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Headrick, Jonathon, Renshaw, Ian, Davids, Keith, Pinder, Ross, & Araujo, Duarte
(2015)
The dynamics of expertise acquisition in sport: The role of affective learning design.
Psychology of Sport and Exercise, *16*(1), pp. 83-90.

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https://doi.org/10.1016/j.psychsport.2014.08.006

The Dynamics of Expertise Acquisition in Sport: The Role of Affective Learning Design

Jonathon Headrick [a, b], Ian Renshaw [a, b], Keith Davids [c, f], Ross A. Pinder [d], Duarte Araújo [e]

[a] School of Exercise and Nutrition Sciences, Queensland University of Technology, Victoria Park Road, Kelvin Grove, QLD 4059, Australia

[b] Institute of Health and Biomedical Innovation, Queensland University of Technology, Musk Avenue, Kelvin Grove, QLD 4059, Australia

[c] Centre for Sports Engineering Research, Sheffield Hallam University, United Kingdom

[d] Australian Paralympic Committee, Sydney Olympic Park, Sydney, Australia

[e] SpertLab, CIPER, Faculdade de Motricidade Humana, Universidade de Lisboa, Cruz Quebrada Dafundo, Portugal

[f] FiDiPro Programme, University of Jyväskylä, Finland

Corresponding author details:
Name: Jonathon Headrick
Email: jj.headrick@qut.edu.au
Postal Address:
School of Exercise and Nutrition Sciences
Queensland University of Technology
Victoria Park Road, Kelvin Grove
QLD 4059
Australia
Phone:

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Abstract

Objectives: The aim of this position paper is to discuss the role of affect in designing learning experiences to enhance expertise acquisition in sport. The design of learning environments and athlete development programmes are predicated on the successful sampling and simulation of competitive performance conditions during practice. This premise is captured by the concept of representative learning design, founded on an ecological dynamics approach to developing skill in sport, and based on the individual-environment relationship. In this paper we discuss how the effective development of expertise in sport could be enhanced by the consideration of affective constraints in the representative design of learning experiences.

Conclusions: Based on previous theoretical modelling and practical examples we delineate two key principles of *Affective Learning Design*: (i) the design of emotion-laden learning experiences that effectively simulate the constraints of performance environments in sport; (ii) recognising individualised emotional and coordination tendencies that are associated with different periods of learning. Considering the role of affect in learning environments has clear implications for how sport psychologists, athletes and coaches might collaborate to enhance the acquisition of expertise in sport.

Keywords: representative design, affect, emotion, expertise, learning, ecological dynamics

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Introduction

In sport, performers must adapt to the constraints of dynamic performance environments, with commensurate variable conditions and situations, while performing under different emotional states that constrain their cognitions, perceptions and actions (Jones, 2003; Lewis, 2004). Despite the documented presence of emotions[1] in sport performance, thus far (see Vallerand & Blanchard, 2000), limited attention has been paid to the role that emotions might play during the acquisition and development of expertise. Traditionally, emotions have generally been viewed as negative and detrimental constraints on behaviour, considered better to be removed from practice task contexts until a skill is well established (Hutto, 2012). This reductionist approach to learning design is in line with traditional thinking in the acquisition of skill in which practice tasks are decomposed to putatively reduce the cognitive loading on performers as they attempt to enhance expertise (Lewis & Granic, 2000). Here we raise questions on the reductionist approach to learning design and discuss an alternate principled approach suggesting how affective constraints on behaviour may be included during the acquisition of expertise in sport, drawing on the theoretical rationale of ecological dynamics.

In existing research on movement behaviours, ideas from dynamical systems theory have been integrated with concepts from Gibsonian ecological psychology, forming the ecological dynamics approach to understanding performance and learning (Araújo, Davids, & Hristovski, 2006; Davids, Williams, Button, & Court, 2001; Warren, 2006). An ecological dynamics approach to enhancing expertise recognises the need for individuals to form mutual

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[1] The broad term of affect refers to a range of phenomena such as feelings, emotions, moods, and personality traits that interact over different time scales. Here affect will be used interchangeably with emotion to follow previous modelling of cognition, emotion and action (Lewis, 2000a; Vallerand & Blanchard, 2000).

functional relationships with specific performance environments during practice and training (Araújo & Davids, 2011; Davids, Araújo, Vilar, Renshaw, & Pinder, 2013; Seifert, Button, & Davids, 2013). In a functionalist approach to the study of perception and action, Gibson (1979) emphasised the role of the environment and proposed that an individual's movements bring about changes in informational variables from which affordances (invitations for action) are perceived to support behaviours (Withagen, de Poel, Araújo, & Pepping, 2012). As a result a cyclic process is created where action and perception underpin goal-directed behaviours in specific performance environments (Gibson, 1979).

