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Victoria Brackley[1, 3], Sian Barris[2], Elaine Tor[3, 1] & Damian Farrow[1, 4]

[1]*Institute for Health and Sport, Victoria University, Melbourne, VIC, Australia*

[2]*South Australian Sports Institute, Adelaide, SA, Australia*

[3]*Victorian Institute of Sport, Melbourne, VIC, Australia*

[4]*Australian Institute of Sport, Canberra, ACT, Australia*

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Correspondence Address:

Victoria Brackley

Office PB201

Victoria University Footscray Park Campus, Ballarat Road, Footscray, Victoria, 3011, Australia

Email: victoria.brackley@live.vu.edu.au

Sian Barris - sian.barris@sa.gov.au

Elaine Tor - elaine.tor@vis.org.au

Damian Farrow - damian.farrow@vu.edu.au

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This study aimed to explore the experiential knowledge and preferred training approaches of elite swimming coaches in regards to general skill development and then looking specifically at the freestyle stroke. A qualitative thematic analysis approach was employed to identify, analyse and report themes within the content of the collected data. Twenty elite swimming coaches participated in semi-structured interviews. Several themes revealed that the most common training practices employed to improve skill learning included the use of task decomposition (part-task) techniques. The findings also indicated that swimming coaches believe practice should be specific / representative to the intended performance outcomes. It is believed that such viewpoints may have been influenced by coaches' interaction with skill acquisition consultants and may have also shaped some coaches use of variants of constraints manipulation in their practice design. While swimming coaches seem to mix both traditional and contemporary skill acquisition theories in their training prescriptions, the traditional approach is dominant as evidenced by coaches seeking to reinforce "perfect" swimming technique and mechanical consistency. Considering coaches' experiential knowledge and training prescriptions may benefit future research protocols and better facilitate the transfer of empirical findings to coaching practice.

Keywords: expertise, coaching, skill development, drills

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Introduction

Research has illustrated coaches' intentions of integrating more scientific-based approaches into practice (Waters, Phillips, Panchuk, & Dawson, 2019; Williams & Kendall, 2007); yet the diversity and complexity of the coaches' role (Côté, Young, North, & Duffy, 2007) has caused a tendency for coaches to rely on their experiential knowledge when designing practice (Dehghansai et al., 2019; Williams

& Kendall, 2007). Coaches' pedagogical approaches, as a consequence, can sometimes lack support from empirical or evidence-based foundations (Davids, Renshaw, Pinder, Greenwood, & Barris, 2017). For this reason, high performance coaches may work with a sport scientist to help translate and apply empirical concepts into practice (Dehghansai et al., 2019; Phillips, Farrow, Ball, & Helmer, 2013; Steel, Harris, Baxter, & King, 2013). Ultimately, the coach and sport scientist attempt to bring their different viewpoints together in order to create a practice environment that facilitates athlete performance in competition (Martindale & Nash, 2013; Waters et al., 2019).

A considerable challenge for coaches and sport practitioners is ensuring that training practices facilitate the transfer of learning from training to competition (Maloney, Renshaw, Headrick, Martin, & Farrow, 2018). The coach plays a central role in creating the learning environment to best promote skill learning and prepare the athlete for competition performance (Masters, 2008; Mooney et al., 2016). In individual sports such as swimming, coaches generally plan on building athletes' fitness and technique at the beginning of the training cycle and as major competition events approach, their focus shifts to more race-specific training prescriptions (Pyne, 2016). Empirical evidence has illustrated how well-intentioned changes to practice environments (Barris, Davids, & Farrow, 2013) and practice tasks (Pinder, Davids, Renshaw, & Araújo, 2011a) can inadvertently change performance and movement responses in competition. However, there is a limited understanding of the extent skill acquisition theories have been applied in current high-performance coaching and practice design.

To gain a better understanding of the extent skill acquisition principles have been translated into practice, researchers have explored the experiential knowledge and practice prescriptions of elite coaches (Greenwood, Davids, & Renshaw, 2012, 2014). In elite swimming, training observations have revealed that coaches emphasised principles of deliberate practice within their training regime, implying the importance of the time spent in feedback rich, specific technical practice from an early age (Côté & Gilbert, 2009; Ericsson, Krampe, & Tesch-Römer, 1993; Junggren, Elbæk, & Stambulova, 2018). In contrast, experiential data drawn from elite coaches in rugby league (Rothwell, Stone, Davids, & Wright, 2017) and field hockey (Slade, Button, & Cochrane, 2015) provide support for representative game scenarios where players draw on other sports experiences and learn to regulate and adapt their performance actions (Araújo & Davids, 2015). While both practice approaches seek to train the athletes in a manner than ensures transfer of learning to competition, a fundamental philosophical difference exists centred on the relative importance the coach places on how the athletes execute their skills. Swimming coaches strive for execution of the same action repeatedly, whereas the rugby and hockey coaches encouraged their athletes to develop adaptable movement patterns.

A traditional skill acquisition recommendation for coaches is to prescribe practice tasks that promote the invariant repetition of a single ideal movement pattern (Brison & Alain, 1996; Davids et al., 2017; Schmidt & Lee, 2011). For example, to simplify learning or reduce movement variability, coaches may decompose a task into its component parts (e.g. the full swimming stroke is reduced into a kicking drill) (Davids, Kingsbury, Bennett, & Handford, 2001; Ford, Yates, & Williams, 2010; Reid, Whiteside, & Elliott, 2010) or progress a skill from basic coordination to the full movement, with an emphasis on volume and exact repetitions (Pinder, Headrick, & Oudejans, 2015). However, contemporary theories (e.g. ecological dynamics,) on skill acquisition have criticised such practice approaches as they fail to consider the circular coupling between an individual and their performance environment, and the wide array of constraints which influence an individual's learning and performance (Davids et al., 2017; Newell, 1986; Seifert, Button, & Davids, 2013). Ecological dynamics approaches have argued variability in movement patterns can be viewed as functional when it supports the performance flexibility needed to adapt to changing constraints (Davids, Button, & Bennett, 2008; Seifert & Davids, 2012). As this argument has garnered empirical support, there has been a shift towards encouraging coaches to identify and preserve key constraints and information–movement couplings, used to regulate behavioural patterns in a specific performance context, in the design of their practice prescriptions (Araújo, Davids, & Passos, 2007; Krause, Farrow, Reid, Buszard, & Pinder, 2018; Pinder, Davids, Renshaw, & Araújo, 2011b). Constraints, in this context, are boundaries or features that limit (and enable) the dynamics of emergent functional behaviours and have been typically classified into three core categories: organismic, environmental, and task (Newell, 1986). The constraints-led perspective (Newell, 1986) highlights how through the dynamic interaction of constraints during goal-directed activities a learner will self-organise in an attempt to generate functional movement solutions (Renshaw, Chow, Davids, & Hammond, 2010; Renshaw, Davids, Newcombe, & Roberts, 2019). As an example, Guignard et al. (2019) manipulated the task constraint of swimming speed and the environmental constraint of fluid flow in a flume and illustrated how elite swimmers adapted (and maintained performance) by changing their arm-to-leg coordination patterns.

Further, it has been argued that one of the most pervasive principles of skill acquisition that coaches should seek to apply is that of specificity (Farrow &

Robertson, 2017). Within the traditional skill acquisition literature, the specificity of learning hypothesis (Proteau, 1992) contends that learning is specific to the visual information sources present during learning and skill performance deteriorates if there are changes to the information in a transfer test. Largely derived from basic research, the specificity of learning hypothesis has been generalised to more applied sport skill training contexts by referring to the extent to which the training reflects the conditions typically experienced during competition performance (Farrow & Robertson, 2017). More recently the representative learning design (RLD) concept has been advocated from an ecological dynamics perspective, which argues that learning is specific to the interaction of constraints (not just visual information) during practice, yet functional learning is dependent on the extent to which practice tasks are representative of the competition setting (Barris, Davids, et al., 2013; Chow, Davids, Button, & Renshaw, 2015; Pinder et al., 2011a).

