An explicit look at implicit learning

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An Explicit Look at Implicit Learning: an Interrogative Review for Sport Coaching Research and Practice

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ABSTRACT

Over the past 30 years, implicit coaching has emerged as a popular learning tool and pre-emptive intervention to avoid choking under pressure. Despite advocacy in the sport coaching literature, however, we are concerned that theoretical, methodological, and practical issues have potentially inflated or obscured its utility for coaching practice. In this paper, we lay out and elaborate on these concerns to stimulate critical dialogue that benefits sport coaches, performers, and their support teams and better situates the tool within the realities of real-world practice and delivery. Based on our review of extant evidence, we conclude that available implicit-learning methods are impractical and presently offer limited utility for sport coaching. Going forward, if scholars are to establish the relevance and impact of implicit methods, then research must directly address and respond to the challenges presented in this paper and adopt a more pragmatic perspective that better accounts for applied sporting contexts.

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In this paper, we take an applied and theoretical perspective towards evaluating a coaching approach that has received considerable attention over the past 30 years: implicit motor learning (Masters, 1992). Rooted in cognitive models of skill acquisition (e.g., Fitts & Posner, 1967), where learners progress from verbal-cognitive through to associative and then autonomous stages, implicit motor learning has been explained as "the acquisition of a motor skill without the concurrent acquisition of explicit knowledge about the performance of that skill" (Maxwell, Masters, & Eves, 2000, p. 111) that is "applied automatically or independently of working memory" (Maxwell, Masters, & Eves, 2003, p. 378). According to Masters and Maxwell (2008), "evidence counsels against the development of a large amount of consciously accessible, task-relevant declarative knowledge during motor learning" (p. 163), because such declarative knowledge is

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associated with reinvestment (i.e., propensity to consciously control and disrupt automatised movement) and choking. Instead, Masters and colleagues have argued that "there are benefits if motor skills can be learned implicitly" (Masters, 2000, p. 538), rather than explicitly, as "implicit motor learning appears to give the learner immunity from reinvestment" (Masters & Maxwell, 2008, p. 164). Elaborating on this, Maxwell et al. (2000) clarified that "skills that are initially learnt through explicit processes, and subsequently become automated, may be referred to as implicit but do not fall into the categorization used" (pp. 111–112). In other words, if we have understood correctly, implicit learning is the *process* by which skills are acquired and not an eventual performance *state*. In the literature, implicit learning has typically been characterised as universally effective, providing advantages compared to traditional explicit instructions for coaching the acquisition of motor skills in sport. In this regard, proponents of the approach argue that implicit methods promote skill acquisition that is robust to psychological pressure, physiological fatigue and cognitive distraction (see Poolton & Zachry, 2007) and represent a potential long-term tool for developing elite athletes (Gabbett & Masters, 2011; Masters, 1992). Commenting on its potential utility for sport coaching, in his conclusion to the initial study to investigate implicit learning in sport, Masters (1992) stated:

> The [implicit learning] results draw critical attention to long-accepted methods of coaching, particularly the somewhat 'hit and hope' identification of potentially elite performers, followed by an earnest attempt to nurture them through to world class standards of performance with prolonged, explicit instruction in how to execute the skills of the sport. It is the contention of the author that such prolonged explicit instruction can increase the chance that the skill of the potentially elite performer will not withstand the pressure accompanying performance in the world arena (p. 356).

In the years that have followed, scholars have built on these initial claims, extolling the benefits of implicit methods and how they may be broadly applied to sport coaching practice (e.g., Poolton & Zachry, 2007). For instance, Gabbett and Masters (2011, p. 574), in their advocation of "an effective implicit learning culture" for professional sports such as rugby league, argued that analogies, dual-task paradigms, and errorless learning represent methods "designed to facilitate the development of *implicit* skills that transfer robustly to high-performance competition". In more recent research relating to coaching, Cormack and Gillman (2022) explored and advocated the integration of implicit methods by curling coaches for "robust skill acquisition", while Powell, Wood, Kearney, and Payton (2021) recently examined the practices of coaches in the British Para Swimming World Class Programme, including their use of implicit techniques for reducing "opportunities for reinvestment and performance breakdown" (pp. 1098–

1099). Implicit learning is, therefore, of current interest across both research and applied domains.