Studying emergent behaviours and the acquisition of expertise at this individual-environment scale of analysis takes into account how perceptions, actions, intentions, feelings and thoughts continuously emerge under the constraints of information external and internal to the individual (Seifert & Davids, 2012; Warren, 2006). Humans, conceptualised as complex dynamic systems, exhibit self-organising, coordination tendencies during learning and performance to achieve specific task objectives (Kelso, 1995; Lewis, 2000b). The informational variables in a specific performance environment, along with associated goals and intentions, constrain how each individual behaves (Davids, et al., 2001; Freeman, 2000; Juarrero, 2000). Coordination tendencies (e.g., behaviours in human movement systems) that are stable are described as attractors (Kelso, 1995; Zanone & Kelso, 1992). Stable attractors are states of system organisation that represent well learned, stable patterns of behaviour (Kelso, 1995; Thelen & Smith, 1994). It is important to note that coordination tendencies may be functional or dysfunctional in terms of meeting the demands of a specific task, or during learning (Warren, 2006). Depending on the depth or stability of an attractor, changes in informational variables that act as control parameters have the potential to perturb (disrupt) coordination tendencies (e.g., Balagué, Hristovski, Aragonés, & Tenenbaum, 2012; Passos et al., 2008). Perturbations can lead to phase transitions in coordination tendencies, often producing changes in behaviour. Unstable system states correspond to a ‘hill’ above potential ‘wells’ where coordination tendencies may be variable and possibly less functional (Kelso, 1995; Vallacher & Nowak, 2009). Unstable system states are more open to influence by changes to informational variables both internal and external to an individual during performance (Davids, et al., 2001). Through practice and experience in sport, athletes, considered as dynamic movement systems, can learn to enhance stability of performance behaviours and increase their resistance to perturbations, including negative thoughts, and emotions (e.g., differences in ice climbing performance between experts and novices, see Seifert, Button, et al., 2013; Seifert et al., 2013). An important question for sport psychologists and coaches concerns how practice programmes can be designed to provide athletes with learning experiences that help them to exploit functional coordination tendencies (i.e. system states which are stable yet adaptable) under the affective constraints of sport performance.

Ecological dynamics is an integrated theoretical rationale of human behaviour that can underpin a principled approach to learning design in clinical (Newell & Valvano, 1998) and sport performance environments (Araújo, et al., 2006). The basis of behavioural change through learning involves the systematic identification and manipulation of system control parameters (informational constraints) to perturb stable states of organisation and facilitate transitions to more functional system states (Kelso, 1995, 2012). Attractors can take the form of intentions, and/or goals that a performer is 'attracted to' following changes in values of system control parameters (Davids, et al., 2013; Davids, et al., 2001; Warren, 2006). Stable system states often represent desired forms of organisation that are functional. Enhanced functionality, i.e. ‘what works’ (see Thelen & Smith, 1994), is achieved when an athlete establishes a successful relationship with a performance environment and task goals are achieved (e.g., through more accurate or faster performance outcomes). Simultaneously, functional coordination tendencies can satisfy the psychological needs (i.e. ‘what feels good’) of each individual performer in particular performance situations (Carver, Sutton, & Scheier, 2000; Hollis, Kloos, & Van Orden, 2009; Lewis, 2004). In order for a behavioural attractor to become stable through learning, the intrinsic dynamics (the predispositions and tendencies) of each performer and the task dynamics (e.g., specific performance requirements) must converge (Davids, et al., 2001; Zanone & Kelso, 1992). The relative stability of behavioural attractors is important to facilitate achievement of successful performance at specific points in time. But, learning environments also need to be dynamic and variable to allow an individual to adapt to changing individual, task and environmental constraints over the short and long time timescales of development (Lewis, 2002; Newell, 1986). A key task for sport psychologists and practitioners is to understand how to effectively manipulate constraints to facilitate the development of new behavioural attractor patterns essential for expertise acquisition.

