movement variability when observing games played on larger dimensions.

Communication Networks

As previously mentioned, team sports rely heavily on the interactions between both teammates and opposition. Thus, when trying to understand and analyse both successful or unsuccessful outcomes, the ability for members to comminute implicitly and explicitly is important. Teammates can be 'linked' to one another through the exchange of passes or the intentional switching of positions (Passos *et al.,* 2011).

Synergies

As mentioned previously, invasion-based team sports are conceptualized and analysed as complex adaptive systems (Bar-Yam, 2003; Davids *et al.,* 2015; McLean *et al.,* 2017). The open-ended nature of the environment allows for behaviour to be formed as a result and reaction to physical and informational constraints (e.g., opposition tactics, playstyle, and behaviour; Handford *et al.,* 1997). In such environments, successful performance is evidenced by higher levels of movement co-ordination and interpersonal coordination during the offensive and defensive phases of play (Dutt Mazumder *et al.,* 2011). A synergy is known to be a functional concept, where-as self-organization represents the structural, component-based concept (Araujo & Davids, 2016). Turvey & Fonseca (2014) defined synergies to be "the adaptive fit of parts of a system to each other and to the system as a whole" (p.152), and by understanding this definition a synergy is evidenced throughout task-specific contexts and levels of organization (Bernstein, 1967).

Araújo & Davids (2016) listed multiple properties of team synergy and ways to measure them. These properties can be broken down into four distinct categories i) Dimensional Compression, ii) Reciprocal Compensation, iii) Interpersonal Linkages, and iv) Degeneracy.

The first variable, dimensional compression is heavily affected by team-based variables such as a teams' "centre of gravity" (Gréhaigne *et al.,* 2011). Coaches can use this variable to understand the intra- and inter-team coordination (Travassos *et al.,* 2012), where the team centre can accurately pinpoint the positioning of both teams in various phases of play. Using prior coaching knowledge, it is often noted that the team in possession of the ball will look to stretch across the playing field to create space (increasing distances between players), whereas the defending team will look close space by falling into a structure that decreases the distances between players. These movement patterns are better observed by quantities

such as the stretch index or the effective playing space (surface area covered by the team; Folgado *et al.,* 2012; Moura *et al.,* 2012). Lastly, for successful performance outcomes, it is important for teams to create numerical advantages (i.e., overloads) during attacking and defending phases (Silva *et al.,* 2014). A study conducted Travassos *et al.,* (2018) posits that by manipulating the number of goal targets it will change the tactical behaviour of the athletes, it also measured synergistic behaviour by looking at a teaming 'centre of gravity' and other dynamic positional data (i.e., distance to the ball, distance to team centre). By manipulation the task, the added informational constraint can change the spatial-temporal relationship between teammates and opponents in relation to the field (i.e., playing space) and the target goal location (Laakso *et al.,* 2017). These manipulations are vital to skill acquisition as they can expose performers to a wide range of opportunities for action, creating adaptive behaviours that is required in competitive performance (Gonçalves, Marcelino, Torres-Ronda, Torrents, & Sampaio, 2016; Seifert, Button, & Davids, 2013).

Secondly, reciprocal compensation can be described as 'the excess of / lack of contribution by a player compared to their positional role, causing adjustments of effort and contribution by surrounding team mates to maintain and achieve goal-directed behaviour (Latash, 2008). In a footballing context this can be seen as a defending player covering for his team mate out of position, or an attacking winger overlapping to provide attacking opportunities. Silva *et al.,* (2016) recently devised a way for measuring reciprocal compensation by measuring the delay in co-positioning by players in response to the movements of their teammates. By capturing the ability, a team must be ready and react to various outcomes, understanding this measure shows the coherence and fluency in team sport. Lower delay values indicate a faster adjustment to movement, and a greater spatial temporal synchronicity, whereas larger delay values could indicate a breakdown in coherence. Even though reciprocal compensation has received little academic attention, Silva *et al.,* (2016) conducted a study that showed that through a 15-week training program it is possible for coaches to reduce the

values in delay, evidencing that this synergistic property can be evolved through continuous practice.

The third synergistic property is interpersonal linkages. Better known as sharing patterns (Latash, 2008), or division of labour (Duarte *et al.,* 2012; Araújo *et al.,* 2015), can be described as the individual contribution to each specific element to achieve goal directed behaviour (Latash, 2008). Factors such as player positioning on the playing space with relation to teammates and opponents, tactical objectives, playing phase (attacking or defending), and the rules of the game all inform the forming of interpersonal linkages. To better measure interpersonal linkages, the common use of heat maps is deemed effective. Araújo *et al.,* (2015) advocates for the use of heat maps as they can provide a clear picture showing the distribution of player positioning on any given field, with warmer zones indicating longer periods of occupation in that specific area. Yue *et al.,* (2008), further discusses measuring division of labour in team sports by quantifying the area covered by each player. This allows coaches to observe player preferences and habits (i.e., preferred spatial positions, preferred/default playing style, and tactical tendencies; Araújo *et al.,* 2015).

Lastly, the final synchronous property is degeneracy. Turvey (2007) explains that to understand synergistic behaviour there needs to be an equal understanding of the causality of movement, as well as an understanding of the emergence of synergies. Degeneracy specifically explores the idea that in sporting performance, different components in a system (i.e., teammates and/or opponents), will execute similar but not necessarily identical movements with respect to context to achieve goal directed behaviour (Edelman & Gally, 2001). Degeneracy further signifies that successful team sport performance is governed by the ability to perceive shard affordances (action cues) in both a stable and flexible manner (Seifert *et al.,* 2016). Flexibility in this context does not mean a loss of stability, however, emphasizes the need for adaptability (i.e., perceptual and motor adaptations to interacting constraints; Komer *et al.,* 2014). As performance in team sports such as football, basketball,

rugby, is dictated by continuous adaptive interactions to players and the environment (Davids *et al.,* 2006; Araújo *et al.,* 2015), and to understand such behaviour it becomes a case of understanding the network of links (weighted by frequency of interactions) between various nodes (players). Passoss (2011) posits that by examining the social networks, it can help analyse the local structure of player organization, and a close inspection of social networks can uncover focal nodes and links within team sports. Duch *et al.,* (2010) also states that by understanding social networks, it can extract tactical behavioural patterns such as a) the number of players that pass to a focal player, b) the number of players to which the focal player passes to, and c) preferential links between team members in certain matches. By understanding these variables, it allows coaches to observe functional variability in sub-phases of play, with information provided on which player tendencies to interact with the team, ball and the goal/basket/try line in competitive situations (Araújo *et al.,* 2016). When applying this measure to analyse collective team synergies, it showed that within each team there are large synergistic relationships especially in the longitudinal direction (goal to goal) of the field as compared to the lateral (side to side) direction.

Intra / Inter Team Dynamics

The small subphases and subunits within team sports are valuable in understanding the intra- (teammates) and inter- (opposition) co-ordination. Studies by Lames, Erdmann, & Walter (2010) analysed the spatiotemporal interactions between opposing players and observed how each team maintained stable synchronization with few and small losses in control during the playing phase. They concluded that further research was needed to understand the dependency and mutuality between two opposing teams. Frencken and colleagues (Frencken & Lemmink, 2008; Frencken, Lemmink, Delleman, & Visscher, 2011) further confirmed the ideas put forward by Lames *et al.,* (2010) by analysing team center values as well as understanding the surface area of the playing area in 4 v 4 small, sided games. They concluded that the variable occupied surface area did not provide enough

information about the interactions of opposing teams but however, intra-team coordination is based of cooperative goal directed behaviour (i.e., several teammates coordinating to create a goal scoring opportunity). Studies by notational analysts have further posited that 75-80% of shots on target in elite international competitions in football come as a result of short passing sequences (Hughes & Franks, 2005). These short passing sequences are usually seen within subunits of play where reduced numbers will aim to play the ball to each other in a more fluid motion with a faster tempo to try and break down the stability of the defending team (i.e., the Tiki Taka playstyle of the Spanish National Team).

Decision Making in Team Sports

Within academic literature tactics can be defined as the "movement of players within a set playing surface" (Garganta, Guilherme, Barreira, & Ribelo, 2013), however, for any given tactic to be successfully implemented it relies on the decision-making skills of the agents within the system. Many different factors such as the variability in game states, unpredictability of outcomes and other outcomes all shape the decision making that can take place (Pagnano-Richardson & Henninger, 2008). In theory, Greco (2006) suggests that sporting success is the ability of a team to execute coherent actions. The challenge lies in making individuals in a multi-agent system, coordinating their actions with their peers while matching the movement of their opposition to create goal-scoring opportunities (Bourbousson *et al.,* 2010; Gesbert & Durny, 2017).

Decision making is a process in which players can choose their actions to try and positively support the tactical outlook of the team (Barata & Araujo, 2005). In the current field of professional sport, governing bodies (i.e., clubs & academies) are seeking out athletes who can efficiently, effectively, and consistently make coherent decisions while adjusting to the open-ended nature of their environment (Mesquita, 1998). With the aim of most invasion team sports to be to 'score more points than the opponent' (Richards, Collins, &

Mascarenhas, 2017) the importance of player decision making has been highlights through the vast volume of research dedicated to understanding decision making processes better (Araujo *et al.,* 2019; Raab & Araujo, 2019; Toner, Montero & Moran, 2015). Although there is a myriad of research towards decision making processes and how it affects team sports, academics have yet to settle on one perspective from the three primary perspectives: information processing, ecological psychology and naturalistic decision making.

Information processing and ecological psychology have already been introduced as theories within this literature review, but to summarize information processing perspective understands decision making as a conscious effort to process task specific information to avoid performance errors (Toner *et al.,* 2015; Toner & Moran, 2015). In contrast, ecological perspectives advocate those decisions are made through an automated and internalized processes where the couplings of perception and action through the information provided by the environment (Gibbs, 2006; Araujo, Davids, & Hristovski, 2006). The major dispute between the two theories is pinned down to the role 'memory' plays. Information processing theories posit that expert players extrapolate information from the environment (Muller, Abernethy, & Farrow, 2006), recognize and interpret familiar patterns of play (Lorains, Ball & MacMahon, 2013) and form expectations by understanding situational probability (Farrow & Reid, 2012), ecological perspective describe decision making as a product of the ongoing relationship between the performer and the environment (Greenwood, Davids & Renshaw, 2016).

Furthermore, naturalistic decision making (Zsambok & Klein, 1997; Klein, Calderwood, & Clinton-Cirocco, 2010) has argued that in high pressure, time sensitive situations decisions are made through a recognition primed process (RPD). In this process, the performer interacts with information from a spectrum of automated to conscious interactions depending on the familiarity of the situation and their prior knowledge of results (Klein *et al.,* 2010). Decision making in this perspective is formed at three levels; i) simple match, ii) diagnose

the situation and iii) evaluate a course of action (Klein *et al.,* 2010). Simple match is the most operated and the fasted level of decision making. It occurs when the information is familiar to the player and the situation was anticipated beforehand (Zsambok & Klein, 1997). Diagnose the situation are situations where information creates unfamiliarity to the player. The decision maker must then characterize the goals, the expectations, while scanning for affordances to create a course of action (Zsambok & Klein, 1997).