Despite the popularity of and advocacy for implicit instruction from sport coaching scholars and practitioners, however, implicit strategies have recognised limitations as noted in the sport psychology (e.g., Beek, 2000; Bobrownicki, Collins, Sproule, & MacPherson, 2018) and motor learning literature (e.g., Bobrownicki, MacPherson, Coleman, Collins, & Sproule, 2015) that we feel significantly impact their utility for applied coaching practice. Crucially, this other side of the argument has not yet been presented for sport coaches. As such, we posit that there is a need to address these issues and extend further concerns very specifically for sport coaching audiences to provide needed balance to the discourse in this area. From an academic perspective, we must point out that previous attempts to critically engage with implicit learning researchers on such issues has yet to yield any responses (see commentaries of Bobrownicki, Carson, & Collins, 2022; Bobrownicki et al., 2018), while the continued application of identified limitations within research suggests limited progress towards recognising the value of these attempts. With this in mind, we aim to explicitly lay out these concerns with an interrogative review of research and practice concerning implicit instruction in sport coaching. In doing this, we wish to stimulate a critical dialogue that (a) puts the reality and needs of sport performers at the forefront of what drives good translational research and improvements in coaching and coach education and (b) more accurately captures the complexities and nuances that characterise real-world practice.

Academic focus with limited applied utility

To date, researchers have investigated implicit instruction using a range of methods – such as dual-task (e.g., counting backwards in threes; Maxwell et al., 2000), errorless (e.g., reducing the likelihood of a bad result; Maxwell et al., 2003), and subliminal learning (e.g., unconscious perception of knowledge of results; Masters, Maxwell, & Eves, 2009) – and have subsequently promoted these tools to coaches for use in real-world sport (e.g., Gabbett & Masters, 2011; Poolton & Zachry, 2007). Upon initial inspection, these learning strategies and their associated studies appear well designed and informative, but a closer examination reveals that the utility and relevance of these studies are predominantly academic and laboratory focused with limited validity for real-world sport. For instance, given the difficulty of (a) manipulating realistic levels of challenge or (b) only subliminally permitting knowledge of results (i.e., allowing observation of results for such a short time interval that athletes are not consciously aware of ever perceiving those results), as acknowledged by Poolton and Zachry (2007), research using these strategies can only realistically cater to

scholarly interests. In other words, these laboratory-restricted strategies are exploring psychology *through* sport rather than *for* sport (see Collins & Kamin, 2012). As Ely et al. (2021) recently pointed out, an intervention that works well in theory offers limited meaning or purpose – in addition to inviting scepticism – if it cannot be readily applied in practice.

There is a place for science-focused research that explores fundamental mechanisms *through* sport, but such research, which pervades the implicit-learning literature, is currently insufficient to support the recommendations directed toward coaches and athletes for implicit learning. As it has been 30 years since scholars began researching implicit learning in sport, the dearth of *for*-sport or applied research in this area is deeply concerning in the face of its active and frequent promotion to coaches. Adding to these concerns, the literature has also principally focused on novice participants (see Table 1) in short-term interventions with task-irrelevant pressure manipulations, raising more questions regarding its applied utility and further suggesting that the applied recommendations have forged far ahead of the available research evidence.

Issues raised with investigative designs used to evaluate implicit methods

In order to investigate the merits of instructional tools for coaching practice, it is *essential* to employ representative and robust research designs with equitable comparison groups (Bobrownicki, Carson, MacPherson, & Collins, 2022); otherwise, any resulting theoretical developments or recommendations for applied practice may be dubious and open to question. Concerningly, the literature has highlighted persistent methodological concerns of this manner in implicit learning studies over the past 3 decades (e.g., Bobrownicki et al., 2018, 2015; Bobrownicki, MacPherson, Collins, & Sproule, 2019) which will limit or compromise translation to sport coaching contexts (Bobrownicki, Carson, MacPherson, & Collins, 2022). A critical issue relates to the selection of inequitable and unrepresentative comparison groups when evaluating implicit learning methods (Bobrownicki, Carson, MacPherson, & Collins, 2022). For analogy learning specifically, which was designed to address the limitations of the laboratory-based methods mentioned in the preceding section, the comparison groups typically feature at least six times as many verbal instructions (see Bobrownicki et al., 2018 for detailed breakdown of studies in this area) and often provide superfluous information without equivalence in the analogy group (e.g., eight explicit instructions that detail movement before, during and after a softball swing vs. a single softball batting analogy that describes movement only during the swing; Capio, Uiga, Lee, & Masters, 2020). As coaches would ordinarily provide relevant instruction in manageable chunks (Tse, Fong, Wong, &

Table 1. Characteristic tendencies across the implicit learning literature, including a focus on novice participants at the earliest stages of motor learning and/or inequitable comparisons between experimental and comparison groups.