Sport psychologists have begun to identify control parameters to design effective learning environments that are carefully matched to each individual’s intrinsic dynamics, or predispositional behavioural tendencies. Carefully designed learning environments can guide athletes towards *metastable* performance regions, in which a functional blend of coordination stability and adaptability can result in rich behavioural solutions emerging (Hristovski, Davids, Araújo, & Button, 2006; Pinder, Davids, & Renshaw, 2012). Metastability is a state of partial organisation where a system ‘hovers’ in a state of dynamic stability, switching between functional states of organisation in response to changing constraints, and displaying subsequent behavioural flexibility (variability, instability) (Fingelkurts & Fingelkurts, 2004; Phillips, Davids, Araújo, & Renshaw, 2014). Metastability allows a system to transit rapidly between co-existing functional states of organisation, essential for adaptive performance behaviours in dynamic environments (Chow, Davids, Hristovski, Araújo, & Passos, 2011;

Kelso, 2012; Kelso & Tognoli, 2009). During learning events in specific performance environments, being in a state of metastability allows performers to discover and explore performance solutions (Kelso, 1995; Seifert, Button, et al., 2013). In sport, empirical data has revealed how locating samples of boxers and cricketers in metastable performance regions during practice helped them to explore and exploit rich and creative performance solutions to achieve their task goals (Hristovski, et al., 2006; Pinder, et al., 2012).

Adopting novel and potentially functional states of system organisation is a consequence of learning and/or development, as individuals transit from the ‘known’ to the ‘unknown’, i.e., moving from a familiar task or situation to one that is new or different. Of interest to sport psychologists is the fact that increases in movement variability during phases of learning are often accompanied by increased intensity and range of emotions (Lewis, 2004). These emotions can be attributed to: (i) the challenges of learning a new movement pattern; (ii) the perceived risk of failure to achieve specific performance outcomes; and (iii), the underlying uncertainty and/or excitement associated with performing in an unknown situation. Observable changes in behaviours and emotions of athletes are of importance since they can act as predictors for potential phase transitions in system behaviours, such as coordinated movement response characteristics (Chow, et al., 2011; Kelso, 1995). The theoretical rationale of ecological dynamics suggests that it is essential to design learning environments that guide athletes towards metastable regions of a perceptual-motor workspace during performance (physically and emotionally) to aid the acquisition of expertise in sport (Oudejans & Pijpers, 2009; Pinder, et al., 2012). In achieving this aim, an important challenge for sport psychologists and practitioners is how to design learning environments that successfully simulate key constraints of competitive performance environments in sport. Egon Brunswik (1956) advocated that, for the study of individual-environment relations, cues or perceptual variables should be sampled from an organism’s environment to be *representative* of the environmental stimuli that they are adapted from, and to which behaviour is intended to be generalised (Araújo, Davids, & Passos, 2007; Pinder, Davids, Renshaw, & Araújo, 2011b). The term *representative design* captures the idea of sampling perceptual variables from an individual's performance environment to be designed into an experimental task (Brunswik, 1956). Recent work has considered how the concept of representative design can be applied to the study of sport performance (Araújo, et al., 2006; Araújo, et al., 2007). Inspired by Brunswik's (1956) insights, the term *representative learning design* (RLD) has been proposed to highlight the importance of creating representative environments for learning skills and developing expertise (Davids, Araújo, Hristovski, Passos, & Chow, 2012; Pinder, et al., 2011b).

Previous empirical work on RLD (Pinder, Davids, Renshaw, & Araújo, 2011a) has focussed on visual information provided during practice in training environments of elite athlete programmes (Barris, Davids, & Farrow, 2013), and changes to the complexity of organisation in tasks for practising passing skills in team games (Travassos, Duarte, Vilar, Davids, & Araújo, 2012). These examples advocate expertise acquisition by nurturing the relationship between key environmental information sources and coordination tendencies of a performer in order for more adaptable and effective movement behaviours to emerge (Davids, et al., 2013; Phillips, Davids, Renshaw, & Portus, 2010). From this perspective the development of expertise is predicated on the accurate simulation of key performance constraints during practice/learning. This approach differs from traditional methods of decomposing tasks to isolate individual components, in order to manage the information load confronting learners (Phillips, et al., 2010; Pinder, Renshaw, & Davids, 2013).

An aspect of RLD that needs attention in future conceptualisation of learning and practice is the role of affective constraints on behaviour (for initial discussions see, Pinder, Renshaw, Headrick, & Davids, 2014). In sport, performers need to be able to adapt to task constraints while performing under differing emotional states induced in competitive performance that can influence their cognitions, perceptions and actions (Jones, 2003; Lewis, 2004). Previous work investigating affect in sport performance has tended to focus on capturing the emotions of athletes in 'snapshots' of performance at one point in time, such as before or after competition (for a recent example see Lane, Beedie, Jones, Uphill, & Devenport, 2012). Such an approach, however, has not considered how emotions might continuously interact with intentions, cognitions, perception and actions to constrain the acquisition of functional coordination patterns and the development of expertise. A holistic approach should consider task demands of learning environments and the dynamic psychological state of each individual learner as interacting constraints influencing behavioural (perception-action couplings), cognitive, and emotional tendencies (Davids, et al., 2013; Newell, 1986). These ideas suggest how sport psychologists and practitioners may seek ways to sample the intensity of emotionally-charged performance conditions in learning environments and practice simulations. To address this issue, in the following sections of this paper, we will discuss why and how emotions could be incorporated into representative learning designs to enhance acquisition of expertise in sport.