A conceptual framework approach has been proposed by Richards, Collins & Mascerenhas (2017; Passos *et al.,* 2008) which understands decision making through three separate faucets; the game, the player, and the coach. In real life sporting situations, all three faucets interact constantly to create new problems that require solutions. Therefore, to effectively navigate the relationship between the three, there must be a sense of communal language within invasion team sports (Ashford, Abraham, & Poolton, 2021).
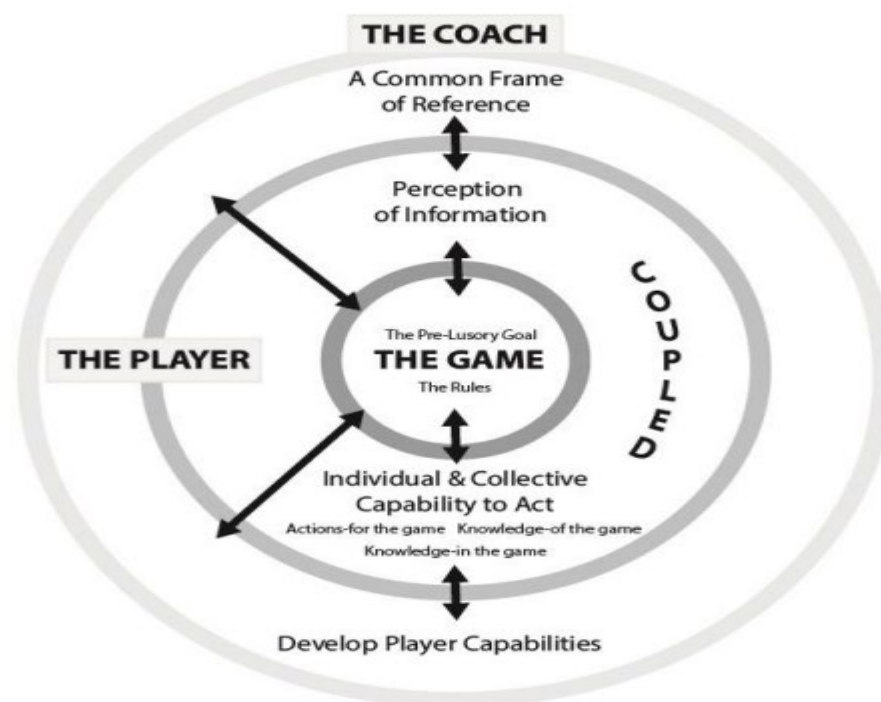

Figure 3 : A unified conceptual framework for player decision making in invasion sports (Ashford *et al.,* 2021)

The Game

The framework in figure 3 describes how the three different components to decision making can interact. The game is poised win the centre of the framework as it is the landscape where majority of the information arises from. Furthermore, invasion sports constantly present 'unstable' environments to the players within it, however, decision making options is governed by two paths. Firstly, it is governed by the pre-performance goals, which should for every team is to win. This is achieved by 'scoring more points than the opposition'. Secondly, the goal is constrained by the rules. In these rules, all appropriate behaviour is controlled with rewards and penalties for adhering or breaking said rules respectively (Grehaigne, Godbout & Bouthier, 1999). Throughout the game, the various intra- and inter- team interactions define the logic of the game (Suits, 1978) and provides game and context specific information the requires the athletes to refine and re-evaluate their decisions to maintain positive goal directed behaviour (Silva *et al.,* 2013).

The Player(s)

The players that are placed within a competitive environment are constantly scanning for various affordances (opportunities to act) for example, an open teammate for a pass, or a gap to run through (Araujo *et al.,* 2019). Players act on role and context specific knowledge (i.e., formations, roles and responsibilities of each player, tactical approach; Dodds *et al.,* 2001), with the senior and more experienced players being able to verbalise a larger spread of solutions or identify the probabilities of different outcomes (McPherson & Kernodle, 2003). This defines the declarative knowledge (the knowledge you say) that each individual may possess. Although it is essential that all players have declarative knowledge, it doesn't enhance the processing time for decisions (Raab, 2012). Procedural knowledge (the knowledge that you do) understand that tacit/intuitive knowledge or skills can be built through practice and experience (Raab *et al.,* 2019). However, for players to effectively interact within the landscape of affordances, they must be self-conscious about their own

skills and capabilities (Kannekens *et al.,* 2009). If players are not aware of their own competencies and capabilities, they will not be able to make the right decisions, leading to turnovers in possession or even making game changing mistakes. Furthermore, as the game progresses and the environment develop, athletes must constantly 'calibrate' and update their in-game knowledge to certain affordances (e.g., opponent strengths, holes in their formations; MacMahon & McPherson, 2009; McPherson & Vickers 2012).

To summarize, a player's knowledge of the game and developing knowledge in the game affects their ability to perceive information, thus changing the dynamic of individual and collective movement patterns (Ashford, Abrahm, & Poolton, 2021).

The Coach

Using this unified approach proposed by Ashford *et al.,* (2021) they posit that the coach has two roles when trying to develop player decision making: 1) setting a common frame of reference, and 2) developing both technical and tactical capabilities of their athletes. Setting the frame of reference is especially important for coaches to do as it will attune all the players to certain pieces of information that the coach may deem vital to successful performances (Richards, Collins, & Mascarenhas, 2012). By defining the desired movement patterns, it helps coaching staff and players to develop a list of buzzwords/shout that can initiate small- or large-scale movement patterns (Richards *et al.,* 2012). For example, an attacker may use hand signals to ask team-mates to occupy a certain space, or a defender using buzzwords to let his peers know that the attacking team have an overload, thus guiding movement and creating changes within the environment.

Secondly, to help attune athlete towards certain affordances and information-rich spots within an environment, the coach must deliver training sessions that can develop their capacity to solve problems (Ashford, Abrahams, & Poolton, 2021) while developing technical

(Travassos *et al.,* 2012) and physical capability (Esteves, de Oliveira & Araujo, 2011). To do so coaches can purposefully manipulate various constraints (i.e., practice space, rules, equipment, players; Chow *et al.,* 2013). Within academic literature this is referred to the constraints led approach (Newell, 1985).

Constraints Led Approach

The constraint led approach (CLA) was first proposed by Newell (1985), has received significant attention by academics and has been posited as a suitable framework to guide and support practitioners through their coaching practice (Davids, Button & Bennett, 2008). With the foundations of CLA being embedded within the ecological dynamics approach (Renshaw *et al.,* 2016). Within current research however, the role of the coach seems to be excluded from the scope of research as previous literature has stated that the coach is not part of the inherent learning environment that the constraints manipulate (Chow, 2013; Immonen *et al.,* 2017; Davids *et al.,* 2015). Such literature has noted that the coach when employing CLA tends to appear to be passive in their interactions within their training session and uses an exaggerated 'hands off' approach (Renshaw *et al.,* 2016).

CLA skill is then defined as the "emergent property based on dynamics couplings on dynamic couplings formed between and amongst components of the individual's movement system and components of the environments whilst solving motor problems" (Orth *et al.,* 2019. p. 148; Glazier, 2015). Whereas traditional coaching approaches focuses on developing internal models or motor programmes specifying ideal movement patterns (Guadagnoli & Lee, 2004). Fitts and Posner (1967) define learning as the process of understanding the rules of the environment, applying them and then internalizing them as a motor programme. Following such approach to coaching then outlines the role of the coach to ensuring all athletes are informed, instructed and are commanded by the of their sport (Côté & Gilbert, 2009). CLA, however, views learning in a very different way to learning and

behavioural change. Instead of prescribing ideal movement patterns, CLA focuses itself on exploration and guided discovery (Chemero, 2009). Through an understanding of affordances (invitations to act; Whitagen *et al.,* 2012), a crucial pedagogical principle arises which relates to how a coach can help attune the attention of performers to relevant affordances, in turn aiding in their skill acquisition (Rietveld & Kiverstein, 2014; Jacobs & Michaels, 2009). Practitioners can build practices using various constraints to help identify relevant affordances in an environment to guide desirable goal directed behaviour from a landscape of affordances (Rietveld & Kiverstein, 2014), and studies by Hristovski *et al.,* (2006) and Gray (2018) have already posited that the use of constraint manipulation has a higher influence on the attention of athletes or learning process than traditional approaches.
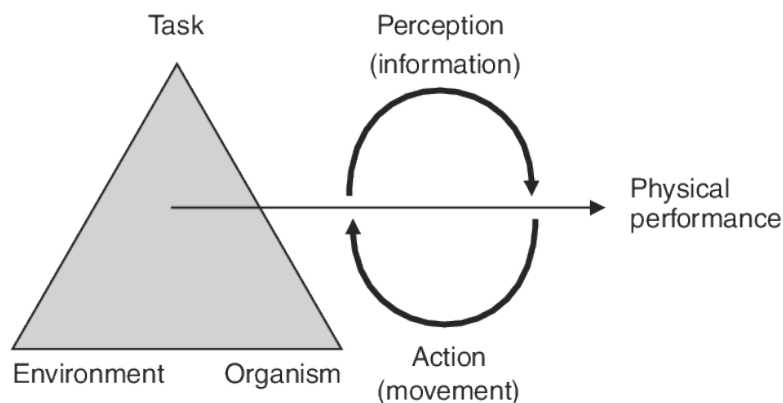
Figure 4 : Newell's (1985) model of interacting constraints

This framework investigates how the behaviour of athletes change under prescribed boundaries (I.e., constraints; Davids & Araujo, 2005). Renshaw & Chow (2019) posits that there are three main constraints that can affect and shape behaviour: i) individual constraints (i.e., age and skill level), task constraints (i.e., the size of the playing area, number of players on each team, point system, scoring options, rules), and environmental constraints can be broken down into physical factors (i.e., temperature and lighting) and social factors (i.e., winning or losing the game, other key moments within the game; William & Hodges, 2005). The reason this approach is so effective, is because it allows the coach to decide what environmental properties disseminate the most information. By following the four

environmental design principles (EDP); 1) Session Intention, 2) Constrain to Afford, 3) Representative Learning Design, and 4) Repetition without Repetition, coaches can effectively utilize CLA to further progress the learning of their athletes.

Environmental Design Principle 1 – Session Intention

The session intention is the first step when planning practices, and acts as an organisational constraint as coaches plan, prepare and deliver their sessions (Renshaw *et al.,* 2019). It is important to have clear session intentions and goals as it can impact the engagement of the athletes. Following the proposed unified approach (Figure 3), creating a clear and concise session intention allows for all athletes to share a common frame of reference thus allowing goal directed behaviour to be exemplified as all individuals can be more aware of the shared affordances within the space (Magill,1998; Passos *et al.,* 2011; Silva *et al.,* 2013).

Creating a session intention also implies that the coach has planned for specific manipulations of practice groups, effective playing spaces, rules and conditions of the SSCG (Correia, Carvalho, Araujo, Pereira, & Davids, 2019).

Environmental Design Principle 2 – Constrain to Afford

Constraints are a key feature within CLA framework and can be defined as the "boundaries which shape the emergence of behaviour in a movement system seeking a stable state of organisation" (Newell, 1986). When task, environmental, and/or individual constraints are manipulated, different perceptual information arises from environments thus affording the athletes to produce different movement solutions (Gibson, 1979; Withagen *et al.,* 2017). This encapsulates the ideas behind constraining to afford.

Environmental Design Principle 3 – Representative Learning Design

"Practice how you play". This phrase encapsulates the meaning of representative learning design. Developments within the field of coaching science has created a link between ecological dynamics and nonlinear pedagogy (Chow *et al,* 2006; Renshaw, Chow, Davids, &

Hammond, 2010). Nonlinear pedagogy further proposes that the processes of perception, cognition, decision making, and action is all underpinned by the information that can be sourced from any given environment (van Orden *et al.,* 2003). Representative learning design (RLD) advocates the manipulation of task constraints to shape desired movement patterns that can also be organically built within competition (Araujo, Davids, & Passos, 2005, Araujo, Davids, & Hristovski, 2006; Pinder *et al.,* 2011). When designing in constraints coaches should consider the affects it may have on; a) how they affect the movement of players (fidelity) and b) what are the task objectives so that each constraint can effectively draw out affordances within the environment (functionality).

When athletes are interacting in a representative environment it enhances their transfer of learning (Seifert, Button, & Davids, 2013). Studies conducted by Pinder *et al.,* (2011) looked at how action fidelity was maintained in batting practice for cricketers. Their study posits that by using bowling machines, the batsman is hindering his performance and learning as they are not allowed to perceive kinematic information that may be displayed by the bowler (i.e., grip on the cricket ball, run up, height of release). The need to maintain action fidelity is essential as it develops accurate and adaptive decision making for athletes both in individual and team sports (Araujo *et al.,* 2007). By allowing players to search for information within representative training environments, it can increase the efficiency of the perception action couplings (Le Ruingo *et al.,* 2005), thus allowing players to anticipate and be quicker to react to changes within the environment.

Environmental Design Principle 4 – Repetition without Repetition

Within coaching, it is important that athletes can consistently practice new skills and refine older ones. Repetition without repetition refers to the way players can experience the ebb and flow of the game, without the feelings of drill like practice (Roberts, 2019). Following the constraints led framework, learners are required to adapt movement behaviours in order achieve consistency of outcomes during unexpected changes in the environment (Liu, Newel, & Mayer-Kress, 2009).

It allows athletes to constantly solve problems as they would do in a competitive environment as they aim to maintain stability in a collective system (Kelso & Engstrom, 2006). Variability within movement solutions can be created within an environment by adding in specific instabilities and 'noise' to the practice (Williams *et al.,* 1999).

Non-linear pedagogists further encourage athletes to be versatile and adaptive within their movement solutions (Davids *et al.,* 2012), this can be done if coaches continuously place athletes within states of instability requiring them to use existing knowledge of events to quickly solve problems and restore stability within a system (Renshaw *et al.,* 2010).