Study	Task	Participant groups	Conditions	Number of words in instructions	Number of rules for instructions	Other notes
Zeniya and Tanaka (2021)	Dart throwing	Novices (45 young adults)	Rule-based analogy	47	3	
			Information-integrated analogy	23	1	
			Explicit	20	3	
Meier, Frank, Gröben, and Schack (2020)	Tennis serve	Intermediates (44 junior athletes)	Analogy	104	8	
			Explicit	71	8	
Capio et al. (2020)	Softball batting	Novices (20 adults)	Analogy	16	1	
		Intermediates (20 adults)	Explicit	69	8	
Bobrownicki et al. (2019)	Dart throwing	Novices (20 adults)	Analogy	50	4	Analogy and explicit instructions balanced and provided one by one
			Explicit	65	4	
			Baseline	5	1	
Meier, Fett, and Gröben (2019)	Tennis serve	Intermediates (44 junior athletes	Analogy	104	8	Specific analogy/explicit rules provided dependent on athlete needs over 5 weeks
			Explicit	71	8	
van Duijn et al. (2019)	Hockey push pass	Novices (48 adults)	Analogy	15	1	No instruction group provided goal-oriented instruction
			Explicit	48	6	
			No Instruction	12	1	
Tse, Wong, and Masters (2017)	Table tennis topspin forehand	Novices (36 young adults)	Analogy	14	1	
		Novices (34 older adults)	Explicit	78	9	
Tse, Fong, Wong, and Masters(2017)	Rope skipping	Novices (32 children)	Analogy	104	11	Skill instructions also included directions for study protocols
			Explicit	113	11	
Bobrownicki et al. (2015)	High jumping	Novices (21 adults)	Analogy	20	2	First analogy study to try control volume of instruction in line with real-world coaching practice
			Explicit Light	20	3	
			Traditional Explicit	96	8	

(*Continued*)

Table 1. (Continued).

Study	Task	Participant groups	Conditions	Number of words in instructions	Number of rules for instructions	Other notes
Schücker et al. (2013)	Golf putting	Novices (41 young adults)	Analogy	6	1†§	Participants also received visual instructions in each condition
			Explicit	86	6§	
Vine et al. (2013)	Golf putting	Novices (45 young adults)	Analogy	22	1	
			Explicit	n/r	6	
Schlapkohl, Hohmann, and Raab (2012)	Study 1: Table tennis forehand	Novices (56 young adults)	Analogy	11	1	
			Explicit	88	5	
	Study 2: Table tennis forehand	Novices (56 young adults)	Analogy	11	1	
			Explicit	88	5	
	Study 3: Table tennis	Novices (56 young adults)				
	Undercut stroke		Discus analogy	10	1	
			Explicit	83	5	
	Counter hit		Soldier analogy	14	1	
			Explicit	88	5	
	Topspin forehand		Stroke analogy	16	1	
			Explicit	82	5	
Koedijker et al. (2011)	Table tennis topspin forehand	Novices (15 young adults)	Analogy	14	1	
		Experts (15 young adults)	Explicit	46	5	
Rendell et al. (2011)	Netball shooting	Experts (2 adults)	Secondary task and modified ring	n/a	n/a	
Zhu, Poolton, Wilson, Maxwell, and Masters (2011)	Golf putting	Novices (18 young adults)	Errorless	n/a	n/a	
			Errorful	n/a	n/a	

(*Continued*)

Table 1. (Continued).