Affective Learning Design

Yet to be seen in the literature is a principled exploration of the role of emotions in developing expertise in sport (Pinder, et al., 2014; Renshaw, Headrick, & Davids, 2014). The role of affect in developing expertise might be harnessed by adhering to two principles: (i) the design of emotion-laden learning experiences that effectively simulate the constraints and demands of performance environments in sport; (ii) recognising individualised emotional and behavioural tendencies that are indicative of learning. These principles suggest, two complementary perspectives on *Affective Learning Design* (ALD), linking the development of representative learning designs with the identification and recognition of individual behavioural tendencies exhibited while learning.

Benefits of creating emotion-laden learning events have been demonstrated within the psychology literature. Emotions influence perceptions, actions and intentions during decision-making, with the intensity of emotion generated reflecting the significance of stimuli to an individual, shaping the strength of the response on the visual cortex (Pessoa, 2011). Emotion also acts to strengthen memories (positive or negative) and produces greater engagement in ambiguous, unpredictable, or threatening situations when individual and group goals are influenced (e.g. learning when failure might have significant consequences such as non selection for a team, or a team failing to qualify for a future event) (LaBar & Cabeza, 2006; Pessoa, 2011).

Despite these proposed benefits, the role of emotion in the pursuit of expertise in sport has often been neglected (or removed) during practice because emotion-laden responses are traditionally considered irrational or instinctive, and therefore perceived as a negative influence on action (Hutto, 2012). A neglected issue is that a significant constraint in competitive performance environments is the emergent emotional tendencies of each individual. Therefore a key question is, how can individuals be supported while exploring and exploiting emotional constraints when learning to perform in competitive performance environments? Emotionless responses made from a purely informational stance have been described as ‘cold cognition’, and emotion-laden responses as ‘hot cognition’ (Abelson, 1963). The expression of ‘sit on your hands’ in relation to choosing a move in a game of chess exemplifies a traditional view that it is necessary to suppress or remove emotions in order to make more rational decisions (i.e. cold cognition) (Charness, Tuffiash, & Jastrzembski, 2004). However, during competitive performance in sport, athletes are often not afforded this ‘thinking’ time and need to be able to act immediately based on the initial, fleeting interaction between their perceptions of the task and pre-existing physical, cognitive, and emotional capabilities (Davids, 2012). This performance capacity has been referred to as ‘ultrafast’ behaviours (Riley, Shockley, & Van Orden, 2012).

Progress in understanding emotions during learning has also been limited by a tendency towards traditional linear thinking, where cognitions related to events are considered to result in preconceived emotional reactions (Lewis & Granic, 2000). Some psychologists have recently begun to acknowledge the advantages of considering humans as complex, highly integrated dynamical systems in explaining emergent behaviours (Lewis, 1996; Lewis & Granic, 2000). From this approach cognition and emotion are considered to constrain each other interactively (similar to processes of perception and action), with cognitions bringing about emotions, and emotions shaping cognitions (Lewis, 2004). This cyclical interaction underpins the emergent self-organisation of cognitions and emotions experienced during task performance (Lewis, 1996, 2000a). Established emotional experiences represent stable patterns of behaviour that are formed when emotional and cognitive changes/responses become embodied in behavioural tendencies (Lewis, 2000a). In other words, intertwined emotions, cognitions, and actions can become stable, characteristic responses to particular experiences (Lewis, 1996, 2004). In this line of thinking, affect, cognition, and behaviours exhibit self-organisational tendencies to underpin characteristic performance responses, and shape the intrinsic dynamics of an individual (Davids, et al., 2001; Schöner, Zanone, & Kelso, 1992). For example, in the development of personality, trait-like behaviours, thoughts and feelings become predictable, stable responses of an individual under certain performance conditions (Lewis, 1996).

During the development of emotional interpretations, changes in performance constraints may lead to metastable periods where an individual could rapidly transit towards one of a ‘cluster’ of possible cognitive-emotive states (Hollis, et al., 2009; Lewis, 2000b, 2004). When in a metastable performance region (for example during learning), behavioural tendencies of an individual would be expected to fluctuate (exhibit increased variability) until a more stable state of behaviour emerges (Chow, et al., 2011; Hollis, et al., 2009). Accompanying this variability in performance behaviours, variable and individualised emotional responses also emerge (Lewis, 1996, 2004). Much like movement variability, emotion during learning (and performance) has previously been considered as ‘unwanted system noise’ (Davids, Glazier, Araújo, & Bartlett, 2003; Smith & Thelen, 2003). An ecological dynamics approach questions this assumption, suggesting that the presence of emotion during learning is indicative of a performer being engaged in task performance as they seek to utilise available affordances to satisfy their intentions and goals (Jones, 2003; Seifert, Button, et al., 2013).