The RLD concept has been proposed as a framework for coaches to enhance the skill learning of their athletes and for researchers and sport scientists to assess the extent to which practice and experimental tasks are representative of the information (e.g. perceptual stimuli, task constraints) encountered in the performance context (Krause, Farrow, Buszard, Pinder, & Reid, 2019; Pinder et al., 2011a, 2011b). While there has been a significant amount of research investigating RLD within sports coaching settings over the last decade (Barris, Davids, et al., 2013; Guignard et al., 2017; Pinder et al., 2011a) it remains unclear as to how well the concepts have been incorporated in coaching practice. While the concept is intuitively appealing, the language used and some of the basic tenets of the approach may make it inaccessible to coaches when it comes to application in the coaching environment without the direct assistance of a content expert, such as a skill acquisition specialist (Dehghansai et al., 2019; Waters et al., 2019;Williams, Ford, Causer, Logan, & Murray, 2012; Williams & Ford, 2009; Williams & Kendall, 2007) .

Swimming coaching research has typically been concerned with understanding performance improvement from a physiological or biomechanical perspective (McGowan, Pyne, Raglin, Thompson, & Rattray, 2016; Mooney et al., 2016; Nugent, Comyns, & Warrington, 2017). In contrast, the learning processes underpinning enhanced performance has not been systematically examined to the same extent. In an exception, Junggren et al. (2018) established that high-performance Danish swimming coaches incorporated methods of observational learning, verbal feedback, and individualised training within their practice regime. While other studies have explored the effects manipulating swimmer coordination via task constraints such as the use of tethered swimming or adding hand paddles (Guignard et al., 2017; Telles, Barbosa, Campos, & Júnior, 2011). However, the underlying skill acquisition approaches adopted by coaches to inform these specific training tasks and drills has been under represented in the literature.

The aim of this study was to explore the skill acquisition approaches applied by elite swimming coaches in their design and prescription of training tasks. This aim was addressed by considering both general swimming skill development and learning, and then specifically how these approaches apply to freestyle. A specific focus was placed on freestyle as it is the fastest and most effective form of human locomotion through the aquatic environment (Counsilman & Counsilman, 1994; Deschodt, Arsac, & Rouard, 1999; Yanai, 2003) and, therefore, tends to be the dominate training stroke regardless of swimmers' specialisation in one of the other form strokes (Stewart & Hopkins, 2000). The research questions guiding this study were: What skill acquisition approaches do swimming coaches apply in training? What are the key goals behind the freestyle training tasks (drills) most commonly prescribed by swimming coaches? Based on the applied insights of the authors and previous coaching observation research (Junggren et al., 2018; Slade et al., 2015), it was hypothesised that elite swimming coaches heavily apply traditional skill acquisition approaches (e.g. part-task training through the prescription of drills) in their practice prescription; yet are shifting towards prescribing more contemporary skill acquisition approaches (e.g. constraints-led approach or RLD) within their training program.

Methods and Methodology

Philosophical Assumptions

This study is situated within an interpretive paradigm and framed by ontological relativism and epistemological constructionism (Braun & Clarke, 2013; Smith & Sparkes, 2013) .

Participants

Twenty elite Australian swimming coaches (19 male and 1 female) voluntarily participated in the study. The recruitment of these participants was informed by purposeful (criterion-based) sampling to ensure key informants in the field of high-performance swimming could address the topic of investigation the most productively (Fleming, Young, Dixon, & Carré, 2010; Patton, 1999, 2002; Thompson, Bezodis, & Jones, 2009). To be eligible, participants had to: (a) have experience working in high-performance swimming with freestylers, and (b) be willing to openly share thoughts and practice examples regarding skill acquisition. Among the 20 participants, six were classified ‘Platinum’ level coaches by the Australian Swimming Coaches and Teachers Association (ASCTA) which is the highest recognition of achievement given at the elite level. These coaches, aged between 49 and 70 years (M_{age}=60.64 years, SD = 8.34), had a minimum of 20 years coaching experience ($M_{experience}$=34.83 years, SD = 11.20) and / or were on the Australian national coaching team. The remaining 14 participants held either a ‘Gold’ or ‘Silver’ high-performance qualification given by the ASCTA which is the second and third highest recognition of achievement at the elite level, respectively. These coaches had between 8 and 39 years of coaching experience ($M_{experience}$= 22 years, SD = 10.38) and were aged between 28 and 61 years (M_{age}= 44.49 years, SD = 10.38) at the time of the interview.

Ethical approval to conduct the study was sought and provided by the first author’s university Human Research Ethics Committee. Members of the research team approached and recruited the participants, either in person or via email, informing them of the nature of the study. Participants agreed upon convenient times for the interviews and gave informed consent before data collection.

Data Collection

To address the research aim, face-to-face semi-structured interviews were conducted by the first author who was trained in qualitative research and engaged with elite swimming coaches and athletes on a regular basis. The interview guide was divided into three main sections starting with warm-up questions on the coaches’ swimming background and experiences. The second part of the interview guide focused on coaches’ approach towards skill and technique development (e.g. “How do you teach skill and technique development within your squad?”). This was followed by questions looking specifically at the freestyle stroke and drill prescription (e.g. “What types of drills do you find most effective when you are working on developing skill and technique in your squad?”). Probes were used throughout to engage further elaboration or to ensure the participant’s description was accurately understood (Louise & While, 1994; Patton, 2002). This approach ensured that the responses given were consistent in terms of depth and complexity yet allowed the flexibility to pursue responses beyond the scope of the specific interview questions (Fontana & Frey, 2005; Hardy et al., 2017). Furthermore, the semi-structured approach was adapted to reflect the nature of such interviews where participants will often cover tangent points of interest or make observations not necessarily anticipated by the interviewer (Slade et al., 2015).

The interview guide was developed by all four authors and was reviewed by an independent expert in the field of qualitative research (Hardy et al., 2017). The independent expert had a PhD in psychology, over 10 years experience working in health psychology, and conducted multiple research outputs in social science, epidemiology, and public health disciplines. Pilot interviews were conducted with a non-elite coach and an elite coach (n=2) to assess the appropriateness of the topic areas and interview flow (Pilgrim, Robertson, & Kremer, 2016). This process ensured that the interviewer could understand the coaches’ colloquial language and probe questions appropriately. As no adjustments were made to the interview guide, the interview results from the elite participant was included in the full analysis. All interviews were audio recorded, ranged between 23 and 48 minutes in duration ($M_{interview}$= 36.92 minutes, SD = 7.39), and transcribed verbatim by a professional transcriber. The NVivo 11 analysis software (QSR International Pty, Ltd, 2017) was used for the management and analysis of the interview data.

Data Analysis

Inductive thematic analysis was used to analyse the interview data (Braun & Clarke, 2006; Braun, Clarke, & Terry, 2015; Braun, Clarke, & Weate, 2016). The six-stage thematic process began with (1) the first author becoming familiar with the data through listening to the audio recordings, checking the transcription against the audio recording, reading and re-reading the final transcripts, and making brief notes of prompted ideas relating to the research aims. The second stage (2) consisted of organising data or identifying patterned responses into initial codes and then (3) collating initial codes into potential themes and sub themes (constructing thematic map). The process of generating codes and potential themes was an active process where the first author drew from personal experiences and interpretation of the coach accounts (Braun et al., 2016; Patterson & Backhouse, 2018). At this stage, the findings were discussed in-depth with the last author. The researchers were mindful that given the ontological relativist perspective where realities are multiple and subjective, coaches' perceptions and training practices are likely to be diverse (Patterson & Backhouse, 2018). For this reason, the focus was on identifying patterns in the data that represent contrasting finding, not consensus. It is also worth noting that while the described process of thematic analysis appears relatively linear (e.g. 'following the rules'), the analysis undertaken was rather an interactive and cyclic process (Braun & Clarke, 2013; Braun et al., 2016). The fourth stage (4) involved reviewing each interview transcript against the codes, themes, and subthemes to ensure they fit within the overall research aim. During the fifth stage (5), the final refinements were made which included reviewing, defining and naming final themes. The sixth and final stage (6) consisted of generating an accompanying narrative describing each theme in the context of the research question (Braun & Clarke, 2006; Braun et al., 2016; Pilgrim et al., 2016).