Using these principles, coaches are tasked with creating an environment that can re-enforce optimal learning, being a key factor of athletic development (Horton *et al.,* 2005). However, being able to design a session, and deliver a session both have equal effects to learning. Ford, Yates and Williams (2010) address that coaching behaviour, and the relationship between coaching behaviour and practice design are two essential faucets in the development of an athlete.

<u>Coaching Behaviours</u>

During coaching sessions coaches must be aware about how their micro-level interactions can affect exploratory behaviours of the learners rather than prescribing specific solutions (Correria *et al.,* 2019). The interactions between both practitioner and learner through both verbal and non-verbal modes of communication play and important role within the changes of behaviour as they seek to optimize their performance solutions (Chow, Davids, Button, & Rein, 2008). Traditionally coaches are seen to be at the centre of the learning process, therefore are put into a position of power and influence over development and performance of the learners (Cushion *et al.,* 2006, Smith & Smoll, 2007), and coach behaviour that can be delivered or interpreted in the wrong manner can negatively affect the development (e.g.,

poor performances, higher levels of competitive anxiety, dropout; Amrose, 2007). The behaviour (actions and words) of the coach, thus not only affect the physical development of individuals but also their social and emotional well-beings (Jones *et al.,* 1997; Horn, 2002).

It then becomes within the best interest of the coach to appeal to developing the self-efficacy of their athletes. Bandura (1997, p.3) defines efficacy as "belief in one's capabilities to organize and execute the courses of action required to produce given attainments". Further research has built on the definition and shown that self-efficacy contributes to increased motivation, pushing to attain more challenging goals, increased effort, which in theory should produce better performance (Feltz & Lirgg, 2001; Feltz, Short & Sullivan, 2008). Within team sport contexts, the learning that development that takes place is not done so in isolation, therefore, Bandura (1997) extends efficacy theory to allow for the inclusion of collective efficacy, better defined as "a group's shared belief in its conjoint capabilities to organize and execute the courses of action required to produce given levels of attainment" (p.477). Feltz *et al.,* (2008) has conceptualized collective effecicay into five pillars: ability (e.g., playing better than the opposition), effort (e.g., playing to the best of the teams capabilities), persistence (i.e., endurance within the face of failure) , preparation (e.g. mental preparation prior to competition) and unity (e.g. the ability for the collective to perform in harmony).

Following efficacy theory, an understanding that team that are highly efficacious will appear more motivated, be willing to exert more effort, in turn performing better (Trininic *et al.,* 2009), but how do teams become confident in their ability to perform? Research has observed that the previous performances of a team, where a team has been successful in competition or mastery of a skill in training through efforts from the collective unit, the efficacy should increase (Feltz & Lirgg, 2001; Feltz *et al.,* 2008). Fransen *et al.,* (2012) has also revealed that the interpersonal communication between players (i.e., encouragement and tactical information) during competition also enhanced the collective efficacy. Further research has understood how the development of a motivational climate, coach leadership behaviours and team cohesion can influence the athletes (Feltz & Lirgg, 2001; Heuze,

Raimbault. & Fontayne, 2006). The role of the coach holds significant important towards the development of collective efficacy, and it can be reasonable to assume that their behaviours can have lasting impacts on both individual and collective dynamics.

Multi-dimensional Model of Leadership & Coach Leadership Behaviour

To investigate the impact and role of the coach, Chelladurai (1978, 2007) developed the multi-dimensional model of leadership (MML). Originally, devised in 1978, Chelladurai the MML states that there are three explicit forms of coach leadership behaviour states that affects performance and satisfaction of the athletes: required behaviour (what the situation requires from the coach), preferred behaviour (how the athletes want the coach to behave), and actual behaviour (what the coach actually does).
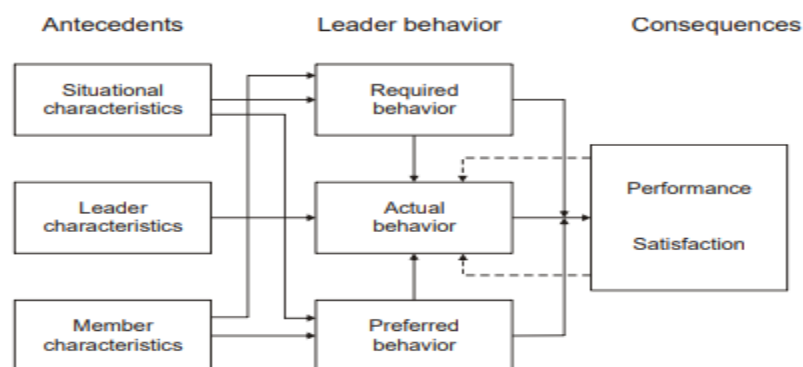
Figure 5 : Chelladurai Multidimensional Model of Leadership in Sport

Coaching leadership behaviours can be defined as a procedure to influence both individual and collectives to strive toward set goals (Chelladurai & Reimer, 1998). Chelladurai (2007) further develops his model to include the concept of transformational leadership. Transformational leadership is the ability to motivate members within a team to perform beyond their expectation (Bass & Bass, 2008). Working through the MML, Chelladurai and Saleh (1980) further develop The Leadership Scale for Sport (LSS), a scale frequently used

by academics to quantify coach leadership behaviours. The LSS breaks down coaching behaviour into five different subscales: democratic decision making (encouraging autonomy in decision-making to members), autocratic decision making (ability for independent decision making by group leaders), training and instruction (coaching behaviour employed to improve athletic performance), rewarding behaviour (how do coaches reinforce good performance), and coach social support (how do coaches develop positive coach-athlete relationships, creating good team atmosphere and looking after general well-being of the athletes; Fletcher & Roberts, 2013).

Motivational Climate

Baric (2007) further posits that the coach is a major stakeholder in the creation of the motivational climate within any performance context. There is a general assumption within the field of competitive sport that the coach's ability to lead their athletes is connected to the performance and competition efficacy (Trninic *et al.,* 2009). Preliminary studies showed that a team's average perceptions of the coach's leadership behaviour acted as an important predictor of competitive success (Weiss and Friderichs, 1986).

The motivational climate has the ability to change the motivation, performance, and potential of athletes (Trininc *et al.,* 2009). Motivational climate refers to how a social environment such as the training session or competitive games is moulded to reflect against the definition a coach may have regarding competence and success (Harwood *et al.,* 2008). A motivational climate can be observed through the coach's ability to orientate the goals of their athletes towards different task- and ego- components (Weiss *et al.,* 2021). A team with a higher task-climate reflects the emphasis of effort, improvement, and personal mastery (self-set targets), whereas a higher ego-climate revolves around social comparisons and results (societal norms) to define success (Horn, 2019).

Team Cohesion

The connection between coaching behaviour and team cohesion has been observed by a variety of researchers (Chelladurai, 1984; Gardner, Shields, Bredemeier & Bostrom, 1996). With the continuous coming and going of athletes, the makeup and quality of the team always changes (Matheson, Mathes, and Murraym 1997), it becomes the coach's responsibility to make sure that the team can perform at high levels while being able to adjust to the changes within quality. Cohesion or 'cohesiveness' is better defined as "the way in which members all work together for a common goal, or where everyone is ready to take responsibility for group chores (Cartwright, 1968, p.70). Team cohesion can be broken down into two interacting schools of thought: task cohesion and social cohesion. Task cohesion focuses on the ways in which members of the team can work together and maintain unity while achieving group objectives, whereas the latter understands the willingness for members within a group to create interpersonal relationships, and if they enjoy the company of their teammates (Carron *et al.,* 1985, Al-Yaarbi and Kavussanu, 2017).

Summary of Literature Review

In CAS, collective behaviour emerges from the patterns of interpersonal coordination of agents within a system (i.e., teammates & opposition; Bar-Yam, 2004) and information from the environment (i.e., the performing context that constrains behaviour; Beek, Peper, & Stegeman, 1995). The open-ended nature of the environment allows for behaviour to be formed as a result and reaction to physical and informational constraints (e.g., opposition tactics, playstyle, and behaviour; Handford *et al.,* 1997). In such environments, successful performance is evidenced by higher levels of movement co-ordination and interpersonal coordination during the offensive and defensive phases of play (Dutt Mazumder *et al.,* 2011). Araújo & Davids (2016) define collective behaviour as the organization of individuals with varying DOF's that is dictated by a task specific goal (i.e., keeping possession to defend a lead, covering teammates and space and dribbling). To create such behaviour, it is important to understand the effects of self-organization. Thus, academics (Araújo *et al.,* 2006; Duarte

et al., 2010) argue that the behaviour exhibited in these systems should be examined through ecological variables or context-based measures. Work within the department of performance analysis has helped conceptualize the various means of group coordination using group-based measures. There are five different variables: i) team centre, ii) team dispersion (stretch index, team spread etc…), iii) team synchrony, iv) division of labour (heat maps) and v) communication networks.

To successfully allow athletes to develop their ability to self-organise current pedagogic literature has asked coaches to divert from traditional norms of skill acquisition that focus on creating "optimal movement patterns or technique" (Ericsson *et al.,* 1997) but to create adaptable athletes through an ecological approach to development which focuses on reproducing an outcome, and not a specific movement pattern (Seifert & Davids, 2017).

Within any context human behaviour derives from cyclic coupling of perception and action of an individual to the affordances within an environment, therefore athlete decision making is a product of the performer's interaction with relevant affordances. For a synergy to form, two or more agents within a system must perceive the same outcome from a shared affordance, and act in a complimentary fashion to allows for successful self-organisation and performance outcomes. For a coach to optimize or create change in decision making tendencies, they can manipulate task constraints to change the nature of an interaction with an affordance, or to attune the perception of athletes toward new affordances that create desired goal-directed behaviours. As highlighted the constraints led approach is a framework that discuss how coaches can understand individual, environmental and task constraints to allow exploratory behaviours through meticulous practice design, but also how do they create an exploratory learning environment and use their language during coach-athlete interactions to continuously promote exploratory learning behaviours, attune the perceptions and re-enforce student led guided learning. This paper will then look to investigate the following research questions:

- How do coaches plan & deliver coaching sessions that challenge athlete decision making tendencies?

- How do coaches assess the development of collective behaviour while developing each athlete individually?

- What techniques do coaches use to gather and action feedback?

Methods

A qualitative approach was taken for this project. Qualitative research allows the researcher to be more interpretive by nature (Sparkes & Smith, 2014). The main goal of said methods of research is to understand how individuals (i.e., research participants) interpret their lives through interactions with their surroundings (Sparkes & Smith, 2014). Although, when conducting qualitative research, one must always be careful and critical in identifying the presumptions/assumptions that help frame the investigation (Braun & Clarke, 2013).

Philosophical & Disciplinary Assumptions

This study was underpinned by a constructivist approach. Guba and Lincoln (1994) define constructivism as a method of creating meaning (knowledge) through the interactions and dialogue between the multiple realities of the researcher and the participant. To stay aligned with this paradigm, researchers should report their values and biases, as they are fundamental beliefs that shape the research outcomes (Guba & Lincoln, 1994). Adhering to this, the author of this study, was previously enrolled in a higher education program that focused heavily on an ecological dynamics background, thus, shaping much of the study through a Gibsonion view of human movement (i.e., constraints, affordances, perception-action couplings; Gibson, 1979) and the idea that for movement to emerge, all individuals must self-organize around their environment.

Procedure

Once ethical approval was granted by the Research and Ethics Committee at Oxford Brookes University, participants were contacted through the authors prior interactions with each coach through via their professional network which was developed through professional development courses (i.e., Undergraduate Degree), networking events, vocational coaching courses. Each coach was initially contacted via email, with a participant information sheet that contained full details of the project including their involvement within the research. Enclosed within the email was also a GDPR Notice which informed each potential participant of how the data is collected, stored, and used to complete the research project. Each participant was given a minimum of 48 hours before confirming participation within the study, with informed consent being obtained before data collection processes commencing.

<u>Participants</u>

The sample of this study consisted of 7 coaches in team sports (6 football coaches, 1 hockey coach) undertook the interview process. Each coach is currently working with an academy affiliated team or part of a university club. Demographic information (i.e., years of experience, age group coached, coaching qualification) was collected, however all of that data will be anonymized to maintain confidentiality in the project. The sample although small did allow for a diverse range of participants from different ages, qualifications, and years of experience (Fassinger, 2005).