For example, gymnasts attempting routines on balance beams of increasing height have been found to display performance decrements, elevated heart rate, and increased prevalence of perceived dysfunctional emotions (e.g. reporting feeling nervous or scared) particularly on a first attempt (Cottyn, De Clercq, Crombez, & Lenoir, 2012). Similarly, comparisons of performance during climbing traverses, identical in design but differing in height from the ground, have revealed that higher traverses increased anxiety, elevated heart rates, lengthened climbing duration, and increased exploratory movements in climbers (Pijpers, Oudejans, & Bakker, 2005). Such findings highlight the intense emotions often involved with moving out of a ‘comfort zone’ when confronted with a new or more challenging task. This idea can also be interpreted through work in cybernetics where individuals are viewed to adapt to situations until reaching a critical point where they must undergo a shift or reorganisation to maintain effective action and emotion characteristics (see, Carver & Scheier, 1998, 2000; Carver, et al., 2000).

A relevant body of work has investigated the potential advantages to learning outcomes when training under pressure and the constraints of induced performance anxiety in a range of tasks (Oudejans, 2008; Oudejans & Nieuwenhuys, 2009; Oudejans & Pijpers, 2009, 2010). This work focused on the task constraint of anxiety and training under pressure, with findings providing clear implications for developing context-specific expertise by acknowledging the role of emotions in learning. For example, in a dart throwing task participants who trained under the task constraint of mild anxiety were found to more successfully maintain their performance levels in high anxiety conditions, compared with those who trained in low anxiety conditions (Oudejans & Pijpers, 2010). In this case anxiety was manipulated by positioning dart throwers at different heights on an indoor climbing wall (also see, Oudejans & Pijpers, 2009). Similar findings were revealed in a study comparing the role of pressure in a handgun shooting task involving police officers (Oudejans, 2008). Here the control group (low pressure) shot at cardboard targets, while a high pressure group shot at opponents who could fire back with marking cartridges. Prior to practice, the performance of both groups was found to deteriorate when switching from low to high pressure task constraints. After completing three practice sessions, performance scores indicated that the shooting performance of the experimental group was maintained for the high pressure condition. In comparison, the performance of the control group deteriorated under high pressure as observed prior to the practice sessions. Induced anxiety was again used as a task constraint during practice sessions in an attempt improve basketball free throw shooting under pressure (Oudejans & Pijpers, 2009). Participants in an experimental group were made aware that their practice sessions were being recorded, viewed and evaluated, along with being constrained by simulated competitive performance scenarios and the possibility of receiving performance rewards. As with the previous examples, the experimental group was found to maintain free throw performance during low pressure tasks into high pressure tasks. The performance of the control group, who practiced under low anxiety, deteriorated in high pressure conditions following five weeks of practice.

The findings of these studies have clear implications for how affective task constraints can be manipulated for the acquisition of expertise in sport. The data highlight that sport psychologists need to consider how behaviour and performance outcomes can be constrained by simulated emotional and cognitive states of individual performers during practice. In acquiring expertise, performers will experience periods of failure or success as they strive to achieve a high level of 'fitness' for specific performance landscapes (Collins & MacNamara, 2012). Learning environments need to be designed to include situation-specific informational constraints that shape and regulate movement behaviours and the emotional constraints of a task in relation to the intentions of a performer (Davids, et al., 2001). From this approach, emotions are influenced by the constraints of the task and also act as constraints on future behaviours emerging across interacting timescales (i.e. performance, learning and development timescales) (Lewis, 2000a, 2004). Drawing on this interaction, ALD advocates for the design of emotion-laden learning experiences that represent the constraints of competitive performance and promote the acquisition of expertise within/for that context. Underpinning the design of representative experiences is the observation and analysis of emotions in conjunction with movement behaviour to identify periods of learning.

Affective Learning Design in Practice

The intertwined relationship between movement behaviour and emotions poses many challenges and implications for sport psychologists and other practitioners interested in understanding how the concept of ALD can be applied to the acquisition of expertise in sport. Key considerations for implementing ALD include (i) adopting an individualised approach, (ii) acknowledging different time scales of learning, and (iii) embedding emotions in situation -specific task constraints. Sport psychologists implementing ALD need to sample, predict and plan for the potential emotional and cognitive circumstances in competition, and adequately sample them in learning simulations. This premise links to the two previously identified principles of ALD regarding the design of representative emotion-laden learning experiences, and identifying emotional and behavioural tendencies that are indicative of learning. The following discussion of these ideas includes a series of practical examples of how ALD might be embraced by sport psychologists, pedagogues, coaches, and athletes.