Research Quality and Rigor

Contemporary views to enhance the quality of this study included conversation with ‘critical friends’ and reflexivity (Braun & Clarke, 2013; Nowell, Norris, White, & Moules, 2017; Smith & McGannon, 2018) . The research team acted as ‘critical friends’ who encouraged the first author to continually reflect on the interpretation of data and they also questioned the decisions made relating to the organisation and analysis of the data (Smith & Sparkes, 2013) . Further, participants were sent their interview transcription and also offered to share any subsequent feedback (Williams, Smith, & Papathomas, 2018) . Two participants responded and reported that the data resonated with how they, as coaches, approach skill acquisition in their design and prescription of training tasks.

Throughout the study, the research team paid close attention to how their behaviours, thoughts and assumptions were impacting the research process (Braun & Clarke, 2013). The first author came from a non-swimming background, yet engaged regularly with swimming coaches during their regular training sessions. Additionally, the remaining members of the research team worked as a biomechanists or skill acquisition consultant in swimming and / or a broad selection of sports (e.g. cycling, tennis, Australian football). Reflexivity is crucial to qualitative research; therefore, given the interpretivist approach, the research team acknowledge their influence on the study design and processes. Further, the working relationship the participants had with some members of the research team may have shaped current practice approaches and responses given. To demonstrate rigor, the recruitment of participants continued until data saturation was achieved (O’reilly & Parker, 2013). Data saturation was claimed when no new codes or themes could be constructed from the last seven interviews as no new information was elicited (Fleming et al., 2010; Vella, Oades, & Crowe, 2011).

Results

The two high-order themes that were identified through thematic analysis included *Freestyle Drills* and *Acquisition of Technical Skills* (see Figure 1). The supporting subthemes are discussed and illustrated using representative quotes from the participant coaches (Nugent et al., 2017). To secure confidentiality, participants were assigned a pseudonym label (e.g. SC1 - SC20).

****FIGURE 1. NEAR HERE****

Figure 1. Australian swimming coaches' skill acquisition approaches in training and key goals behind the freestyle training drills most commonly prescribed

Freestyle Drills

All of the freestyle drills described by the participants involved breaking the stroke into component parts. In particular, sub-themes identified were categorized into *freestyle fundamentals, drill purpose,* and *training strategies.*

Freestyle Fundamentals

The freestyle drills mentioned by all participants were based around their outlook on the most important components (fundamentals) of freestyle. Most participants emphasized the importance of athletes' maintaining a good body alignment in the water and used words such as "posture", "body alignment", and "long axis" to describe the setup in the water. Other components such as the arms (e.g. to create propulsion) the legs (e.g. kick for balance), breath timing, and rhythm (e.g. timing and relaxation of stroke) were acknowledged. Yet, the body position was illustrated as the foundation to swimming freestyle efficiently by sixteen of the participants:

> Body position and balance before everything…Everything else is ineffective without it. If you can't switch your core on, you can't apply force, you can't consistently kick well, you're compromising, you're in a high drag state and you're in a low propulsive state compromising both. There're only two things that are going to make you better in freestyle and that is decreasing your drag and increasing propulsion. If you're compromising both by those two things, you're stuffed. It starts at the central theme and everything else, pull weaknesses, kick weaknesses, are all derived from a lack of balance and a lack of body position. (SC2)

Over 20 freestyle drill variations were discussed, however only the drills mentioned by a minimum of six participants are presented. These drills, in order of most mentioned, include: (1) *single arm*, (2) *long dog*, (3) *polo*, (4) *kicking*, and (5) *sculling*. A summary of the drills' description, key task goal, and variations are presented in Table 1.

Table 1. Most mentioned freestyle drills, key task goals and variations

****TABLE 1. NEAR HERE****

> The drills that I've used and probably continue to use, are things like that might isolate one part… So, body position, snorkel, with or without fins, hands by your side, just feeling the water getting the body position right so you're not under the water… long dog and then polo over the top working on entry point and finishing as well. And then some alternate swimming - six on left, six on right, six on whole preferably without breathing, and then adding the breathing in. So, it's sequential ensuring that each part, each important part which is body position, timing of the arms and legs, getting any rotation and making sure the patterning of the arms is right…So, I could have given you another different set of drills and progressions and there are many, many, many we haven't even touched on. But you have to keep coming back to what elements are important in freestyle and what is your swimmer's height, makeup, talent and capability. (SC10)

While fourteen of the participants mentioned various combinations and progressions of the single arm drills, one participant raised opposing comments:

> I do single arm drill but I’m just not convinced… It just seems awkward to me, always has done… I’m just not sure with the single arm whether in the long run it actually correlates… Timing and breathing, I think maybe that, but then it just always, it’s not natural, you know… I just think the percentage of people doing it properly is very small. (SC3)

Drill Purpose

All participants described that the purpose behind prescribing drills was to either (i) “fix” or (ii) “reinforce / activate” technique. Two coaches noted that for senior athletes, drills are predominately prescribed to “prepare for good technique” whereas for junior athletes, drills are used to fix technique flaws:

> I see drills for senior athletes as more of that [preparation for good technique], and I see drills for junior athletes as more of an exposure to an area of the stroke you see is flawed…. so you isolate it, put it under pressure, correct it and then try to condition it. (SC16)

When describing the use of drills to address a weakness in the swimming stroke or reinforce aspects of technique, seven of the participants cautioned on potential negative consequences associated with over- or misuse:

> I would say, and this is the problem with any drills that if you’re using it to focus on a specific aspect, nine times out of ten it’s going to negatively affect at least one other part of the stroke. So, whenever you use a drill you’ve got to understand is, I know at one stage it was all the rage especially when I was swimming catch up freestyle… so you’ve got to be very mindful of the affect. (SC4)

> You’re not trying to swim in the drill, you’re trying to use the drill to address an aspect of the swimming that will improve with the whole stroke of swimming – not have you swim like the drill. (SC11)

Training Strategies

Participants described the swimming regularity, distance, speed and execution of the drills within their weekly training program. When asked where in the session drills are prescribed, all described that drills are often placed in the warm-up (prior to the main set) as athletes “have greater attention.” Nonetheless, placing drills in the recovery (post main set under fatigue) or in the main set, with the intended goal of applying pressure or load to some of the drills, were other perspectives mentioned by eight of the participants.