Table 1 : Participant Demographic Information

	Age Group	Years with Team	Years of Experience	Relevant Qualification
Coach A	U12s	1 ½ years	2 years	BSc (Hons) Sports Coaching, FA Level 1

Coach B	BUCS University Hockey	~0.5 years	10 years	Level 2 in Hockey Coaching
Coach C	Under 16s	~0.5 years	10 years	UEFA B, FA Youth Award
Coach D	Senior Women's	6 years	15 years	UEFA B, FA Youth Award
Coach E	U14s	~0.75 years	1 year	FA Level 1, Diploma in Sport and Exercise Science
Coach F	U15s	1 year	1 ½ years	FA Level 1, FC Barcelona Level 1 Coaching

Data Collection

Interviews ranged in length from 30 minutes to 50 minutes (n = 40 minutes & 53 seconds ± 5 minutes and 7 seconds), where each coach participated in a semi-structured interview (Rubin & Rubin, 2012). Each interview was conducted through Zoom calls due to ease of scheduling and as a covid contingency which were audio recorded so that they could be transcribed after.

The data collection process originally featured a live data collection, where the coaches would be asked to record a video of their training session with a GoPro for example, to further examine the specific language used during sessions, however, due to the COVID pandemic, live data collection access was restricted thus following a simpler form of data

collection. The use of semi-structured interviews was seen as the most appropriate tool for this study as the goal was to explore the self-perceptions of coaches. In semi-structured interviews all participants were asked the same major open-ended questions but depending on their responses the researcher could ask to follow up questions to elicit more detailed and in-depth responses. An interview guide was created to help ensure the trustworthiness of the data. The first section of the interview guide was to collect demographic data about each coach (i.e., coaching experience, age groups coached, coaching environment). The second section of the interview focused on trying to identify how much knowledge the coach may already have about synergistic movement (I.e., "can you define synergistic behaviour?", "what do synergies look like within your practice?", "Is this something you try to coach?"). The third section looked all at the various involvements of the coach, from a) planning and delivery of coaching session (i.e., "Can you walk me through your planning process before a session?", "Do your sessions look similar throughout periods of the season"?, "what counts as a successful training session?"), b) the coaches/teams tactics and philosophy (i.e., " What are you tactics and philosophy with the team?". Furthermore, to allow participants to elaborate further on certain questions the use of probes such as "What would that look like in your practice?", or "Can you give me an example of how you instil X value onto your players?".

Data Analysis

Thematic analysis (TA) is a method used in qualitative research that systematically identifies, organizes and offers insight into patterns of meaning across a dataset (Braun & Clarke, 2012). It allows the researcher to find shared meanings across different perspectives and the various 'created' realities of the participants. The flexibility of TA also allows the application of inductive and deductive methodologies (Frith & Gleeson, 2004; Hayes, 1997).

An inductive approach allows the researcher to build generalizations through underpinning theories, thus more effectively aligning the themes to the dataset (Patton, 1990).

Each interview was audio recorded through the built-in recording function provided by Zoom. It was then transcribed verbatim and analysed through a hybrid (deductive and inductive) approach following Braun and Clarke's (2013) guidelines on thematic analysis, which can be separated into six phases: (1) familiarization with the data, (2) coding the data, (3) searching for themes, (4) reviewing themes, (5) theme titles, and (6) writing results. The first four phases of TA will be discussed in this section, with phases 5 and 6 being evidenced in the results section following. A hybrid approach to data analysis appeared to be the most effective as it allowed prior knowledge of academic literature to create codes that easily aligned with the research questions, thus allowing simple identification of codes within the transcripts. An inductive approach proved useful when trying to develop deeper meaning within the themes when investigating the coaches' real-world settings.

Phase 1 – Familiarization with the data

A key tenet to conducting qualitative research is the ability to immerse yourself as the researcher within the data sets by reading and rereading the texts (i.e., transcripts of interviews, responses within a survey). This is important as it can allow the researcher to be more critical and analytical when it comes to developing and identifying the codes and themes and can ask themselves questions like "How is the participant depicting their reality?", "What assumptions do they make when interpreting their experiences?"(Braun & Clarke, 2006). All these questions will help in the casual note taking that happens through the different readings across the data set.

Phase 2 – Coding the Data

Codes are essential to the makeup of higher order themes, as it allows the researcher to group contextually similar data across the various transcripts through comments that identify information vital to answering the research question (Braun & Clarke, 2012). The analyst will use codes as a shorthand method of drawing out key information and be as inclusive to the data provided. Coding is the initial stage of constructing themes, therefore the researcher (myself) must be extremely careful to not exclude data that may not seem relevant as it may help in the development of themes in the future.

Phase 3 – Searching for Themes

Braun & Clarke (2006) defines a theme as a patterned response that captures vital information in relation to the research question. Qualitative researchers usually understand themes to 'emerge' from a data set, but Braun & Clarke argue it is much more of an active process. Themes are developed through the use of the code clusters from phase 2, as it allows the analyst to cluster codes that share meaning or a unifying feature.

Phase 4 – Reviewing Themes

Reviewing themes, is essentially a quality check to ensure that all the data that is included within the themes answers or adds value to the research question. Braun & Clarke (2012) have outlined a checklist for novice researchers to ensure that TA is being applied effectively and appropriately:

- Is this a theme, or just a code?
- Does this theme reveal something useful throughout the data set and answer the research question?
- What are the boundaries (included and excluded data) for this theme? Do they need to be changed?
- Is there enough data to support the theme?

- Is the data within the theme to diverse? Is the theme coherent?

Trustworthiness

Qualitative researchers are always encouraged to demonstrate quality within their findings by detailing their personal decision-making processes throughout the data collection and data analysis stages of the project (Sparkes & Smith, 2014). An element of trustworthiness of this data can be found through the use of critical friends. To avoid researcher bias during the data collection process, all questions were neutrally worded so that the responses of the participants did only incur inductive data.

Referring to Appendix 2, a portion of Coach A's coded transcript is provided to better demonstrate the coding process undertaken to create the themes and results within this study.

Results & Discussion

The results and discussion are presented in order of the three higher order themes identified during the thematic analysis process (Table 2). First, we discuss the way in which coaches design training sessions. Secondly, the learning environment created by the coach, and lastly, the behaviours they may use to aid the development of athletes. All though, the data is presented within these themes, each theme is interrelated and comes together to provide a complete image of the participants' coaching environment. To give an example, each training session will have a specific session intention and to satisfy the session intention, the delivery (i.e., coaching behaviour and time on task) and planning (i.e., small-sided games or drill-based practice) of the practice design will also change.

Table 2: Thematic map displaying the lower and higher-order themes of the data set

Higher-Order Themes	Dimension
Small-Sided Games	

Session Intention	**Practice Design**
Representative Learning Design (RLD)	**(The coaches use of constraints to develop athletes)**
Goal Setting: Results vs. Performance	
Scaffolding Learning	**Learning Environment**
Coaching Philosophy	**(The way coaches want their athletes to develop)**
Feedback	
Instruction	**Coaching Behaviour**
Questioning	**(How coaches affect the learning process)**

Practice Design

The first dimension explored is practice design. Coaches are frequently seen as environment architects, who can create environments that can invite or encourage learners to explore different movement solutions. With a portion of the interviews being focused on the tools and tactics coaches use to create the training sessions, the results have shown that all coaches have an explicit or implicit understanding and application of the constraints led approach to increase the synergistic capabilities of the team. In this section we will explore the that coaches do not want to tell their athletes what is expected of them, but rather to build environments that challenge performers to adapt their behaviour and become directed to the relationship between: (i) what the environment intends (intentionality), (ii) perception of information within the environment, and (iii) the availability of different action possibilities in a performance environment (Chow *et al.,* 2011) through effective application of the principles of CLA (i.e., representative learning design, constraining to afford) and the use of Small-Sided Conditioned Games (SSCGs; Silva *et al.,* 2014; Travassos, Vilar, Araujo, & McGarry, 2014)

Using Small-Sided Conditioned Games
SSCGs as the name implies, are constructed for athletes to experience 'smaller and more condensed' versions of the formal game (Hill-Haas *et al.,* 2011). At competitive levels of participation, this method of training is seen to be more efficient method for the physical

preparation of athletes, to train movement patterns, technical execution all while maintaining action fidelity when compared to more traditional forms of coaching (Lopez & Gutierrez, 2018; Flores-Rodriguez & Ramirez-Macias, 2020). Studies have also shown that coaches most often manipulate task constraints in relation with the playing dimensions (i.e., pitch size and effective playing surface) as well as the number of players within the game (i.e., the use of equal or unequal players in teams; Ramos *et al.,* 2020) as opposed to organismic (individual) constraints or environmental constraints (Ometto *et al.,* 2018). Many of the participants within the sample stated that they incorporated forms of small, sided games within their coaching practice:

> *"So, in terms of the problem being solved will always be focused back to how we want them to play. So in that sense, kind of, it's always kind of the same. However, some weeks we may work on the overall problem, sort of a more global point of view. So that might in turn that might look like um, More small sided games passages of play, sort of more representative pitches or bigger, bigger teams. But sometimes I think there's also a very good argument in need, and a need for sort of more or less representative style matches, which might be working on a more specific area of play, saying that maybe less representatives, not the right word there. What sort of sessions are working on more of a specific focus, like you said, kind of breaking it up a little bit. So for example, that might be working on receiving the ball and playing out under pressure. And with the global focus of being able to receive the ball from the goalkeeper to then play out and beat the press, we might have to do a lot of work on sort of passenger saving under pressure, and bit of work on sort of accurate fizzing the ball in in first touch with the overall view of being able to improve them in that specific situation, which will then have a knock on effect, positive knock on effect to how we'll be able to play more globally." (Coach A)*

> *"And so there's a lot of player to player interaction there where they're sort of working together to solve the problems that happened in the previous week. In terms of the unpitched context, sometimes we'll do small unit play, where together, players are working to problem solve with players that they are in a unit with on a game day. And then I think within sessions, there's a lot of competition, where we split off into teams, there's points, which we rack up per week. So like playing in small teams. So I imagine there's some elements were there. working together in pairs or more to beat another three or four players, as it were. If I was thinking quite literally in our context, I guess then within all the practices we do, there's elements where you have to work with other players to solve the problem in front of you." (Coach B)*

> *"In senior football, I would be looking S&C, unopposed passing practice, something involving pressing and real intensity to our press, then would move into a phase of play, and then onto a conditioned game. That's what session would look like." (Coach D)*

> *"So that arrive activity, it could be without the ball, it could be with the ball as well. And then possession-based practice, which would progress to do more complex stuff to start unopposed, and go to an opposed kind of session. And then from there, we*

would kind of go through maybe some phases of play. So they and then finish off with small sided games." (Coach E)

A coach further discussed why they use pitch dimensions as a constraint :

"Another constraint would be the size of the pitch. If we want to work on more fitness, we can make it bigger for the midfielders and the presses have to run further. If we're working more on our technical skills, we can make it smaller they don't have to run as far but their touch and the way they move the ball has to be more accurate and quicker." (Coach F)

Studies have gone to evidence that manipulation of playing dimensions and space promotes higher level of variability within player movement (Silva *et al.,* 2014), development physical performance (Olthof *et al.,* 2017) and more opportunities for creating overloads (e.g., 4 v 3, 3 v 2, 2, v1; Silva *et al.,* 2015).

A number of coaches also elaborated on using numerical superiorities within learning environments :

"In terms of the on-pitch context, sometimes we'll do small unit play, where together, players are working to problem solve with players that they are in a unit with on a game day. And then I think within sessions, there's a lot of competition, where we split off into teams, there's points, which we rack up per week. So like playing in small teams. So I imagine there's some elements were there. working together in pairs or more to beat another three or four players, as it were. If I was thinking quite literally in our context, I guess then within all the practices we do, there's elements where you have to work with other players to solve the problem in front of you. So for instance, on Monday evening, we did player up player down where we had, you can basically play cards during the game like chips almost. And the players have to work together to decide when they're going to play those to create an overload. And then they have to decide the way that they then press from that. So I guess we have a lot of instances where players would be working together to do solve a problem, do something within a game context." (Coach B)

"It's a case of doing a match at the end, where one team has seven players, and one team has eight players, and seeing how the team of seven react." (Coach F)

Studies by multiple academics (Silva *et al.,* 2014; Travassos *et al.,* 2014) that by manipulating numbers of players involved within a SSCG, the numerical advantage/disadvantage constraint the intra-team coordination during performance, in most cases creating a greater effect on teams with the numerical disadvantage.