The individualisation of affect

Of major significance for the design of affective learning environments is catering for individual differences between performers. Sport psychologists must collaborate with coaches to exploit their experiential knowledge to individually tailor learning experiences based on skill level, personalities, learning styles, and psychological strengths/weaknesses (Renshaw, Davids, Shuttleworth, & Chow, 2009). For example, it is worth considering some data on how skill-based differences might interact with emotions to constrain cognitions, perceptions and actions of different individuals (Seifert, Button & Davids, 2013). A comparison of the performance of ice climbers revealed that the intra-individual movement choices (e.g. kicking, hooking into the ice) and inter-limb coordination modes of novices displayed less variability than those of experts (Seifert & Davids, 2012). In this research novices tended to intentionally adopt an ‘X’ position with their arms and legs that provided highly stable interactions with the surface of the ice. These coordination patterns were functional for novices since they provided stability on the ice surface. However, adoption of these highly secure patterns was not functional for the goal of climbing the ice fall quickly, as demonstrated by the levels of variability in positioning of the experts. The implication is that energy efficiency and competitive performance were not prioritised in the goals of novice performers, whose specific coordination tendencies emerged as a function of their fear in interacting with the ice surface. This emotion was a major constraint on their particular cognitions, perceptions and actions.

In this example, the intentions (i.e. stable position vs. efficient and effective climbing movements) of each performer, based on their individualised perception of affordances, provide scope for a coach or sport psychologist to design targeted learning events. Key constraints can then be implemented and manipulated to simulate challenges that are anticipated to enhance situation-specific expertise at an individualised level, based on identified stable emotional and behavioural tendencies. In implementing this approach a coach could develop an understanding of the most successful methods for pushing each performer into metastable regions, where established action-emotion tendencies become destabilised. As a result, the performer will be forced to explore performance environments simulated during learning to harness new functional states of stable system organisation, or at least experience situations with different task demands (Chow, et al., 2011; Renshaw, et al., 2009). This approach is synonymous with psychological ‘profiling’ and shares some ideas with the notion of individual zones of optimal functioning (IZOF) model advocated by Hanin (e.g. Hanin, 2007; Hanin & Hanina, 2009) in which the interaction between emotions and actions during optimal performance is considered to be highly individualised.

Time-scales and affects

The individualised nature of emotions must also take into account the different interacting time scales of learning that influence the development of expertise (Newell, Liu, & Mayer-Kress, 2001). The critical relationship between the timescale of perception and action (short term over seconds and minutes) and those of learning and development (longer term over days, weeks and months) predicates how an individual might approach specific situational constraints. From a complex systems perspective, perception and action constrain the emergence of long term patterns or behavioural states (Lewis, 2000a, 2002). Initial experiences of a performer will influence how he/she approaches tasks in the future, which emphasises the importance of tailoring the design of learning tasks to individual needs at all stages of the expertise pathway (Côté, Baker, & Abernethy, 2003).

For example, qualitative evidence from interviews with expert team sport athletes revealed that the roles and expectations of coaches (and performers) change along the pathway to expert performance (Abernethy, Côté, & Baker, 2002). Perceptions of 'expert' coaches at early stages of sport participation were based on creating positive environments (leading to positive emotions) that were engaging and fun while also developing basic skills. Essentially, these early experiences were more concerned about meeting the basic psychological need of learners to demonstrate competence (Renshaw, Oldham, & Bawden, 2012), leading to higher levels of intrinsic motivation that sustain engagement over longer time frames necessary to achieve expertise. As athletes progressed through the developmental phases (i.e. from Romance to Precision to Integration, see Bloom, 1985) the relationship with the coach became more tightly coupled and tended to increasingly emphasise the acquisition of sport specific knowledge for managing the physical, emotional, and cognitive needs at an individual level (Abernethy, et al., 2002; Côté, et al., 2003).

Hence, by designing learning environments that cater for changing emotions, cognitions and actions, performers are more likely to engage with or 'buy into' the rigorous demands of long term development programmes (Renshaw, Chow, Davids, & Hammond, 2010; Renshaw, et al., 2012). This reinforces the importance of recognising individualised physical and psychological tendencies across various periods of learning, as well as the critical role of a coach or sport psychologist in designing learning programmes that simulate and sample the intended performance environment to effectively accommodate such behavioural tendencies.