> I think I did them probably both in the beginning as part of a warmup, but also would use them as a bit of a recovery as well at the back end of the session. And have used them even in a main set where there has been, trying to apply even a load to some of the drills as well. So just depending on a particular time of the season or really what I was looking for. And sometimes even just be doing drills if, as an aid to recovery as well, just low level aerobic (SC17)

Conversely, one participant raised concerns in regards to the whole approach to skill learning and development in swimming. This participant explained that in the warm-up coaches are often distracted (e.g. writing the session on their whiteboard) when they should be continually watching their athletes to ensure technique is maintained:

> You tell me a program you’ve been to and they [the athletes] haven’t just flopped up and down in the warm up and the coach hasn’t been on the side watching what they’re doing… So, if a coach comes in and writes a session on the board and then carries on writing once the swimmers have got in [the water], he isn’t going to be looking at the skill acquisition. So, to say they do the drills and all that in the warm up, it doesn’t mean a lot. (SC3)

As drills are often placed in the warm-up, one participant illustrated how drills are incorporated within the prescribed 2 km warm-up, for example. The specific distance of drill swimming varied among the participants from 200 m to 800 m. Ten of the participants explained how they only prescribed 25 m or 50 m of drill at a time before incorporating freestyle swimming again:

> I think it's pointless in my view giving someone 400m of drills. Because drills are very difficult to do, they're very hard to do. Concentration's got to be 100%. So, my rules are … this is just for me, I'm not saying it's right or wrong. We stick normally to 25 meters. Because over 25 meters they're able to hold and focus and concentrate more I believe than giving a 50 [of] drill. Having said that I do do 50's but I do more 25's than I do 50's. Especially for freestyle…. So, the warmup might be two kilometres and there might be 400 meters, or 300 meters, or 200 meters of drill work in there. Most sessions I do it. (SC12)

When participants were asked what speed drills are performed at, there were mixed responses. Six of the participants explained that the speed at which a drill is swum depends on athlete skill level, if the drill is reinforcing or correcting technique, and the training variation, as stated by this participant:

> I think it depends on the level of the athlete and the level of the skill. So, say if you're working on your kick timing so your timing of your up kick would be catch position, that's, you have to start slow and then get close. If you're looking to reinforce it because they know how to do it or you can do, it's closer to race specific speeds. (SC1)

Throughout the participant's illustration of the drills, seventeen of participants made mention of using drills within a progression – starting with a simpler drill and building the complexity with the inclusion of full freestyle swimming or starting at a slower pace and increasing speed, as several participants explained:

> I didn't have one drill but basically hundreds of combinations to train different skills. And every time challenge them a little bit different and always followed by just proper swimming on various speeds, maintaining their skill. And if I could see they can't do it, go back to the drill and try it again. So really deconstruct the stroke a little bit and try to build it and progress it from skill level. (SC9)

> A series of drills might need to be linked, like I've just talked about, to get to the outcome in the swimming that you're after. Often, we just don't use a drill in isolation. There's usually a progression then to swim. Then we could continue to swim to consolidate. There's no value in doing some drills, say, in freestyle, and not swimming in the end. (SC11)

Two of the participants also expressed differing training prescriptions of drills implemented within their program:

> I got them to make them to make up their own drills and then try and teach that to someone else. And a big part of it the program is I always put in an element of play… Kids these days they don't have that natural feel for the water or that athletic intelligence on stuff… The way you discover is by playing, so just go and do what you want, swim backwards, do whatever. So, we do that and some of kids think it's a waste of time while others are, ah geez, I felt this. (SC5)

> I don't do as many drills as a lot of people. It's more attentional focus swimming… It's more what your focus is on or what you're trying to achieve. (SC1))

Further, one of the participants expressed how his session planning and coaching approaches has changed since his involvement with a skill acquisition consultant:

> I think my coaching's changed, he [skill acquisition consultant] helped me actually just believe in myself a little bit more. There're some things that I play around with my coaching and having a stamp of approval from him in making me believe that that's the way forward… I think we [as coaches] get caught up in doing the volume day after day and we don't look at the detail of it. [For example, adding a fatigue component when periodising a skill change]. So, I try to be a little bit smarter with my planning. (SC5)

Acquisition of Technical Skills

The participants' outlook towards skill learning and transfer was described in this high-order theme. Training practices mentioned to improve technical skills were categorised into three subthemes: *specificity / representativeness*, *constraints manipulation* and *instructional approach*.

Specificity / Representativeness

Ten of the participants acknowledged that behaviours in training should be representative of competitive performance, as this participant stated:

> I think it's very important to swim freestyle at training how you want to race freestyle. So, what you do at training can't be a different looking stroke, and a lot of swimmers make that mistake…. (SC19)

The training practices mentioned included task decomposition, task progression and race-pace (speed) training. All participants illustrated that they "break the stroke down" or isolate particular segments, in order to simplify and facilitate skill learning, before reintegrating the segments back into the full stroke:

> Generally, there's too many things for them to work on. So, we break it down and put it pretty simply to see if we can create the change. By slowly bringing back some of the complexities to the stroke and then adding speed and pressure, they're more likely to get change. (SC14)

Fourteen participants also referred back to the same principles of skill progression they described in regards to the execution of freestyle drills to ensure transfer was achieved when swimming the full stroke:

> So, for example you might go 25 meters left arm, both arms out in front, left arm, then I'll go 25 swim to the end, then I'll come back right arm slow, might do four, five, six times. Then I'll do it fast, where they're trying to work at hand acceleration, where it's similar to what they're doing with their stroke. So, I get them doing it at slow speed and I'll just get them feeling. (SC12)

Ensuring the development of swimming speed for competition was noted by six of participants:

> Well race pace is super important to me because it's really all that we're preparing for. Everything… Like I'll do this, there's plenty of other aspects of the program but they're all built in towards if I can do pace well. I mean a race is pace, that's just practice pace work and for me there is sometimes a gap between training and racing that the kids don't know how to execute so everything is built around pace and I'm after getting their pace right and they're improving and they're doing it well and they're technically good with it and they're specific to what they want to do in a race and we build the program around that and they've got the best chance of swimming faster. (SC2)

Constraints Manipulation

Twelve of the participants explained how the personal characteristics of an individual (e.g. organismic constraints) can affect the acquisition of technical skills:

> There's a general plan for the whole group and then you've got to individualise it from there because everybody's going to respond differently. (SC4)
>
> You're looking at each individual athlete because each of those athletes will respond differently to certain sorts of stimuli. So, I'd have two sprinters at the same time and same age, but you'd have to train them differently. (SC20)

Further, eight of the participants illustrated that they make modification to practice tasks and environments (e.g. task and environmental constraints) in the attempt to promote adaptive behaviours required in competition performance:

> I think when I watch in the training environment people are able to perform and make great decisions, but can they do it under the constraint of competition?…I want to train my athletes' capacity to think under all the constraint they're going to have at an event whether its pressure, lack of oxygen, lactate or fatigue - lots of different things. I try and simulate all of those stresses in the training environment, all of those stimuli, for not only a

> physiological response but also then from a skill acq perspective. Can they perform the task under any different constraint that I give them? I want them to be able to execute a great decision under the worst circumstances… I'm going to preload them with one goggle blindfolded. I'm going to preload them with lots of different sounds... So, a bit of interference. So, lots of different things to train the brain's ability to have a greater capacity for making good decisions under pressure. (SC6)

> I do a lot of sensory swimming. Like swimming with a sponge on or with a static rope or with something like paddles… [I think] good timing and body position is important in freestyle swimming but some drills [decomposed tasks] throw your timing out. This is why I rather do a lot of sensory swimming. (SC18)

> So, I would say that a lot of the time we do a body position drill is more to increase the awareness of where the body is in space, even though they're trying to improve it by decreasing… So, we might put weights on them or the opposite and make them more buoyant by putting like a buoyant strap under their hips and stuff. So, it's just a contrast. But does that position of hands by side kick exactly the same as when they're swimming? No. But does it improve one or the other by increasing awareness I say, yes. (SC1)

Instructional Approach

The instruction process used by the participant coaches to help their athletes learn and acquire technical skills included: visual demonstrations, providing feedback, and athlete self-regulation of performance. All participants indicated how verbal instructions are often used with visual demonstrations to both convey information, and provide feedback and cues to the athlete in regards to technique:

> I'd always provide feedback if I could visually, iPad, iPhone, whatever, just so you could see that you need the change. And then what I'd do is, I'd say – I try to stay away from the word "feel"– but I'd say, are you noticing a difference in position? What do you notice? And I'd listen for you to say cues to me that I could use back to you. (SC16)