Lastly, Silva *et al.,* (2014) also posit that athletes will adhere and self-organise to the specific game rules applied within SSCGs. Coaches within the study described the use of modified scoring systems to promote the engagement of athletes within in the learning environment :

> *"And and then sort of a scoring system as well to sort of encourage those behaviours. In terms of what those behaviours are, it'll change according to set the session aim. And yeah, that that scoring system is quite important. And just for me personally, and the boys seem to quite like that. They found it quite a good way to encourage that certain behaviour. So toying around with those scoring systems as well, and sort of altering the way or being successful rewards you in a certain different way, they seem to quite like some sort of quite novel ways of doing that. And that seems to quite resonate with them and sort of get them going a little bit." (Coach A)*

> *"So that's generally what our sessions look like. Lots of competition. Lots of points on offer. So yeah, that's that's kind of it really, I guess, that we've been doing over the last few weeks." (Coach B)*

Understanding the nested nature of constraints and affordances, the development of collective behavioural properties such as; exploration (Torrents *et al.,* 2016), degeneracy (Siefert *et al.,* 2014; Pinder *et al.,* 2011), synergies (Passos *et al.,* 2018) and synchronization (Duarte *et al.,* 2013) can all be developed through engagement in diverse and challenging environments (Pol *et al.,* 2020). Adding specific scoring system then further promote engagement within the constraint and can aid in creating goal directed movement patters for both individual and collective behaviour.

Coaches tend to focus on manipulating the task constraints mentioned above as through an interpretation of Newells constraint model (1985) with reference to team sporting contexts have suggested that the task constraint is the easiest to manipulate by practitioners, which is in line with previous research (Ometto *et al.,* 2018). The use of small, sided games and manipulation of task constraints such as the pitch dimensions and number of players affects the interpersonal coordination processes affect the synergistic properties such as dimensional compression (Goncalves *et al.,* 2018) and reciprocal compensation (Araujo and

Davids, 2016) within members of a team. Traditional pedagogies that create a narrow field of affordances tend be one-direction, predictable, and rigidly pattered (i.e., drill-based practices; Vaughn *et al.,* 2021). The use of small-sided games such as the rondo, promotes the constant co-adaptation between attack and defence (Passos *et al.,* 2016; Lopez-Felip & Turvey, 2017). Due to the nestedness within constraints and affordances, the movement of attacking and defending players will further change the affordances and possible movement outcomes as coordinated movements will pose new challenges as each team will try and play "through, around, and over" the opposition. From a learner standpoint the appeals to the exploration of the environment as they are constantly finding ways to navigate the challenges posed by opposition movement of environment design to create stability (Woods *et al.,* 2020)

When understanding practice design, Roberts, Newcombe, and Davids (2019) have recently outlined those coaches under appreciate the nuanced nature of the constraints led approach, thus leading to vague practice environments, however, one coaches within the study sample showed awareness to the delicate nature of constraints and their implications towards athlete development :

> *"But then, what is more significant for coaching, is the constraints that we use in training sessions. And I hear quite often especially at a lower level, if you don't know what to do, just chuck the kids in a game and throw a few constraints on them, you hear that quite a lot. And that statement frustrates me quite a bit sometimes, because I think constraints are something that should be thought out with care, because the best way that kids learn football is by just playing. (Coach F)."*

Other coaches evidenced their thoughtfulness towards designing practice environments by focusing on preparation techniques that align with the principles of CLA (i.e., session intention, representative learning design).

Session Intention

Referring to the literature review, the first principle of CLA is having a clear session objective(s)/intention. The importance of having a session intention is that it allows coaches

and the athletes to have a shared frame of reference, to maximise engagement (Silva *et al.,* 2013). A couple of the coaches noted, that when it comes to planning each session, they start with identifying their session intention and desired learning outcomes.

> *"When it comes down to planning, and having a clear session, aim or session intention, and what you want to work on, that, obviously, is builds upon the foundations of how you want the team's play, and then sort of wants that, that Sessions ongoing, it's kind of been able to recognize what behaviours going on at that moment in time? And is that in line with the sort of the end of the session? Is that sort of been in line with how we want the team to play? And are we seeing the behaviours that we're not what we want to see? And then if we're not seeing those behaviours, then what can we do differently?"* (Coach A)

> *"With a topic? So yeah, once you know, the topic, quite lucky, we got SPOND as well. So we get, obviously, an invitation. So I know pretty much 24 hours before how many players have got and at that level as well, you know, grassroots players, you can have it, I've had it before, where, in the hour before a session, you've gone from 16 players to 10. Unfortunately, that's not an issue I normally have, because they are extremely reliable. So yeah, is knowing the topic. Also, knowing the space, I've got number of players, and then just start planning from there. A lot of time, I'd try to come up with my own practices. So I know, I know that the standard I know the amount of players and know the space, we've got a note of what the outcome is, I want to get out of the session, and then try to plan practices around that, to be honest with you, if I'm struggling or I might have a look online, have a little look up what else I can find out there. But I don't I find copy and paste and practices hardly ever works. You know, if I do that, then I'd then spend that time thinking about how would that work with my players? But yeah, that's the main sort of crux of it."* (Coach C)

Furthermore, coaches use a variety of sources to help plan their sessions. Within this sample, coaches talk about the value of creating blocks of training and the use of periodization within training (I.e., micro-, meso- and macro-cycles; Morgans *et al.*, 2014; Casamichana *et al.,* 2013)

> *"So I think in the past, I'd been sort of guilty of sort of firefight coaching, and sort of by that, I mean, just trying to solve the problems week by week. So for example, if we played one week, and there was x problem, which next two training sessions, we'll be focusing on X problem. And sort of I did that last year and didn't see as much development of how we wanted to play it, it's a lot of light to have done. So this year, the emphasis on the start the season till Christmas, is that we're going to play in a certain way. So regardless of what matches or how we performed on a Saturday, most of the focuses on training on Mondays and Wednesdays will be on what that initial goal was at the start of the season, if you try and get them to play in a certain way, and sort of different working on the different aspects of that over sort of longitudinal period of time."* (Coach A)

"Yeah, it's not so much reactionary. So there were some things that we decided at the start of the year that we'd be looking at. So one of our themes, sort of for the first half of the season is, like I said about being able to read the situation on the pitch. Generally, in hockey, there's a card system green, yellow, and red. And generally, you'll get a lot of green and yellow cards in the game. So that's you've always got a flux of player up player down. And the level that we play, if you can't react to that quick enough, you either you don't score goals, or you end up conceding quite a few. So one of our themes till Christmas is is looking at that." (Coach B)

"Now see the topics down to the syllabus, obviously, you know, try not to be too reactionary in terms of I've done it before, we're grassroots where every time we have a result, if at all, well, that's that fix in that and that never really worked. So there might be a little bit we might link into from the game past but it's probably more looking forward to opposition's that we're going to play so if there's the tactical stuff might be led by the what we're doing in that block of learning" (Coach C)

"So, I plan before every session. And what I'm also planning is the long-term plan. So, make mesocycle. So, I don't think it's easy to plan for the whole season, there's a number of things can affect it. But at least for the upcoming week. So, for example, now, we are working in defendant. So, we set a six-week period of time, we'll have that's 12 sessions, which will be focused on defending and different aspects of defending." (Coach E)

"At a younger level, you might have a more defined scheme of work across the season, obviously, your planning process will come within that scheme of work. So, for example, we might know from August to November, we're going to be working on our defensive principles and pressing from the front, for example. Whereas what I tend to see, especially from the under 15 level, I've already noticed this this season, the head coach and myself have moved into and also at the adult level that I coach at it's about the performance problems" (Coach F)

However, on the other hand, coaches are also aware that results can affect performance outcomes in training, thus designing in practices that can address those issues while maintain overall focus within training blocks.

"Then obviously, if there are a couple pressing matters, or urgent matters that need to be covered, we'll try and cover them a little bit. But it all kind of stems from from sort of a macro or the global view of how we want the team to play rather than a sense of attending to issues week by week, whilst obviously still having based off their importance to play." (Coach A)

"So I took over this year, and I think we had a lot of new players. So it is quite reactionary at the moment, because I need to sort of see how those guys react. We've done a lot of work with the guys who've been there before. So I kind of have a half year focus. And then there'll be another half year focus, and then we'll sort of re address next year and be a bit more detail with the planning that we've got. But at the moment, it is quite short term thinking because our aim is to stay up. And that's kind of what we're focused on at the moment. So it's kind of fighting fires, rather than looking at the long term." (Coach B)

"So I'll make notes on match days. So sort of we went back through the back from the notes in terms of most of the formation may change. Their pressing structure may change potentially." (Coach C)

"So if we've been beaten badly, and we've struggled, I might just or if we've been beaten badly, and we've played well, and might then just make a really fun session. And just, you know, they've been they know they've played well, but they've, you know, they've lost the game, so they're going to be disappointed, they've lost the game." (Coach D)

"I can identify that instantly from our last few games with Oxford City we've had a problem bringing the ball up from the back. We've taken too many touches in when we're building up we've restricted ourselves to one side of the pitch too much. For example, we play a 3-4-3 Diamond inverted fullback, we might give it to the right center back and then completely closed off that side of the pitch because the back three too close together. So I might identify that as a performance problem, right, we need to work on our distribution of, of players within the space when we're building up from the back. And then in our next session, I would always start the session with obviously some sort of warm up and then a Rondo warm up with the ball, Rondo's adheres to the way that we want to play football, get the ball moving" (Coach F)

Representative Learning Design

Maintaining representativeness within practice session is key to the transfer and development of skills (Seifert, Button and Davids, 2013). Coaches do this by ensuring that the affordances seen within the training environment, can also be frequently evidenced within competition. Responses from the participants alluded towards the element of representativeness within their practices :

"Generally with corners, I like to have it going on through the gameplay. So if they win a penalty corner, we would play it within the like the game context. We haven't been doing that so much recently, just because of time. But yeah, that's probably what session would look like, full 11 v 11. With kind of our decision making player up player down theme." (Coach B)

"I find a balance of hopefully, you're going to get a balance, he would, under 16 certainly said, we're going to get the scale going up from repetition to realism as the session goes along. Sort of, you know, even if it's like two v twos, I want to be broken down, and then sort of built back towards a a game situation, obviously finishing with a game." (Coach C)

"I'm out there I'm working, you know, I'm busy I'm in amongst it, you know, I'll get out if I see people are going too slow, I'll get after them, you know, I'll get behind them and sort of drive it that way. So anything that I can do to, to get the tempo down and get balls in quicker, just keep driving that tempo to get to the level, because I'm a great believer in training in trying to train the way that you play." (Coach D)

"A key word that we're taught at Barcelona in the university courses preferential simulating situation. So every practice I would design with a constraint be it a match, be it a possession game, be it a pattern of play game, it would be a preferential simulating situation. So the preferential where we have a preference towards what we want to be teaching them, a simulation of a live match scenario so it has to be can't be players passing in straight lines to each other from 18 yard box to the byline and just one-two one-two no, it has to be within the context of the game. And then the situation part is, is when we got the ball and we haven't gotten the ball or when we're in transition." (Coach F)

Creating representativeness is important as part of the environment design as it offers athletes authentic learning environments where athletes can feel safe to create and/or explore movement solutions without the fear of failure (Woods & Robertson, 2020). Coaches within this study have also evidenced that the end of their training session are normally marked by playing a practice game. These games differ to SSCGs as they are unbound by constraints and just allow the individuals to experience the competitive environment and build on their competencies.