Emotions are embedded in situation-specific task constraints

Emotion-laden experiences are considered to energise behaviour and facilitate an investment in tasks because emotions add context to actions, rather than an athlete merely ‘going through the motions’ in isolated practice drills (Jones, 2003; Renshaw, et al., 2012). Creating individual and/or group engagement in learning experiences through the manipulation of specific constraints enhances the representativeness of a practice task. Through the inclusion of situation-specific information, the demands of a competitive performance environment can be simulated (Pinder, et al., 2011b; Pinder, et al., 2014). Based on this premise, to facilitate the holistic development of expertise, performers should be immersed in learning environments that challenge and stimulate both physically and psychologically to coincide with the constraints of prospective performance environments (Davids, et al., 2013; Renshaw, et al., 2012).

For example, rather than allowing an athlete to practise shots on a driving range, a coach might walk alongside a trainee golfer, creating specific ‘vignettes’ (e.g., 1 shot behind with one hole to play or 2 shots ahead in the same situation) to simulate competitive performance conditions under which a learner might need to adapt their golf shots (e.g., play more conservatively or take more risks). Some previous work in team sports research has incorporated vignettes into the design of practice and performance tasks to investigate how manipulating situational constraints might influence emergent behaviours in athletes. In basketball 1v1 sub-phases, the manipulation of instructional constraints to simulate competitive performance conditions was found to influence the specific intentions and emergent behaviours of attacking players (Cordovil et al., 2009). In that case game time and score-based scenarios were implemented to encourage players to experience adopting risk-taking, conservative, or neutral strategies that might emerge in competitive game play. Similarly, in football, 1v1 attacker-defender dyads, located at different locations on the field of play (by manipulating distance to the goal area) were found to constrain how attacking and defending players interacted with each other (Headrick et al., 2012). Providing contextual information through vignettes engaged the players in the task by specifying goals or objectives that simulated typical game situations for each field position.

Further work originating from elite sport programmes has discussed the importance of designing practice tasks that effectively replicate competitive performance conditions for athletes. An example is the development of the ‘Battle Zone’ in cricket as an alternative to traditional, decomposed, net-based or centre wicket batting and bowling practice (Renshaw, Chappell, Fitzgerald, & Davison, 2010). The Battle Zone concept combines a regulation cricket pitch with a downscaled netted field area to increase involvement and intensity for all players, compared with full sized centre wicket practice. Vignette-based tasks such as the Battle Zone maintain the critical performer-environment interactions while also affording coaches the opportunity to manipulate specific performance constraints to physically and psychologically engage batters, bowlers and fielders simultaneously (Renshaw, Chappell, et al., 2010; Renshaw, et al., 2012).

Practice task designs, such as the Battle Zone, manipulate the space and time demands on players which is captured by the *Game Intensity Index* (GII) concept (Chow, Davids, Renshaw, & Button, 2013). The GII (pitch area in m^2/number of players) can be used in various team and invasion games to create game intensities representative of competition, compare types of games, and cater for different levels of expertise. Coaches can systematically manipulate GII to match task demands to current performance capacity (i.e., place the player’s in their comfort zones) before pushing learners into metastable regions that lead to instability and hence increased range and intensity of emotions, cognitions and actions. For example, if a coach wished to observe how a young player could cope at the next performance level, (s)he could manipulate the GII to simulate the spatiotemporal demands of that level.

In fast ball sports like cricket and baseball, the temporal demands of batting become more severe as performance levels increase. In cricket, while present methods of preparing for this added temporal constraint often include resorting to bowling/ pitching machines or intensive net sessions with ‘throw-down’s by coaches from shorter distances, previous research has shown that removing essential information in practice tasks (i.e., the bowler) results in changes in batter’s timing and co-ordination (Pinder, et al., 2011a; Renshaw, Oldham, Davids, & Golds, 2007). A more effective way, could be to face current fast bowling teammates in Battle Zone vignettes, to replicate the time demands of facing faster bowlers. For example, to replicate a 150 kmh^{-1} delivery a 140 kmh^{-1} bowler would need to release the ball closer (1.75 m) to the batter than the ‘legal’ delivery distance to replicate the time (0.41 s) available when facing the 150 kmh^{-1} bowler. As well as requiring the batter to adapt on a perception-action level, simulating the faster bowling speed also enables the batter to experience the potentially intense emotions associated with facing bowlers of this speed. These task constraints also allow learners to experience the consequent changes in perception, cognitions and actions associated with the interaction between internal and external constraints underpinning performance.