> If they [the swimmers] hadn't seen the drill I'd say, okay, you do this drill, this is the drill, one of my guys who's used to the drill, you demonstrate, so

> they [the swimmers] watch it, they see it, okay, they understand. So, it's how you explain it and I think you have to let them see it as well as explaining it. So, there's an old saying an eyeful is better than a gob-full and it's very true. (SC19)

One participant also explained the importance of providing constant feedback and correction to the athlete when working on addressing a weakness in the swimming stroke or reinforcing aspects of technique:

> So, I think when they're doing the drills you talk to them and I think you've got to be there and you've got to be correcting. If they're doing you know 16 25's of drill / swim or whatever, you can't make a comment about technique on number 15. I think you need to be there making it sort of all the way along, watching them when they're doing their drill, not just allowing them to do a drill on their own. (SC12)

Thirteen of the participants acknowledged that the coach can provide the training plan and practices but, ultimately, the athlete needs to take ownership of their own program. Consequently, athletes are encouraged to ask questions, do their own research on successful swimmers and self-regulate their performance:

> And all my coaching's based around reward and consequence. As a coach I'm not the reason they swim. They're the reason they swim. They're the reason they get the performance. So, in training I design it around them self-regulating their performance and self, they're driving the process so if they achieve what they need to achieve they're rewarded. If they don't achieve there has to be a consequence to that to make them shift their mind-set to be able to make the change. (SC5)
>
> I think the challenging part is rather than a coach just telling the athletes what to do, is to try and get them more empowered and asking them more questions and getting them more aware of what they're doing… So, trying to get them to be more engaged. (SC14)
>
> The swimmers who have the best technique think about it all the time. They're obsessed about it. (SC18)

Discussion

This study aimed to explore the variety of skill acquisition approaches applied by elite swimming coaches in their design and prescription of freestyle training tasks (e.g., drills), and how these approaches are applied to general skill development and learning. Using the six-step thematic analysis, two high order themes were identified: *Freestyle Drills* and *Acquisition of Technical Skills* (Figure 1). The schematic illustrates that while two distinct high order themes with supporting subthemes were constructed by the researchers' interpretation of the participant interviews, there are numerous overlapping findings between the two themes. Notably, the most mentioned freestyle drills illustrated by the coaches reflect the traditional skill acquisition recommendation of reducing movement variability by decomposing a movement task into smaller components (Davids et al., 2001; Ford et al., 2010; Reid et al., 2010).

Freestyle Drills

Drill Purpose

The purpose behind prescribing drills was twofold; (i) to improve aspects of the swimming technique by simplifying learning, and (ii) to reinforce current technique performance. Two participants noted that in junior athletes the focus of drill prescription was on learning – implementing a set of underlying processes within practice to lead to permanent behaviour changes (Davids et al., 2008); whereas in senior athletes, the focus was to aid performance outcomes and technique. Recently, however, it has been shown that decomposing the full freestyle stroke into a single arm drill (e.g. part-task practice) can cause significantly different hip and body rotation patterns than swimming the full freestyle stroke (Arellano, Domínguez-

Castells, Perez-Infantes, & Sánchez, 2010). Part-task training practices may facilitate some skill learning; yet there is a debate within the skill acquisition literature whether the skills acquired during such practice approaches are transferable to the intended performance environment (Barris, Farrow, & Davids, 2013; Pinder et al., 2011b; Seifert et al., 2013). The participants use of part-task practice approaches, contextualised within recent skill acquisition literature, highlights a possible disconnect between theory and practice. Our results suggest that swimming skills are being overly deconstructed in the belief that working on isolated aspects of technique can then be transferred back into the whole skill, despite empirical evidence to the contrary.

Training Strategies

Seventeen of the participants described prescribing drills at a slow pace and increasing the speed or progressing from a simpler to more difficult drill. While methods of task progression from basic coordination to competition-specific training are likely to provide a degree of learning success (Pinder et al., 2015), contemporary swimming research has demonstrated that the speed at which the full stroke (or drills) are swum can impact coordination patterns atypical to performance (Guignard et al., 2017). Further, while participants typically located the drill practice at the beginning of the training session, eight of the participants also questioned whether this approach is transferrable to competition racing especially when athletes fatigue (and technique "breaks down") towards the end of the race. These insights reflect that while swimming coaches are heavily biased towards traditional skill acquisition recommendations, many may be aware of and unknowingly apply contemporary skill acquisition principles.

Acquisition of Technical Skills

Specificity / Representativeness and Constraints Manipulation

Participants indicated that a common training strategy believed to improve skill learning was to break the stroke into small constituent parts and / or using simplified stroke activities. Decomposing a learning task into manageable components (e.g. part task training) is believed to help manage the information load on learning (Magill, 2007; Whelan, Kenny, & Harrison, 2016). This was echoed among all the participants, despite applied research demonstrating that the transfer of learning may be limited by this approach (Davids et al., 2001; Reid et al., 2010; Renshaw et al., 2010). While removing movement variability and decomposing the freestyle stroke were common skill acquisition approaches, ten of the participants illustrated how they believe practice should be specific / representative to the intended performance outcomes. Such viewpoints may have been influenced by coaches' interaction with a skill acquisition consultant as one participant noted that through recent interactions with a skill acquisition consultant, he now incorporates fatigue components into his session planning when reinforcing or correcting skills. Further, eight of the participants also illustrated the incorporation of contemporary skill acquisition approaches (e.g., constraints-led approach) into their training program when working on fundamental components of the stroke. For example, one of the participants described focusing on the complete stroke through the application of a sponge (e.g., constant resistance attached to the swimmer) or hand paddles rather than prescribing drills that decomposed the skill. Schnitzler et al. (2011) found that adding a constraint (resistance provided by a parachute) to freestyle alters the propulsive phases and coordination parameters of the stroke; however, transfer of learning may be promoted as swimmers are encouraged to become more adaptive performers and attuned to their surrounding environment (Guignard et al., 2017; Renshaw, Davids, Shuttleworth, & Chow, 2009). Consistent with the rationale of Schnitzler et al. (2011), one of the participants also agreed that some constraint manipulations (e.g., attaching weights to swimmer) may limit the swimmer's ability to execute the skill "perfectly"; yet shared the belief that adaptable movement behaviours may be better promoted. Such insights demonstrate that some ecological theories are acknowledged and applied within the swimming training environment.

Instructional Approach

In order to communicate technique information back to the athlete, participants argued that coaches must place their undivided attention on that individual. Key instructional approaches used to facilitate skill learning involved using visual demonstrations and providing verbal feedback. Participants also highlighted the use of verbal cues underpinned by the key goal of reinforcing "perfect" swimming technique and mechanical consistency. Such training prescriptions may be the result of how many of the participants were coached themselves when they were swimmers, their coaching education, or the influencers from fellow coaches / mentors. Newell and Ranganathan (2010) has criticised, however, the use of instructions to impose an invariant movement pattern and rather argued that instructions should facilitate a learners search process towards effective coordination patterns. Additionally, Seifert, Button, and Brazier (2010) have cautioned that instructional cues be implemented as a method of task simplification rather than a supplement to task decomposition.