Study	Task	Participant groups	Conditions	Number of words in instructions	Number of rules for instructions	Other notes
Schücker, Ebbing, and Hagemann (2010)	Golf swing	Novices (51 adults)	Analogy	30	n/a	
			Explicit	30	n/a	
Lam, Maxwell, and Masters (2009a)	Seated basketball shooting	Novices (24 young adults)	Analogy	17	1	
			Explicit	81	8	
Lam et al. (2009b)	Seated basketball shooting	Novices (27 young adults)	Analogy	19	1	
			Explicit	78	8	
Masters, Poolton,andMaxwell (2008)	Rugby passing	Novices (41 young adults)	Errorless	n/a	n/a	
			Errorful	n/a	n/a	
Koedijker, Oudejans, and Beek (2007)	Table tennis topspin forehand	Novices (34 adults)	Analogy	≈ 33	2‡	
			Explicit	88	14‡	
Poolton et al. (2007a)	Rugby passing	Novices (46 young adults)	Errorless	n/a	n/a	
			Errorful	n/a	n/a	
Poolton, Masters, and Maxwell (2007b)	Table tennis topspin forehand	Novices (28 adults)	Analogy	14	1	
			Explicit	n/r	6	
Poolton et al. (2006)	Table tennis topspin forehand	Novices (35 young adults)	Analogy	14	1	
			Explicit	53	6	
Law, Masters, Bray, Eves, and Bardswell (2003)	Table tennis topspin forehand	Novices (28 young adults)	Analogy	n/r	1	
			Explicit	n/r	6	

(*Continued*)

Table 1. (Continued).

Study	Task	Participant groups	Conditions	Number of words in instructions	Number of rules for instructions	Other notes
Liao and Masters (2001)	Table tennis topspin forehand	Novices (30 young adults)	Analogy	≈ 29	2‡	Participants also provided additional visual demonstrations or verbal instructions
			Implicit	n/a	n/a	
			Explicit	n/r	12‡	
Bright and Freedman (1998)	Golf putting	Novices (48 adults)	Dual-task	n/a	n/a	Replication of Masters (1992)
			Explicit	n/r	13‡	
Hardy, Mullen, and Jones (1996)	Golf putting	Novices (32 adults)	Dual-task	n/a	n/a	Replication of Masters (1992)
			Explicit	n/r	13‡	
Masters (1992)	Golf putting	Novices (40 adults)	Dual-task	n/a	n/a	
			Explicit	n/r	13‡	

Notes: n/a = does not apply n/r = not reported. § Participants also received pictures demonstrating technique ‡ Exact wordings of instructional groups not provided

Masters, 2017), rather than in the long lists that typify the research, analogies need to be evaluated against comparison groups that better reflect and correspond to real-world best practice. In the case of implicit learning, any issues with the comparison groups will have unintentionally enhanced the apparent efficacy of implicit learning, relative to explicit instruction, while stigmatising traditional coaching practices.

Unfortunately, comparison groups featuring these unrepresentative and mismatched imbalances are common (e.g., Capio et al., 2020; Lam, Maxwell, & Masters, 2009b; Liao & Masters, 2001; Poolton, Masters, & Maxwell, 2006; Schücker, Hagemann, & Strauss, 2013; Tse, Wong, & Masters, 2017; van Duijn, Hoskens, & Masters, 2019) and characterise the implicit learning literature (see Bobrownicki , Carson, & Collins, 2022 for more detailed discussion). These disparities in instructional quantity, quality and relevance have the potential to result in critical differences in, for example, cognitive and physical loading, attentional focus, and athlete understanding that will confound results (see Bobrownicki, Carson, MacPherson, & Collins, 2022) and, we suggest, limit the relevance of such studies for coaches. Indeed, research has empirically demonstrated that matching the explicit instructions to analogies in terms of quantity (i.e., by reducing the number of instructions) and content (i.e., by ensuring the instructions pertain to the same desired movement) reduces the advantages of analogy learning compared to the traditional imbalanced explicit instruction conditions (e.g., Bobrownicki et al., 2015; Zeniya & Tanaka, 2021). Because few studies have addressed or acknowledged these common and critical issues (e.g., by adapting the designs, by justifying the methodological choices, or by responding directly to the points raised), trustworthy evidence supporting implicit learning appears limited and, as a result, we put forward that any results from this literature should be very cautiously interpreted.

Need for internal checks to validate the impact of implicit methods

To this point, scholarship in implicit instruction has predominantly focused on short-term, laboratory-based learning of simple movement skills. Real-world sport, however, often requires long-term permanent learning outcomes of complex skills (Schmidt & Wrisberg, 2008). Indeed, to appropriately guide applied practice and assess the impact of possible interventions, follow-up checks months or even years later are required to fully evaluate the persistence and stability of the desired skills (Carson, Collins, & Jones, 2014). In the one case where there has been longitudinal exploration of implicit and explicit processes, Poolton et al. (2007a) found that participants in the implicit and explicit conditions of a rugby-passing skill demonstrated *no* differences in performance, amount of verbal knowledge, or resilience to fatigue 1 year after the start of the study. These findings were despite significant differences