Learning Approaches

This dimension predominantly focuses on how coaches will create environments to enhance the learning process within athletes through holistic non-linear development, and a movement outcome focus instead of result orientation. Many of the coaches' accounts explicitly describe core aspects of ecological dynamics (i.e., constraints) or are expressed through a more implicit understanding, which can be interpreted as the principles from ecological dynamics can guide their coaching behaviour. Many of the coaches adopted an athlete-led, individualistic approach where each athlete is required to solve problems (Chow *et al.,* 2011)

Goal Setting: Results vs. Performance

The field of coaching is very goals and results focused but are coaches setting goals that can be monitored and achieved by their athletes which can then help achieve desirable

results. Goal setting has always been a fundamental tool for coaches to harness, as it can help them in their planning and delivery of practical sessions. It has been often noted that coaches focus on goals that serve as an easy fix to existing problems but have little to no importance to the overall direction of the team (Clutterback, 2010). Performance goals focus on the successful execution of the task, which is typically expressed through positive external evaluations. Performance goals work on building competence and confidence within the athletes (Gresham, Evans & Elliott, 1988). When working with goals, the achievement of performance goals helps coaches implement continuous buy-in and reinforce the ability to execute fundamental movement patterns. On the other hand, learning goals allow the athlete to be a bit more exploratory and creative in their approach to the task. The main focus within learning goals is to focus on task mastery and adaptability, instead of the direct result of the task (Seijts & Latham, 2001). When trying to understand synergies and their development, coaches need to be aware that performance and results are not always mutually exclusive. In relation to the development of collective behaviour these are the responses of the participants when asked "what does success look like to you?":

> First and foremost, obviously, the challenge or the problem at the start of the season was to play in a certain way. Now, one way to gauge success is of how from the start of the season to now have they started to be able to play in that way. More often, I've been able to execute those kinds of behaviours more often. The answer is yes. So, in my view, they have improved because it's been able to play in that system a little bit more. (Coach A)

> *"Successes really hard thing to measure, I think because obviously you can win games and play badly. I think for me, success is seeing the things that we're talking about happening in training, even if it's just once and then highlighting that to the group. Success is them, managing things for themselves as well. So, you know, the captain being able to deal with all of the administration and things like that. The players starting to take responsibility and standing up. It's been really good over the last few weeks, see some of our freshers doing that and signed to have a voice in meetings and in training. I think that's a success". (Coach B)*

> *"But you know, we were down too bare 11 and then one of our players got injured for our sub goalkeeper had to go on , squad of 12 to include two keepers. So as part of the second half, and we came out that was a seven-nil defeat, but they put 15 past Brighton they put things 17 past Charlton 11 past MK Dons. Okay. So, in fairness, it was no doubt at halftime we to in the second half. So, in terms of success, it's not it's not success in returns or results, but success in terms of where we are compared where the opposition are. And, you know, in the fact that they had three goalkeepers at about five or six subs. So, you know, what you what success looks like, isn't, you*

know, sometimes it can be a result, but a lot of it is in terms of how you play, and you know." (Coach C)

"So, it's then just getting them into that relaxed position where they can go and enjoy it and, and play with a smile on their face. And then they're coachable. You know, then if they're making mistakes, and they're not doing the things you want, then you can talk to them, but and also, they're part of the group. So, the group allows them to make mistakes, because that's all going to be part of the philosophy of getting players happy, and environment. And, again, I'm always happy for players to make mistakes. It doesn't it doesn't bother me, players making mistakes. It bothers me when they constantly make the same mistake. But I don't mind players making mistakes. So, it's then just getting them into that relaxed position where they can go and enjoy it and, and play with a smile on their face. And then they're coachable. You know, then if they're making mistakes, and they're not doing the things you want, then you can talk to them, but and also, they're part of the group. So, the group allows them to make mistakes, because that's all going to be part of the philosophy of getting players happy, and environment. And, again, I'm always happy for players to make mistakes. It doesn't it doesn't bother me, players making mistakes. It bothers me when they constantly make the same mistake. But I don't mind players making mistakes". (Coach D)

"This, I think you're always going to have the off game, if we're moving in a trajectory where I'm seeing what I want, what my principles are. And I've seen that we're controlling games in a better fashion going from here all the way to here. If we talk here, over here be perfection. So, Man City or Barcelona of 2010, for example. That's almost perfection of how to control a game. And then down this level, you've got a team that has 20% possession in a game and tries to hit on the counterattack. And so is the progress from moving between that to here to try and get to as close to here as possible". (Coach F)

Furthermore, when tasked within a complex training environment, learning goals help the learner to face the task as a positive challenge instead of a threat, thus allowing for maximum interaction and enhancement of learning (Deci & Ryan, 2004). Consequently, when posed in an environment that allows for learning without the fear of failure, it can foster between co-ordination and co-operation between individuals (Kristof-Brown & Stevens, 2001).

Distal & Proximal Goals

To set goals, coaches must understand the delicate nature in which they should pose said goals. Firstly, the time frame in which the goal can be achieved affects the ability of the student to interact within the environment and their ability to attain the goal (Karniol & Ross, 1996). Distal goals are imposed by coaches which are longer-term projects that align to a

coach's vision/philosophy (Grant & Green, 2004). An example for a distal goal, could be better understood when examining a prominent coaching figure such as Pep Guardiola. In teams that Pep has managed, it is evident that he prefers his team to play with high levels of possession, higher rates of passes as well as a higher tempo when regarding their pressing the opposition out of possession. During the course of a season, a coach like Pep will outline the distal goals, however, through the use of proximal goals which are shorter in nature, aid in building connected coaching sessions/blocks of practice that can achieve the distal goal (Manderlin & Harackiewicz, 1984) and a suitable combination of the two different time frames can enhance development and develop consistency in successful performances.

Outcome & Avoidance Goals

Outcome and avoidance goals are goals that the coach can set to build desirable behaviours within their athletes. Hudson (1999) suggests that outcomes goals should be straightforward, for example Pep Guardiola could set the goal of "recover the ball within 8 seconds of losing possession". This goal aligns with his philosophy of a high intensity press but will also direct the attention to the athletes to a specific task. The specificity of the goal makes it easier for coaches to monitor and regulate performance, but by explicitly defining clear objectives, it can positively improve performance (Locke, 1996). Researchers have been mindful when using outcome goals, as the specificity of the goal could alienate athletes that do not possess the skills or knowledge required to achieve the goal (Winters & Latham, 1996). To balance this, coaches can set more exploratory tasks to help build the fundamental knowledge as it can be seen as less threatening and less demanding to the individual (Dewck, 1986).

Like outcome goals, avoidance goals aim to achieve the same thing but through the opposite method. When applying avoidance goals, coaches will try to dissuade their teams from reaching undesirable states within competition. In football this may look like "don't lose

possession when playing out the back", "don't make silly fouls" etc… However, the major criticism of the use of avoidance goals is the lack of specificity allowed to pose the goals. The lack of specificity means that performers can successfully avoid many situations through a variety of 'acceptable' solutions but only a few correctly satisfy both the approach and avoidance goal (Elliot & McGregor, 2001).

Scaffolding Learning

While performers may not be able to fully utilize all the affordances within an environment, through learning and experience they may learn to do so, thus resulting higher rates of success within performance contexts (Araujo & Davids, 2009; Renshaw *et al.,* 2016). Understanding this fundamental, coaches should aim to incrementally increase the capabilities and competencies of the athletes. Commonly associated within Vygotsky's (1987) social constructivist approach which assists the learning of within 'zones of proximal development (ZPD). ZPDs can be defined as the gap between tasks that can be completed without assistance and the tasks that require external information to successfully accomplish (Vygotsky, 1987). Coaches within the study alluded to utilizing a scaffolded approach, by delivering variations of similar training session or manipulating task constraints and allowing for learner autonomy to evidence athlete progression:

> *"So, I'm quite lucky in that, in that sense that I've got sort of a longitudinal sort of view of their development, and I've been able to watch them, watch some of not only the whole of last season's over the first half of the season as well. And are they improving? Five weeks apart? First week? Do they struggle with the task? Maybe a little bit towards the fifth week? Are they starting to understand the task? Are they able to sort of successfully complete the task without my guidance? And are they able to set them up set the tasks themselves without me as a facilitator doing it? And that way, for me is seeing that then learning whether that problem is behaving in a certain way on a pitch or interacting with others, or whether that's sort of explicitly answering a question towards them? Is that answer coherent with what we want to be doing? And what we've done over the past six weeks? If it is the probably learning? If it's not, then I probably need to change them and probably need to do something different lengths be able to sort of accomplish success in that sense. (Coach A)*

> *"So, we set a six-week period of time, we'll have that's 12 sessions, which will be focused on defending and different aspects of defending. And then, within those sessions, we will focus on different stuff. So, for example, while we will focus on one*

v one defending, the next week, it could be on the low the defendant, so one against two against free press five." (Coach E)

" I've had it before what I've done that particular practice, where I've introduced five presses, and those midfields three just can't cope, they can't find the space to take the ball on the half turn. And then the back four, just get shut down very quickly can't get it to the other back four. And so, it's a case of just pulling out one of the presses, making them a midfielder. And now we're working four midfielders against four presses with the back fours on either side. And so instantly, there we've, we've had a constraint, it hasn't worked, we've adapted the same constraint, we still got a numerical superiority, it's just got bigger. And so, in that sense, hopefully the players can then find an understanding of the exercise and then potentially move back into five presses afterwards, if they start to, to handle it better" (Coach F)

This evidences that both the coach and the athlete/team constitute the learning environment, as the coach must always be aware of the evolution and progression that the team makes (Pol *et al.,* 2020). This significance of this co-adaptive process outlines that as a team develop, the coach should re-design learning environments that suitably reflect the diversification of movement solution at both individual and collective levels of organization (Hristovski, 2010)

Coaching Philosophy

Coaches as individuals all have their own personal set of views when it comes to understanding learning and coaching. These views are developed over time through the practical and educational (i.e., coaching courses, university courses, coach CPD days) experiences of the coach (Cassidy *et al.,* 2009). The set of views developed by the coach, has been hypothesized to underpin the behaviour and actions during various coaching responsibilities (i.e., session planning, coach behaviour, coach-athlete interactions; Cushion, 2006).

The coaching philosophy as defined by Lyle (1999) is known to be a "comprehensive statement about the beliefs and behaviours that will characterize the coach's practice. These beliefs and behaviours will either reflect a deeper set of values held by the coach or will be the recognition of a set of externally imposed expectation to which the coach feels the need to adhere" (p.28). Jenkins (2010) builds on this definition and describes the coaching

philosophy to be built of beliefs, principles, and values that helps guide coaching behaviour and the characteristics of coaching practice.

All coaches outlined how their coaching philosophy was aimed at building athletes holistically, but to also ensure that the needs of the athletes came first, and each athlete was put in an environment where they can have autonomy of their own learning through problem solving.

> *"So my postgraduate studies looking at sort of ecological dynamics, which sort of underpins the constraints that approach which both inform my view of coaching, and in that sense that the coach is only there as a facilitator, to try and guide players to better themselves, rather than maybe a traditional old school view of the coaches leading everything, and they're in charge of doing everything, and they're in charge of telling the players what to do. So, in terms of that went to my friend, how it relates to my philosophy, my independent belief there leads to my philosophy that players should have as many opportunities and training to solve problems themselves. And as a result of that, is always going to be sort of there for the players, if that makes sense. So, it's not a case of is it for me or is it for the players? My kind of philosophy is all about the players anyway. So, my kind of philosophy does encompass the player's needs, if that kind of answers your question around that kind of way."* (Coach A)

> *"I think, I've never really sat down and thought about what, you know, for me as a coach, what my philosophy is, but I think that I have a philosophy about what I'd like a team to be like. And I think, for me, that's, you know, a culture where the players understand what's expected of them. And they uphold those values. They're a team that works together. Well, I think we always talk about them being, there's always this thing of being friends, but I don't think that's always can happen in a team. But I think that they're together, and they look out for one another. And then I think in terms of playing, I like players to be able to make decisions on the pitch. I think that's a key part of my philosophy. I don't like it to be a reliance on Me as a coach, you know, what are we going to do here? Well, I can have a bit of tactical input, like, we need to change this or change this."* (Coach B)

Another coach also emphasized that his coaching philosophy ensures the enjoyment of his athletes:

> *"So, it's an interesting one. So, enjoyment is, is one of the main things man, I do believe that all the way through from under 7s grassroots to 1st team football, which should be an enjoyable environment, how that looks, has kind of changed a bit, this isn't going from the foundation phase to the youth development phase. It's quite a high-performance environment. So not to not become more of a serious coach, I've kind of maybe had to had to sort of change the way I coach just slightly. And obviously, it is an older age group as well. You know, so that's, that's been an interesting challenge this season. But yeah, it's a lot of it is, you know, player development layers, you know, massive into developing individual getting to know*

the individual as well. You know, so yeah, my philosophy is definitely sort of player orientated in, you know, making sure that the player is the center of attention definetly not the coach." (Coach C)

Another coach suggests that the effectiveness of a coaching philosophy is dependent on the ability of the coach to create engagement from the athletes:

"The first thing on top of my philosophy will be the person. That's, the top thing in my philosophy. So, it's the person, everything else is under that. Because I don't feel that unless you can engage with people with unless you can, to understand how they're motivated. You don't get anywhere anyway. So, you can have the greatest football philosophy in the world. But if you can't communicate, if you can't engage people, if you can't get them to do things that you want them to do, then it's not going to happen." (Coach D)

Although a coaches' philosophy doesn't directly change the way synergies are formed, it changes how the coach will view learning and the design of a team environment. A coach's philosophy, values and beliefs further dictate the way in which coaches may interact with the learners. Concepts such as high levels of enjoyment, posing challenging tasks, appealing towards the intrinsic motivation of the athletes are all associated with the development of a mastery climate (Carpenter & Morgan, 1999; Goudas & Biddle, 1994; Treasure, 1997). By adopting a caring pedagogy (i.e., valuing the individual, being tolerant of mistakes, encouraging and supporting behaviour) all affect the way in which athletes will apply themselves in terms of conduct and commitment when participating in training or games (Whitehouse *et al.,* 2015

Coaching Behaviour

During coaching sessions coaches must be aware about how their micro-level interactions can affect exploratory behaviours of the learners rather than prescribing specific solutions (Correria *et al.,* 2019). The interactions between both practitioner and learner through both verbal and non-verbal modes of communication play and important role within the changes of behaviour as they seek to optimize their performance solutions (Chow, Davids, Button, & Rein, 2008). Traditionally coaches are seen to be at the centre of the learning process, therefore are put into a position of power and influence over development and performance

of the learners (Cushion *et al.,* 2006, Smith & Smoll, 2007). Through the development of research, academics have created a systematic method to collect data when observing coaching behaviours (Smith & Cushion, 2006). Although not directly linked with the development of synergies, a focus on coaching behaviour is prevalent in this research project as it uncovers different ways coaches interact with the athletes, and in turn how the information from the coach can guide the perception and action couplings of athletes during their search for functional task solution and relevant performance behaviours (Newell, 1991; Handford *et al.,* 1997).