Limitations

The present study provides detailed insights into high-performance swimming coaches application of skill acquisition approaches in their design and prescription of training tasks; yet some limitations must be acknowledged. The study involved interviewing elite swim coaches in Australia therefore it is possible that their international counterparts may differ in practice design and prescription as coaching pathways and accreditations vary internationally. However, as eight of the participants have not only coached successfully in Australia but internationally (e.g. America, New Zealand, South Africa, Dubai, Great Britain and the Netherlands), these differences may be minimal. The relationship between members of the research team should also be acknowledged as a potential limitation and influencer of the results. Some members of the research team had or currently worked as a biomechanist or skill acquisition specialist with some of the participants and this may have shaped their current practice approaches and hence some of the responses provided. An additional point worth noting is that the present sample consisted of only one female coach. This imbalance is an illustration of the male-dominance in elite swimming coaching where out of the 24 ‘Platinum’ accredited coaches in Australia, only three are female. Further research is required to establish whether practice prescriptions from female swimming coaches, regardless of their accreditation, are congruent with current findings. Participants were requested to provide answers directly associated with their current training programs; yet, it is possible that the responses given may differ somewhat from their actual practice prescriptions. Finally, including training observational notes with the interview data may have added further clarity and trustworthiness to the data (Polkinghorne, 2005).

Conclusion

This study provided insights into coaches' perspectives of skill acquisition in elite freestyle swimming. It is evident that swimming coaches view swimming as a complex motor skill that requires the invariant repetition of a movement pattern (Seifert et al., 2014). Thus, designing practice tasks to enhance skill learning is viewed as a balancing act between protecting the confidence of the athletes, by providing environments that enable them to be successful, versus exposing them to more demanding tasks or situations where they might be less successful (Renshaw et al., 2009). The prescription of training practices that progress the swimming stroke from basic to full coordination, or decompose the stroke into component parts were common approaches used to develop skill among the swimming coaches sampled. Participants also indicated the use of constraint manipulations (e.g. swimming with a parachute) to better facilitate transfer of learning. The participant responses indicated that swimming coaches seem to intuitively use variants of the constraints-led approach in their practice design, yet they may be unaware of the theoretical context behind using it (Renshaw et al., 2019). The recent interactions coaches had with a skill acquisition consultant may have helped shape the implementation of such approaches in practice. Further empirical research is required to determine the positive (or negative) effect that the common training tasks have on skill learning, transfer, and performance. Regardless, the experiential knowledge from coaches provides insights into swimming high-performance training programmes in Australia and can guide future research protocols to better facilitate the transfer of empirical findings to the performance environment (Greenwood et al., 2014).

Declaration of Interest

None

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References

Araújo, D., & Davids, K. (2015). Towards a theoretically-driven model of correspondence between behaviours in one context to another: implications for studying sport performance. *International Journal of Sport Psychology, 47*(1), 745-757.

Araújo, D., Davids, K., & Passos, P. (2007). Ecological validity, representative design, and correspondence between experimental task constraints and behavioral setting: Comment on Rogers, Kadar, and Costall (2005). *Ecological Psychology, 19*(1), 69-78. doi:10.1080/10407410709336951

Arellano, R., Domínguez-Castells, R., Perez-Infantes, E., & Sánchez, E. (2010). *Effect of Stroke Drills on Intra-cycle Hip Velocity in Front Crawl.* Paper presented at the 6th International Symposium for Biomechanics & Medicine in Swimming, Oslo, Norway: Norwegian School of Sport Science.

Barris, S., Davids, K., & Farrow, D. (2013). Representative learning design in springboard diving: Is dry-land training representative of a pool dive? *European Journal of Sport Science, 13*(6), 638-645. doi:10.1080/17461391.2013.770923

Barris, S., Farrow, D., & Davids, K. (2013). Do the kinematics of a baulked take-off in springboard diving differ from those of a completed dive. *Journal of Sports Sciences, 31*(3), 305-313. doi:10.1080/02640414.2012.733018

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative research in psychology, 3*(2), 77-101.

Braun, V., & Clarke, V. (2013). *Successful qualitative research: A practical guide for beginners*: Sage.

Braun, V., Clarke, V., & Terry, G. (2015). *Thematic analysis.* Paper presented at the Qualitative Research in Clinical and Health Psychology, Basingstoke: Palgrave MacMillan.

Braun, V., Clarke, V., & Weate, P. (2016). Using thematic analysis in sport and exercise research. In B. Smith & A. Sparkes (Eds.), *Routledge handbook of qualitative research in sport and exercise* (pp. 191-205). London: Routledge.

Brison, T. A., & Alain, C. (1996). Should common optimal movement patterns be identified as the criterion to be achieved? *Journal of Motor Behavior, 28*(3), 211. doi:10.1080/00222895.1996.9941746

Chow, J. Y., Davids, K., Button, C., & Renshaw, I. (2015). Specificity of transfer and representative learning design. In I. Renshaw, J. Y. Chow, K. Davids,

& C. Button (Eds.), *Nonlinear pedagogy in skill acquisition: An introduction* (pp. 89-101). London, UK: Routledge.

Côté, J., & Gilbert, W. (2009). An integrative definition of coaching effectiveness and expertise. *International Journal of Sports Science & Coaching, 4*(3), 307-323. doi:10.1260/174795409789623892

Côté, J., Young, B. W., North, J., & Duffy, P. (2007). Towards a definition of excellence in sport coaching. *International Journal of Coaching Science, 1*(1), 3-17.

Counsilman, J. E., & Counsilman, B. E. (1994). *The New Science of Swimming*: Englewood Cliffs, N.J. : Prentice Hall.

Davids, K., Button, C., & Bennett, S. (2008). *Dynamics of skill acquisition: A constraints-led approach*: Champaign, IL : Human Kinetics.

Davids, K., Kingsbury, D., Bennett, S., & Handford, C. (2001). Information-movement coupling: Implications for the organization of research and practice during acquisition of self-paced extrinsic timing skills. *Journal of Sports Sciences, 19*(2), 117-127. doi:10.1080/026404101300036316

Davids, K., Renshaw, I., Pinder, R., Greenwood, D., & Barris, S. (2017). The role of psychology in enhancing skill acquisition and expertise in high performance programmes. In N. Weston, G. Breslin, & S. Cotterill (Eds.), *Sport and exercise psychology: Practitioner case studies* (pp. 329-353). United Kingdom: Wiley-Blackwell.

Dehghansai, N., Headrick, J., Renshaw, I., Pinder, R., & Barris, S. (2019). Olympic and Paralympic coach perspectives on effective skill acquisition support and coach development. *Sport, Education and Society, 25*(6), 667-680. doi:10.1080/13573322.2019.1631784

Deschodt, V., Arsac, L., & Rouard, A. (1999). Relative contribution of arms and legs in humans to propulsion in 25-m sprint front-crawl swimming. *European journal of applied physiology and occupational physiology, 80*(3), 192-199. doi:10.1007/s004210050581

Ericsson, K. A., Krampe, R. T., & Tesch-Römer, C. (1993). The role of deliberate practice in the acquisition of expert performance. *Psychological review, 100*(3), 363.

Farrow, D., & Robertson, S. (2017). Development of a skill acquisition periodisation framework for high-performance sport. *Sports Medicine, 47*(6), 1043-1054. doi:10.1007/s40279-016-0646-2

Fleming, P., Young, C., Dixon, S., & Carré, M. (2010). Athlete and coach perceptions of technology needs for evaluating running performance. *Sports Engineering, 13*(1), 1-18. doi:10.1007%2Fs12283-010-0049-9

Fontana, A., & Frey, J. (2005). The interview: from neutral stance to political involvement. In N. K. Denzin & Y. S. Lincoln (Eds.), *The Sage Handbook of Qualitative Research* (pp. 695-727): Sage.

Ford, P. R., Yates, I., & Williams, A. M. (2010). An analysis of practice activities and instructional behaviours used by youth soccer coaches during practice: Exploring the link between science and application. *Journal of Sports Sciences, 28*(5), 483-495. doi:10.1080/02640414.2010.506490

Greenwood, D., Davids, K., & Renshaw, I. (2012). How elite coaches' experiential knowledge might enhance empirical research on sport performance. *International Journal of Sports Science & Coaching, 7*(2), 411-422.