Other work in the sport of springboard diving studied the practice methods of athletes from an elite-level squad (Barris, Davids, et al., 2013; Barris, Farrow, & Davids, 2013). In these studies, elite divers were observed to baulk (preparation occurs but divers do not leave the board) during practice when the preparation phase was perceived as not being ideal for the performance of a selected dive (Barris, Farrow, et al., 2013). This behaviour posed problems for performance in competitive events where baulked dives result in reduced scores from judges. In a planned intervention, divers were required to avoid baulking unless it was perceived that an injury might occur. Barris and colleagues (2013) reported no significant differences in movement patterns between baulked and completed dives under these new task constraints. However, quantitative analyses of variability within conditions, revealed greater consistency and lower levels of (dysfunctional) variability amongst dives completed *prior to* the training program, and greater levels of (functional) variability amongst dives completed *after* experiencing the training programme. It was concluded that divers should be encouraged to complete (where safe) all attempts to more functionally simulate the adaptive performance requirements of competition conditions. From an ALD approach, data suggested that under these practice task constraints, divers would be more frequently exposed to metastable regions enabling them to explore variable take off positions. These metastable regions were expected to enhance the development of expertise (through increased adaptability) by encouraging divers to complete dives where less than ‘optimal’ preparatory movements were evident. These changes to practice task design created more physically and emotionally demanding performance environments that better simulated competitive performance conditions. As predicted, the elite springboard divers displayed greater consistency in key performance outcome (dive entry). At the end of a twelve-week training program that required divers not to baulk, athletes demonstrated enhanced performance through increased levels of functional movement variability. Data suggested that the intervention resulted in them being able to adapt their movements in the preparatory phase and complete good quality dives under more varied take-off conditions. These results bring to light some important practical implications for athletes in training and competition by means of improving training representativeness, reducing performance anxiety and enhancing feelings of self-confidence (Barris, Davids, et al., 2013).

Each of the examples in this section illustrate how including representative, situation-specific constraints has the potential to embed emotions in learning environments. Considering such examples, in conjunction with the previously discussed body of work focussing on anxiety and training under pressure (e.g. Oudejans, 2008; Oudejans &

Nieuwenhuys, 2009; Oudejans & Pijpers, 2010), provides support for embracing emotions present in learning environments. The advantages to learning and performance outcomes reported (e.g. in dart throwing and basketball shooting) when training with anxiety, and the well established benefits of creating representative learning environments provide diverse, yet complementary, perspectives for how ALD can enhance the development of expertise in sport. By implementing ideas such as these, sports psychologists and coaches will be able to observe and analyse the integrated emotional and behavioural tendencies of athletes during learning. In turn, the identification of these emergent physical and psychological tendencies has the potential to underpin the design of further effective learning experiences.

Conclusions

Founded on ecological dynamics principles, previous work has conceptualised and advocated a representative learning design for effective development of skill and expertise in sport. To take forward the understanding and application of this approach we have highlighted the importance of emotions in learning and introduced an integrated concept of ALD with potential scope for future theoretical modelling. Two key interlinked principles of ALD have been identified: (i) the design of emotion-laden learning experiences that effectively simulate the constraints and demands of performance environments , and (ii), recognising individualised emotional and behavioural tendencies that are associated with different periods of learning. Here we have argued that these key principles of ALD will be valuable in the acquisition of sport expertise by considering affect, cognitions, and actions together as intertwined individualised tendencies which constrain performance and learning. Enhanced understanding of individualised behavioural tendencies during learning will also aid the design of representative learning environments that more effectively develop situation-specific skills.

The concept of ALD also advocates designing learning environments at an individualised level, acknowledging different interacting time scales, and implementing vignettes or scenarios to provide context to tasks. This allows performers to experience the emotional feelings associated with performing in learning situations that simulate the external task demands of a ‘new’ environment. Therefore performers are provided the opportunity to experience how they would (potentially) respond emotionally (e.g. know what emotions were created and how intense they were), how this impacted on the way they thought (e.g. influencing their intentions/goals/motivations), and acted (how this affected their actions). ALD also allows the performer, sport psychologist, and coach to understand the impact of being placed in a metastable region (i.e. in a learning task) and the influence this has on affect, cognitions and behaviours. By recognising this interaction it is envisaged that performers and sport psychologists will begin to understand that variability is a normal (in fact desirable) consequence of learning that can be incorporated to develop enhanced learning experiences in the future.

Future research should aim to investigate the relationship between affect, cognition, and action during learning experiences to provide further support for this, and potentially expanded, ALD models. Upholding a focus on individualised approaches is imperative to effectively capture how individual learners interact with specific task demands and environments. This theoretical conceptualisation of how affect, cognition, and action interact provides implications for the design of integrated, systems-oriented learning environments that enhance the acquisition of expertise in sport through enhancing the functionality of individual-environment relationships.

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