There have been a variety of ways to measure coaching behaviours. Smith *et al.,* (1977) developed a 'Coaching Behaviour Assessment System' (CBAS) which broke down coaching behaviour into 12 distinct groups based on reactive or spontaneous behaviours. The development of CBAS was to analyse coaches working in a youth development context, however, contemporary research has now shown that the CBAS is an outdated method as it does not account for the coaches planning and how they interact with others (i.e., conferring with assistants to make changes to the task; Cote *et al.,* 1999). To challenge the pitfalls of the CBAS, Cushion *et al.,* (2012) devised the 'Coach Analysis and Intervention System' (CAIS). CAIS divides coaching behaviour into 23 different specific groups within six broader groups. These groups are physical behaviour, feedback/reinforcement, instruction, verbal/non-verbal, questioning, and management. Typically, CAIS analyses are conducted through the use of special software and video recordings which is especially beneficial towards coaches as they can review and reflect not only on the proceedings of the session but also reflect on their own actions and the affects they had on the outcomes within training (Stratton *et al.,* 2004; Brennan & Gotz, 2008).

Instead of exploring all 23 different coaching behaviours stated within the CAIS, this section will focus on the more commonly exhibited behaviours such as instruction, feedback, questioning, demonstration, and silent observation.

Feedback

Feedback is a very important tool for a coach. Their ability to place augmented informational constraints can shape the way athletes go on and search for task solutions (Newell, Morris, & Scully, 1985). Using the CAIS model, feedback is broken down into; specific feedback, general feedback, and corrective feedback (Cushion *et al.,* 2012). Specific feedback relates to the information (positive or negative) provided by coaches on the quality of a specific skill (e.g., 'good clearance', 'poor pass selection, try something less risky'). General feedback is just short verbal statements or non-verbal gestures that can be applied concurrently to performance or after the performance but aim to get an overarching evaluation/judgment of the way the game was conducted. Lastly, corrective feedback aims to deliver athletes with information that will improve their next attempt at a certain skill (e.g., 'spread across the pitch, don't all stand in the same space', 'pass it earlier next time'.

Traditional views on feedback show that coaches use it to help develop movement templates and correct performance errors (Davids, Button, & Bennet, 2008). Through the use of nonlinear pedagogy, the role of feedback should educate the attention of athletes to better perceive affordance and utilize relevant information sources without explicitly telling them (Orth, Davids & Seifert, 2018). Furthermore, the specific nature of feedback can impact the performance solutions that can emerge (Chow *et al.,* 2016). If the feedback asks for attention to be focused externally (i.e., how the action changes the environment) or internally (i.e., how to execute a skill more effectively/efficiently; Wulf, Lauterback, & Toole, 1999). Renshaw *et al.,* (2012) further suggests that feedback that is placed externally helps support the inherent self-organizational tendencies within individual and collective systems.

Throughout the interviews, coaches mentioned how the use of video camera and recording technology aided in the identification and delivery of feedback:

"Link it into the classroom session and link into sort of a formations shaped thing, but you can also use it with individuals where you can maybe clip somebody can send it to them in terms of their IDPs and the outcomes they're trying to get and you know maybe sort of coaching around that to be honest so lots of benefits" (Coach C)

"I think so it's one thing is how you see the team play? And then what would you want from the perspective of the players? Where do they see the team? So I can think that maybe that that was actually good, or that was bad, and players can think, Well, I think I did the right thing or wrong thing. So I think, to bring both views so players & coaches view together, can give you a real eye opening experience, really. So looking at from coaches, so we can look at the game and kind of analyze it. Well, what do you think this play could have done better? So usually, after the game, I've watched it a few times, and then tried to focus on different things. So maybe I watch it once where we have the ball, and how we move the ball. And where I could pick the players be. So what I do is I write names under and then I put just few notes to everyone like what do you think this player could do better? Well, he did well, and then maybe on the next session, when I see him, I give him this point across, I think he did really well on Saturday would have been about when you if I could train that if it was something spectacular, or something that he could remember? Or maybe if I could generalize it, and then we are trying to call someone down? How could we approach him? So try to make these different notes about each player from the games which can bring which can change my coaching as you as you said, what how does it affect me as a coach, in terms of understanding of the players and what is needed for that development? And what do they should focus on?" (Coach E)

"We filmed the majority of our games using the video cameras. So I'll go back and watch that. Sometimes I watch it again more than once if I have to just watching specific players or specific sections of the team. And within that it's about identifying those performance problems that I spoke to you about. And then coming up with how do we train those within those preferential simulating situations? And how can I give information to the players before we go out on the pitch on the Wednesday," (Coach F)

When working in these classroom 'tactical' session, coaches use the video footage of game days to identify; a) individual mistakes or individual praise, b) successful application of their principles of play, and c) create development plans for individual(s) or the group.

Observation

Although not thought to be a 'behaviour', observational skills must be essential for a coach's repertoire. Verbal interventions are all instructional constraints that can guide athletes down various path due on the differences in perception from person to person (Davids *et al.,* 2012). When coaches tend to be vocal in their sessions, it can at times 'over-constrain' the

practice by not giving players enough time to explore different methods of achieving the same goal and find a method that can solve a variety of problems (Correria *et al.,* 2019). Observing also allows coaches to reflect on the environment that they create to judge if the constraints that were implemented are successful in achieving the intended changes in behaviour.

Coaches explain that they have adopted a 'hands-off' approach during training sessions:

> *"So that means you're sort of observing the match. So obviously, you've outlined what the sort of session plan is and how it works, and then the on test and you just step away and watch, you don't say anything. So in terms of possibly building that autonomy within the players, that might be quite beneficial, if that was the focus of the session." (Coach A)*

> *"It depends, really, I think it depends on what I want to be to be happening, I think you have to be hands off in the sense of giving them the time to try things. But I think sometimes if the energy isn't there, or the there's something that's happening, that is not what is right, you would hope that the players pick up on that.and then I think I'm probably more hands off than I should be. I usually tend to wait for the breaks in play to talk. But I think sometimes I've noticed that it's maybe a good time to stop the practice, obviously, not straightaway, but three, four minutes in and maybe unpick a decision in real life like is in the immediate context. So it's fresh in their minds, they've all seen it. So for instance, a player's continually not able to connect to the next layer. Okay, well, we might need to stop the game and explain that, you know, this is happening, we need to sort of address this." (Coach B)*

Instruction

Traditional pedagogical practice assumes the role of instruction to be descriptive and prescriptive. Coaches will provide a detailed explanation to learners about desired movement outcomes or performance solutions within specific contexts in hopes to create 'common optimal actions' (Davids, Button, & Bennett, 2008). In typical coaching settings, there is an over-use of verbal instructions as coaches tend to believe that it is the best way to support the athletes in any skill bracket (Correria *et al.,* 2019). Understanding nonlinear pedagogical approaches, it views verbal instructions from coach to player as a constraint in itself as it relies on the ability of the player to properly digest the information provided (Newell & Ranganathan, 2010), however, the role of instruction can be very useful to coaches provide they use it to help athletes explore various solutions and guide actions and

intentionality during problem solving activities (Chow, Davids, Button, Renshaw, Shuttleworth, & Uehara, 2009).

Many coaches showed a general avoidance of instruction wherever possible:

> *"To me learning takes place more there than it does if I'm directly telling them What to do. So in that sense, they're only copying and mirroring and imitating, for the sake of, for the sake of my praise or just for the sake of that's what they've been told to do, as opposed to actually act in a certain way or behaving a certain way, because it's the right thing to do, sort of I receive, if I'm telling my athletes to do certain things, what I understand there is a context and a point in time for that, trying to tell them athletes to move in a certain way or do things in a certain way, I think I'm probably inhibiting their problem solving ability, in the sense that there's no room for creativity. And yet, they may not be able to actually execute what I'm trying to tell them to do."*
> *(Coach A)*

> *"But I'll be driving the tempo with a voice given instructions quickly, and putting them under sort of, almost like a fatigue almost like a mental fatigue, because I'm always at them, and always demanding more, but I'll drive it for short periods. So we'll go really quick for maybe like 90 seconds, and then we'll stop and slow it down." (Coach D)*

> *"So instead of if he has that pass on, and you tell him to pass that ball, for example, we can see that in the grassroots team or from parents shouting on a sideline, I would call it PlayStation coaching. So shoot pass. And what this creates is you tell the player, the answer, and you tell him what to do, instead of really letting him decide for himself. In a short term, it might not go well, in terms of he might struggle at the beginning. So sometimes you just need to find a balance where you actually need to give him a bit of help and actually tell him both you had these options were what do you think which one was the best? But depending on the individual, it's also important to know where you should kind of back out and not really give him the answer. So, if I could give an example, we had a player who was supposed to take a free-kick, and he, he, he took put the ball down. It was quite far from the box, and he wasn't sure what to do. So he came to the sidelines, as he was closer. And he asked us, What should I do? And at this point, I was really kind of what should we? Or should I tell him? And I said decide. So I told him to kind of you decide like, what are we going with is the right option? Or in terms of, I didn't want to give him the answer. So I was encouraged to, you know what to do in terms of where could you pass it? Should he cross it should he shoot? So I really wanted him to take that ownership and more responsibility of his decision." (Coach E)*

> *"So is I'm not necessarily telling him, I'm not laying down a star like on The X Factor on the stage and even stand on here, I'm sending him judge the distance between you and that center back, and when I notice that he's not judging that distance correctly. I'm not necessarily saying he's too close to him, obviously, in that case, he was, I'm just saying you're not judging the distance correctly, the judge better according to where the ball is. And so he will judge that. And that, in itself is a synergy between my information telling him and him taking that on board. And then his synergy with the rest of the players determining well, if that's my sense of about partners, here, are my midfielders here and the ball is there. He's then creating the*

synergy of all of those players and the ball included to some extent. And what I've told him to then create our tactic of what the actual shapes going to look like on the game. So yeah, the tactics are the synergies between the way the way the players carry out and realize the principles that I've given to them in every given match."
(Coach F)

Coaches use instruction, but only when introducing new tasks to players:

However, if we're working on something new, so if we start a new block of training, for example. So for example, tomorrow, I might have to provide them with a bit more direct feedback, for example, I believe that's the not sure if that's the correct phrase, but a bit more sort of feedback in or direct instruction rather, to sort of get them to initially understand sort of global idea of what I'm trying to get them to achieve.
(Coach A)

Demonstration

Demonstration is the use of a visual model (coach or player) that assists in the mental development and representation of how a skill or movement pattern can look like (Bandura, 1977). Although demonstrations can restrict the exploratory search for affordances within an environment they are still equally as useful for attuning athletes to the affordances that are relevant to the task (i.e., session intention). Demonstrations are particularly useful when athletes are exposed to problems or tasks that are deemed to be unfamiliar for them, and a demonstration into what the coach decides to be 'ideal' solutions helps model similar behaviours which can be built on through consistent training (Correria *et al.,* 2019).