Greenwood, D., Davids, K., & Renshaw, I. (2014). Experiential knowledge of expert coaches can help identify informational constraints on performance of dynamic interceptive actions. *Journal of Sports Sciences, 32*(4), 328-335. doi:10.1080/02640414.2013.824599

Guignard, B., Rouard, A., Chollet, D., Bonifazi, M., Dalla Vedova, D., Hart, J., & Seifert, L. (2019). Upper to Lower Limb Coordination Dynamics in Swimming Depending on Swimming Speed and Aquatic Environment Manipulations. *Motor control, 23*(3), 418-442. doi:10.1123/mc.2018-0026

Guignard, B., Rouard, A., Chollet, D., Hart, J., Davids, K., & Seifert, L. (2017). Individual-environment interactions in swimming: The smallest unit for analysing the emergence of coordination dynamics in performance? *Sports Medicine, 47*(8), 1543-1554. doi:10.1007%2Fs40279-017-0684-4

Hardy, L., Barlow, M., Evans, L., Rees, T., Woodman, T., & Warr, C. (2017). Great British medalists: psychosocial biographies of super-elite and elite athletes from Olympic sports. In V. Walsh, M. Wilson, & B. Parkin (Eds.), *Progress in brain research* (Vol. 232, pp. 1-119): Elsevier.

Junggren, S. E., Elbæk, L., & Stambulova, N. B. (2018). Examining coaching practices and philosophy through the lens of organizational culture in a Danish high-performance swimming environment. *International Journal of Sports Science & Coaching, 13*(6), 1108-1119. doi:10.1177/1747954118796914

Krause, L., Farrow, D., Buszard, T., Pinder, R., & Reid, M. (2019). Application of representative learning design for assessment of common practice tasks in tennis. *Psychology of sport and exercise, 41*, 36-45. doi:10.1016/j.psychsport.2018.11.008

Krause, L., Farrow, D., Reid, M., Buszard, T., & Pinder, R. (2018). Helping coaches apply the principles of representative learning design: validation of a tennis specific practice assessment tool. *Journal of Sports Sciences, 36*(11), 1277-1286. doi:10.1080/02640414.2017.1374684

Louise, B., & While, A. (1994). Collecting Data using a semi-structured interview: a discussion paper. *Journal of advanced nursing, 19*(2), 328-335.

Magill, R. A. (2007). *Motor learning and control : concepts and applications* (8th ed. ed.). Boston: McGraw-Hill.

Maloney, M., Renshaw, I., Headrick, J., Martin, D. T., & Farrow, D. (2018). Taekwondo fighting in training does not simulate the affective and cognitive demands of competition: Implications for behaviour and transfer. *Frontiers in psychology, 9*, 25. doi:10.3389/fpsyg.2018.00025

Martindale, R., & Nash, C. (2013). Sport Science Relevance and Application: Perceptions of UK Coaches. *Journal of Sports Sciences, 31*(8), 807-819.

Masters, R. (2008). Skill learning the implicit way—Say no more! In D. Farrow, J. Baker, & C. MacMahon (Eds.), *Developing sport expertise: Researchers and coaches put theory into practice* (pp. 111-125): Routledge.

McGowan, C. J., Pyne, D. B., Raglin, J. S., Thompson, K. G., & Rattray, B. (2016). Current warm-up practices and contemporary issues faced by elite swimming coaches. *The Journal of Strength & Conditioning Research, 30*(12), 3471-3480. doi:10.1519/JSC.0000000000001443

Mooney, R., Corley, G., Godfrey, A., Osborough, C., Newell, J., Quinlan, L. R., & ÓLaighin, G. (2016). Analysis of swimming performance: perceptions and practices of US-based swimming coaches. *Journal of Sports Sciences, 34*(11), 997-1005. doi:10.1080/02640414.2015.1085074

Newell, K. (1986). Constraints on the development of coordination. In M. G. Wade & H. T. A. Whiting (Eds.), *Motor development in children : aspects of coordination and control* (pp. 341-361). Boston, MA: Martinus Nijhoff Publishers.

Newell, K., & Ranganathan, R. (2010). Instructions as constraints in motor skill acquisition. In I. Renshaw, K. Davids, & G. J. P. Savelsbergh (Eds.), *Motor learning in practice : a constraints-led approach* (pp. 17-32). London, New York Routledge.

Nowell, L. S., Norris, J. M., White, D. E., & Moules, N. J. (2017). Thematic analysis: Striving to meet the trustworthiness criteria. *International Journal of Qualitative Methods, 16*(1). doi:10.1177/1609406917733847

Nugent, F. J., Comyns, T. M., & Warrington, G. D. (2017). Quality versus quantity debate in swimming: Perceptions and training practices of expert swimming coaches. *Journal of Human Kinetics, 27*(1), 147-158. doi:10.1515/hukin-2017-0056

O'reilly, M., & Parker, N. (2013). 'Unsatisfactory Saturation': a critical exploration of the notion of saturated sample sizes in qualitative research. *Qualitative research, 13*(2), 190-197. doi:10.1177/1468794112446106

Patterson, L. B., & Backhouse, S. H. (2018). "An important cog in the wheel", but not the driver: Coaches' perceptions of their role in doping prevention. *Psychology of sport and exercise, 37*, 117-127. doi:10.1016/j.psychsport.2018.05.004

Patton, M. Q. (1999). Enhancing the quality and credibility of qualitative analysis. *Health services research, 34*(5 Pt 2), 1189-1208.

Patton, M. Q. (2002). *Qualitative research & evaluation methods* (3 ed. ed.): Sage Publications.

Pilgrim, J., Robertson, S., & Kremer, P. (2016). A qualitative investigation into the role of the caddie in elite-level golf. *International Journal of Sports Science & Coaching, 11*(4), 599-609. doi:10.1177/1747954116654783

Pinder, R., Davids, K., Renshaw, I., & Araújo, D. (2011a). Manipulating informational constraints shapes movement reorganization in interceptive actions. *Attention, Perception, & Psychophysics, 73*(4), 1242-1254. doi:10.3758/s13414-011-0102-1

Pinder, R., Davids, K., Renshaw, I., & Araújo, D. (2011b). Representative learning design and functionality of research and practice in sport. *Journal of Sport and Exercise Psychology, 33*(1), 146-155. doi:10.1123/jsep.33.1.146

Pinder, R., Headrick, J., & Oudejans, R. R. (2015). Issues and challenges in developing representative tasks in sport. In J. Baker & D. Farrow (Eds.), *The Routledge Handbook of Sports Expertise* (pp. 269-281). Milton Park, U.K: Routledge.

Polkinghorne, D. E. (2005). Language and meaning: Data collection in qualitative research. *Journal of counseling psychology, 52*(2), 137. doi:10.1037/0022-0167.52.2.137

Proteau, L. (1992). On the specificity of learning and the role of visual information for movement control. In L. Proteau & D. Elliot (Eds.), *Advances in Psychology* (Vol. 85, pp. 67-103): Elsevier.

Pyne, D. B. (2016). Working With the Coach. *International Journal of Sports Physiology and Performance, 11*(2), 153-153. doi:10.1123/IJSPP.2016-0034

Reid, M., Whiteside, D., & Elliott, B. (2010). Effect of skill decomposition on racket and ball kinematics of the elite junior tennis serve. *Sports biomechanics, 9*(4), 296-303. doi:10.1080/14763141.2010.535843

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

Renshaw, I., Davids, K., Newcombe, D., & Roberts, W. (2019). *The Constraints-Led Approach: Principles for Sports Coaching and Practice Design*: Routledge.

Renshaw, I., Davids, K. W., Shuttleworth, R., & Chow, J. Y. (2009). Insights from ecological psychology and dynamical systems theory can underpin a philosophy of coaching. *International Journal of Sport Psychology, 40*(4), 540-602.

Rothwell, M., Stone, J. A., Davids, K., & Wright, C. (2017). Development of expertise in elite and sub-elite British rugby league players: A comparison of practice experiences. *European Journal of Sport Science, 17*(10), 1252-1260. doi:10.1080/17461391.2017.1380708

Schmidt, R. A., & Lee, T. D. (2011). *Motor control and learning : a behavioral emphasis* (5th ed. ed.): Human Kinetics.

Schnitzler, C., Brazier, T., Button, C., Seifert, L., & Chollet, D. (2011). Effect of velocity and added resistance on selected coordination and force parameters in front crawl. *The Journal of Strength & Conditioning Research, 25*(10), 2681-2690. doi:10.1519/JSC.0b013e318207ef5e

Seifert, L., Button, C., & Brazier, T. (2010). Interacting constraints and inter-limb co-ordination in swimming. In I. Renshaw, K. Davids, & G. J. P. Savelsbergh (Eds.), *Motor learning in practice : a constraints-led approach* (1 ed., pp. 83-98). London; New York Routledge.

Seifert, L., Button, C., & Davids, K. (2013). Key properties of expert movement systems in sport. *Sports Medicine, 43*(3), 167-178. doi:10.1007/s40279-012-0011-z

Seifert, L., & Davids, K. (2012). Intentions, perceptions and actions constrain functional intra-and inter-individual variability in the acquisition of expertise in individual sports. *The Open Sports Sciences Journal, 5*(8), 68-75. doi:10.2174/1875399X01205010068

Seifert, L., Komar, J., Barbosa, T., Toussaint, H., Millet, G., & Davids, K. (2014). Coordination pattern variability provides functional adaptations to constraints in swimming performance. *Sports Medicine, 44*(10), 1333-1345. doi:10.1007/s40279-014-0210-x

Slade, D. G., Button, C., & Cochrane, D. (2015). Do the Structures Used by International Hockey Coaches for Practising Field-Goal Shooting Reflect Game Centred Learning Within a Representative Learning Design? *International Journal of Sports Science & Coaching, 10*(4), 655-668. doi:10.1260/1747-9541.10.4.655

Smith, B., & McGannon, K. R. (2018). Developing rigor in qualitative research: Problems and opportunities within sport and exercise psychology.

International review of sport and exercise psychology, 11(1), 101-121. doi:10.1080/1750984X.2017.1317357

Smith, B., & Sparkes, A. (2013). *Qualitative research methods in sport, exercise and health: From process to product* (1 ed.). New York, USA: Routledge.

Steel, K. A., Harris, B., Baxter, D., & King, M. (2013). Skill acquisition specialists, coaches and athletes: the current state of play? *Journal of Sport Behavior, 36*(3), 291–305.

Stewart, A. M., & Hopkins, W. G. (2000). Seasonal training and performance of competitive swimmers. *Journal of Sports Sciences, 18*(11), 873-884. doi:10.1080/026404100750017805

Telles, T., Barbosa, A. C., Campos, M. H., & Júnior, O. A. (2011). Effect of hand paddles and parachute on the index of coordination of competitive crawl-strokers. *Journal of Sports Sciences, 29*(4), 431-438. doi:Effect of hand paddles and parachute on the index of coordination of competitive crawl-strokers

Thompson, A., Bezodis, I. N., & Jones, R. L. (2009). An in-depth assessment of expert sprint coaches' technical knowledge. *Journal of Sports Sciences, 27*(8), 855-861. doi:10.1080/02640410902895476

Vella, S., Oades, L., & Crowe, T. (2011). The Role of the Coach in Facilitating Positive Youth Development: Moving from Theory to Practice. *Journal of Applied Sport Psychology, 23*(1), 33-48. doi:10.1080/10413200.2010.511423

Waters, A., Phillips, E., Panchuk, D., & Dawson, A. (2019). The coach–scientist relationship in high-performance sport: Biomechanics and sprint coaches. *International Journal of Sports Science & Coaching, 14*(5), 617-628.

Whelan, N., Kenny, I. C., & Harrison, A. J. (2016). An insight into track and field coaches' knowledge and use of sprinting drills to improve performance. *International Journal of Sports Science & Coaching, 11*(2), 182-190. doi:10.1177/1747954116636716

Williams, A. M., Ford, P., Causer, J., Logan, O., & Murray, S. (2012). Translating theory into practice: Working at the 'coal face'in the UK. In N. J. Hodges & A. M. Williams (Eds.), *Skill acquisition in sport: Research, theory and practice* (pp. 353-366). New York: Routledge.

Williams, A. M., & Ford, P. R. (2009). Promoting a skills-based agenda in Olympic sports: The role of skill-acquisition specialists. *Journal of Sports Sciences, 27*(13), 1381-1392. doi:10.1080/02640410902874737

Williams, S. J., & Kendall, L. (2007). Perceptions of elite coaches and sports scientists of the research needs for elite coaching practice. *Journal of Sports Sciences, 25*(14), 1577-1586. doi:10.1080/02640410701245550

Williams, T. L., Smith, B., & Papathomas, A. (2018). Physical activity promotion for people with spinal cord injury: physiotherapists' beliefs and actions. *Disability and rehabilitation, 40*(1), 52-61. doi:10.1080/09638288.2016.1242176

Yanai, T. (2003). Stroke frequency in front crawl: its mechanical link to the fluid forces required in non-propulsive directions. *Journal of Biomechanics, 36*(1), 53-62. doi:10.1016/S0021-9290(02)00299-3

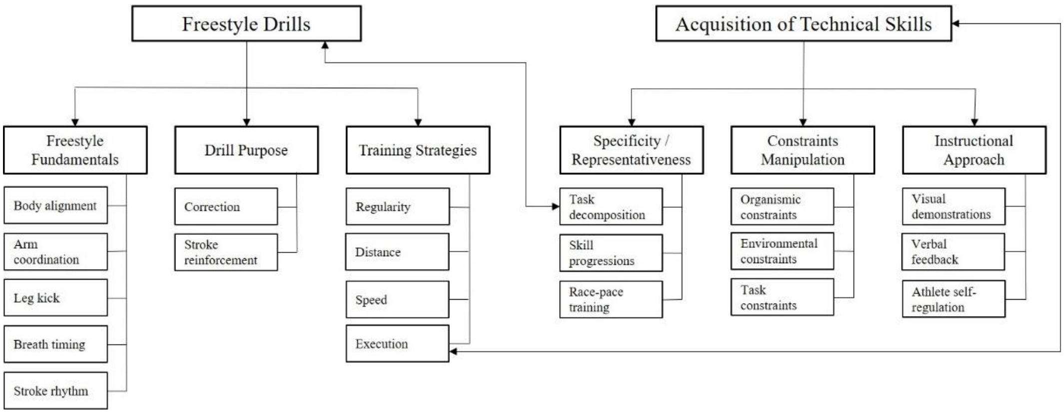

Figure 1. Australian swimming coaches' skill acquisition approaches in training and key goals behind the freestyle training drills most commonly prescribed.

Table 1. Most mentioned freestyle drills, key task goals and variations.

Drill Name(s)	Task Goal(s)	Variations
Single arm *"one arm freestyle"*	• Breath timing • Body position / alignment	Single arm swimming with non-swimming arm straight in front (slightly easier) or arm directly by the athlete's side.
Long dog *"dog paddle"* *"short dog"*	• Catch position (hand entry) • Underwater recovery (pull phase) • Body rotation • Stroke rhythm (arm coordination)	
Polo *"head-up freestyle"*	• Catch position (hand entry) • Stroke rhythm (arm coordination) *"kayaking principle"*	*"head-up freestyle with butterfly kick"* or named *"Popov"*.
Kicking	• Body position / alignment	Kicking either placing arms straight in front (slightly easier) or arms directly by the athletes' side.
Sculling	• *"feel" for the water and to ensure that the "arms and body is in a position to perform well"*	