Coach F gives examples on a time that he may use pre-existing footage of possibly professional players to help mould the specific behaviours within a group or an individual :

So in a better word I don't want them to learn the exercise, I want them to learn the game. And so that's what the aim of that tactical session is to do. And that will be supplemented by my own ideas of what we could do better or where the optimal position of a certain player might have been instead of where they were. And then I try my best to source other videos, be it from professional teams or from any other sources I can find, other teams that have filmed games that I've got access to. To supplement footage of our past games, and then the two of them together will work to deliver this. I guess you could say optimization of the team's tactics.So our left side, the center that would be out here on the touch line, our other centerback would be here, the center one, and then the other one would be here when he should have been out here like this one. And we've got them there with the one in the middle connecting the two. And so that was a simple case of telling him rather than being here, you've got to be here. And we showed him that on the on the video. And that

supplements when we go out on the pitch now he knows which position he's got to take up, so the practice will work effectively to achieve what we want to achieve. (Coach F)

Questioning

Questioning is a great tool in the arsenal of coaching behaviours. When used in the micro-structures of practice it can guide and prompt the learners to the answers to solve problems posed within the playing space. Chow *et al.,* (2016) postulate that when coaches employ a 'guided discovery' style to their coaching. For example coaches during football training or games can pose questions to players near the touchline (e.g., what space are you occupying when out-of-possession?, what can you do to create more space so you can receive the ball?, etc…). Further referring to the CAIS behaviours, questions can be both convergent and divergent within their natures (Cushion *et al.,* 2012). Convergent questions are usually closed questions that feature a limited number of *correct* options (i.e, do you understand what I have asked you to do?, is the best pass out to the flank or into the centre?), and divergent questions tend to be more open-ended that and illicit a more in-depth response (i.e., when can you press the ball?, how can you help team-mates who are out of position?; Cushions *et al.,* 2012).

Coaches pose questions to athletes to promote individual exploratory behaviour:

So that kind of in effect, come on, just come around to answering the questions around what kind of way and the fact that if they're having the opportunity to learn themselves, and figure out problems for themselves and sort of encouraged in a certain way to act in certain ways. (Coach A)

"I've tried to go more Guided Discovery and Q&A in terms of what you know what to do there, what what might you've done differently, rather than going out as a right, you know, your body shape was wrong, you know, you need to do this, you need to do that. But yeah, those those little chats and try to sort of get the players to come up with the answer themselves rather than me having to tell them the answer, I think that's natural is massive when you can see players make those light bulb moments. Hopefully, they can make them without you. You know, you can see, for example, they're one v one defender, and they've shown them into the, towards the goal when they need to be shown into a wide area. And you know, you might hope that they might be able to correct that themselves, but if they don't, then you might want to go

in and have a quick chat with them. And hopefully then, you know what, why would you show into that into that central area? And hopefully then they they get the answer themselves." (Coach C)

Questioning, therefore, allows coaches to manipulate perception-action to achieve a new performance goal or to refocus attention toward the current intended goal (Seifert, Araujo, Komar, & Davids, 2017). In training scenarios, questions can be framed to divert the direction of exploration towards another affordance to enable adaptability in movement solutions (Davids, Bennett, & Newell, 2006).

<u>Limitations</u>

Due to the COVID-19 pandemic, there were a few difficulties retaining participants as schedules constantly changed to accommodate illness or busy professional lives. Originally, this study had interest registered from more participants (~ 10), but through withdrawal of participation and time constraints, restricted the project to 6 participants. With the sample size being relatively small and recruiting participants local to the author means that is difficult applying the results across general populations external to this study, however, some believe the aim of qualitative research is to create recognizability. Delmar (2010) notion of recognizability discusses the need within qualitative research to account for the varying real-world contexts, and by creating recognizability within a data set, coaches external to this study can view the decisions, actions and contexts of the participants and find similarities within their own contexts. By doing so, coaches can use the experiences of those within the study to inform and reflect on their own coaching practices. Furthermore, this paper provides a good stepping-stone for future research that can qualitative analyses coaching impact on collective behaviour.

Implications for Future Research

Currently, research regarding synergistic behaviour and synergies, in general, tend to fall under the scope of quantitative research as they go to measure the physical properties of human movement (i.e., team dispersion, team centre) through the use of cluster phase analysis (refer to Goncalves *et al.,* 2018). Although this information is useful for coaches, it falls under the department of performance analysis, with many coaches unable to process the data.

Future research in this topic should look more closely at the role of the coach and how they can be more aware of synergies within their teams. To investigate this, I propose a longitudinal study with coaches that observes their behaviours to blocks of coaching session to understand how they use language to communicate with their athletes, as well as how do they create training sessions that continually develop various tactical principles that align with their 'ideal' way to play.

Conclusion

To fully investigate the research question of "How does a coaches behaviour influence collective behaviour in team sports," the project investigated synergistic behaviour through coaches practice design and delivery, as well as the coach athlete interactions. A lack of academic literature (to the authors knowledge) explicitly links the use of various coaching behaviours and the development of synergies in sports (i.e., hockey, football). The feedback and coach-athlete interactions can affect the perception of the learner as they may search or be attuned toward different affordances (Davids, Button & Bennet, 2008). By adhering to ecological principles, representative practice design and appropriate feedback strategies the coach can build learners' knowledge *about* various footballing principles (i.e., formations, tactics, positional constraints) as well as developing familiarity within the formation and principles applied to the team. Therefore, it can be argued that the coaches' behaviours and

how it leads their interactions amongst athlete can change the way in which they go about interacting within learning and performance environments, thus manipulating the way in which athletes may co-adapt to teammates' behaviours or even self-regulate their own actions.

The main findings of this study showed that the coaches within this samples effectively used video recording technology (i.e., cameras, drones, GoPro) to reflect and analyse the performance of the team (i.e., team shape, player positioning, performance outcomes) and to generate feedback 'reports' for the group and/or specific individual feedback. Traditional pedagogies have always been focused on the use of instruction, however, within this sample, coaches expressed the use of a more "hands-off" approach that allows the athletes to be more exploratory within their learning, thus uncovering multiple solutions to a single problem, instead of prescribing a single solution to varying tasks. Furthermore, the way in which coaches structure their training sessions (using training blocks that focus on complementary principles of play) can also suggests that coaches view synergies to develop over longitudinal periods of time.

Recommendations for current practitioners

A recommendation for current coaches that may be reading this paper is to use the findings within this study as a tool for reflection, and a tool to compare your own training environments to those of the participants. To simplify the results section, below are a few recommendations for current practitioners to consider when planning and delivering training sessions.

- Careful task constraints manipulation can direct athletes to couple action with perceptual information to achieve goal-directed behaviour
- Task constraints must be implemented in alignment of the strategic game model defined by the coach – this allows training sessions to be more representative (competition-like)

- Encouraging exploratory behaviour through the use of open language (i.e., questioning and praise) can increase athlete interaction with designed environments

- The development of synergistic behaviour is longitudinal. Coaches should utilize training blocks that can tackle similar training principles/objectives through different training methods.

With these recommendations it is hoped that coaches will further develop their understanding of the environments that they are putting their learners through as it is vital that the learning needs of the athletes are met while staying aligned to the club's vision for success.

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Appendix 1 – Ethical Approvcal from DREC/Faculty Research Ethics Committee (FREC) at Oxford Brookes University

Oxford Brookes University

Faculty of Health and Life Sciences

Decision on application for ethics approval

The Departmental (DREC)/ Faculty Research Ethics Committee (FREC) has considered the application for ethics approval for the following project:

Project Title: A rationalization of coach behaviours and its impact on learning and changes of synergistic behaviours within semi-professional football

DREC Ref: 0721_01

Name of Applicant/s: Kabir Bubna
Name of Supervisor/s: Dr Adam Bibbey, Dr Matt Fiander

Please tick one box

1.   The Departmental Research Ethics Officer / Faculty Research Ethics Committee ☐
        gives ethical approval for the research project.

        Please note that the research protocol as laid down in the application and hereby approved must not be changed without the approval of the DREO / FREC

2.   The Departmental Research Ethics Officer / Faculty Research Ethics Committee   **X**
        gives ethical approval for the research project, subject to the
        following:

        Provision of gatekeeper letters before data collection commences.

3.   The Departmental Research Officer / Faculty Research Ethics Committee   ☐
        cannot give ethical approval for the research project. The reasons for
        this and the action required are as follows:

Signed: Approval Date: 11/08/2021

Designation: Departmental Research Ethics Officer

(Signed on behalf of the Faculty Research Ethics Committee)

A Mitchelmore

Date when application reviewed (*office use only*): 11/08/2021

Appendix 2 – Coach A Coded Transcript

Q: Okay, so moving on into the first question, if I was to give you the term synergistic behavior, what would that mean to you?	
Coach A: Great question. I think if you use the word synergy itself, that means kind of sort of all in order and working together. So I guess synergistic behavior or possibly look at the way that team or players within the team can sort of interact and interrelate in a way which is effective for that team, or that those group of individuals at one point in time	A coach's definition of synergies - Linking units - Context dependent
Q: What would you say the definitions of synergy and teamwork are different in your eyes? Or would you say they have quite a big overlap?	
Coach A: It's a good question. I guess they are inherently interrelated with each other can mean different things depending on your understanding of it. So I think, with the synergistic behavior, kind of gives birth to teamwork. And if you had, for example, one group who weren't behaving in a way that was, in a way that sort of resonated with the definition of synergistic behaviors, that team possibly would look from an outsider's point of view, they've got less teamwork involved in that group of individuals.	Synergies = Teamwork?
Q: Okay, and then, in a more general, generic term of the sense, what does synergistic or synergies look like in your in your sport.	
Coach A: So, football being my sport, it looked like so the pattern of play that you're trying to execute. So, for example, in my group, we have to sort of play through it involves the false nine dropping into the pocket and involves a pass into that individual. But once that passes, also going on, it looks like a winger, running gone into the space created by the false nine, who will then see if the past turn received the ball pass into that window moving on, into the space that he's created. And by dropping into the pocket, so quite a few moving parts to sort of execute a plan. And then if you're looking at more of a remote state, and more stable scenario, in terms of set pieces, and you're looking at sort of certain players moving in, in sort of set ways to create space for corner ball to be played in to an individual, but in theory, if the behavior has been correct, and synergistic, that player should be free to receive the ball unmarked.	Certain movement patterns are more desirable Understanding reciprocal compensation – how does x players movement affect consequent movement behaviors of other agents within the system Synergies are formed within larger sequences/patterns of play?
Q: So is this something you put an emphasis on during your coaching sessions? Or is this something you let grow organically?	
Coach A: it's something that I put quite a bit of focus on whether it be explicitly or implicitly kind of depends. Both of which have been covered in the sessions so in a sense that I've said that well for this to work X,Y, & Z that needs to happen. So, going back to previous concepts of false nines dropping the winger needs to make that run. The passes have got to be played into his feet early on and off as quickly as possible. So	Coach explicitly informs tactical outlook/formation to provide structure for the team, but allows them to explore the various

	means of execution.
that's kind of explicitly laid out. So it's kind of focused on their wares sort of from an implicit point of view, the sessions that I've designed and the problem they've got to solve in their sessions has kind of been set in a way that they have to execute those, or move in that certain way to sort of solve the problem in training. And so, in that sense, it's bit more implicit sometimes. Q: So you talk about your explicit & implicit actions are when it comes to your coaching, is this is all down to how you plan? Coach A: ==Yeah, however, when it comes down to planning, and having a clear session, aim or second intention, and what you want to work on, that, obviously, is builds upon the foundations of how you want the team's play, and then sort of wants that, that Sessions ongoing, it's kind of been able to recognize what behaviors going on at that moment in time? And is that in line with the sort of the end of the session?== Is that sort of been in line with how we want the team to play? And are we seeing the behaviors that we're not what we want to see? And then if we're not seeing those behaviors, then what can we do differently? Q: So then what influences your planning. So let's say coming to after a game day, how do you plan your next week's of sessions? What are the contributing factors? What are key influence influences that the help you make a decisions into what sessions you'll create for your, for your players. Coach A: So I think in the past, I'd been sort of guilty of sort of firefight coaching, and sort of by that, I mean, just trying to solve the problems week by week. So for example, if we played one week, and there was x problem, which next two training sessions, we'll be focusing on X problem. And sort of I did that last year and didn't see as much development of how we wanted to play it, it's a lot of light to have done. So this year, the emphasis on the start the season till Christmas, is that we're going to play in a certain way. So regardless of what matches or how we performed on a Saturday, most of the focuses on training on Mondays and Wednesdays will be on what that initial goal was at the start of the season, if you try and get them to play in a certain way, and sort of different working on the different aspects of that over sort of longitudinal period of time. And sort of, and then obviously, if there are a couple pressing matters, or urgent matters that need to be covered, we'll try and cover them a little bit. But it all kind of stems from sort of a macro or the global view of how we want the team to play rather than a sense of attending to issues week by week, whilst obviously still having based off their importance to play.	Clear session intention = frame of reference for players & coaches. Coaches try to predict how certain training situations will affect athlete behavior. Synergistic behavior is developed longitudinally Changing training sessions to combat performance deficits can cause confusion for athletes Constant exposure to new and unfamiliar environments can be detrimental to player development