during the initial data collection in both declarative knowledge and the impact of fatigue on performance. To explain the unexpected similarities after 1 year between the implicit and explicit learners, the authors posited that the explicit group might have experienced a "decay of declarative knowledge" or a "consolidation of declarative knowledge as implicit memories" (p. 456). With either explanation, we would first argue that these results hint at a potentially limited real-world impact for implicit learning in coaching contexts if explicit learners are ultimately going to move and behave as if they had learnt implicitly in the first place. Second, if researchers want to enhance their case for implicit learning and develop greater understanding of its real-world impact, then there will be a need to demonstrate sustained learning via follow-up checks on its impact on performance and, potentially, other relevant factors (e.g., understanding, motivation, adherence, etc.).

Of course, to get to that stage, we must also be aware that checks are necessary not only *after* initial data collection, but also *during*. As Poolton, Maxwell, Masters, and Raab (2006) noted, "performers actively seek out the most efficient sources of information" (p. 98) and, with this in mind, they may choose to rely on other sources of information or instructions than those intended (cf. Orr, Cruickshank, & Carson, 2021). In support of this, internal checks by Bobrownicki et al. (2015) found that several participants were following instructions for other previously taught skills, while Bobrownicki et al. (2019) observed variation in the interpretation of the provided instructions that led to deviations in the desired movement. With this in mind, internal checks on athlete understanding should warrant consideration.

Questions regarding mechanistic processes – is it possible to learn without working memory involvement?

Even if we accepted that implicit learning works for tightly controlled tasks under short-term laboratory conditions, scholars have not established that it alone can lead to sustained benefits for complex, whole-body tasks in real-world coaching contexts. In fact, in studies with expert performers, evidence suggest that conscious access to specific and important mechanical factors is involved in and facilitates performance (Ericsson, 2020). Furthermore, we are unaware of empirical data published within sport coaching to show that elite athletes/performers achieve their status using implicit motor learning practices or techniques that are independent of working memory. Conversely, what does appear to be growing within the literature is the evidence base and prevalence for conscious interventions toward movement mechanics as an action-focused strategy to avoid negative anxiety–performance effects (e.g., Kearney, Carson, & Collins, 2018; Landman, Nieuwenhuys, & Oudejans, 2016; Nicholls, Holt, Polman, & James, 2005; Orr et al., 2021), even within the performance arts where the aesthetic

qualities of movements represent crucial elements of performance (Montero, 2015). Therefore, given the almost exclusive use of novices within implicit learning studies, it would seem ill-founded to advise that the method be used for those seeking lifelong engagement within, or at the top of, a performance domain.

Putting aside the practicality of becoming an elite performer using implicit methods, another important challenge must be addressed: identifying strategies for promoting technical change to skills that are already well established, long practised, and learnt. For elite performers and experienced non-elites alike, the requirement to make small technical changes is an almost inevitable feature of their training. Indeed, several motivations for implementing such modifications might include physical changes to one's body due to ageing or injury (or potentially injurious technique); changes to equipment technology, rules or conditions, as a response to other competitor innovations; or aspirations for a new "edge" for the experienced performer. To date, we are only aware of one study attempting small technical modifications with appropriately skilled and experienced participants using an implicit approach. In this study, Rendell, Farrow, Masters, and Plummer (2011) showed that implicit methods did not successfully change the skill in the desired way with data revealing that kinematic outcomes were unpredictably in the *opposite* direction to that intended. It *could* be argued that an incremental method to change could implicitly "shape" the movement in a desired direction; however, smaller changes are shown to be less persistent within memory when compared to larger changes (Kostrubiec, Tallet, & Zanone, 2006; Kostrubiec & Zanone, 2002; Tallet, Kostrubiec, & Zanone, 2008, 2010), or at least small changes that are made more noticeable (Collins, Morriss, & Trower, 1999; Hanin, Malvela, & Hanina, 2004). Accordingly, implicit instruction has yet to address widely held and supported views that change must include an initial stage of conscious de-automation of the to-be-changed technical component (Beilock, Carr, MacMahon, & Starkes, 2002; Carson & Collins, 2011; Christina & Corcos, 1988; Oudejans, Koedijker, & Beek, 2007; Toner & Moran, 2014), which would, therefore, limit its relevance within elite, high-performance environments.

Self-acknowledged issues in application and relevance of implicit methods

Typically, when it comes to changing professional practice, there is a certain amount of buy-in or "selling" required, which is an established and expected component of the applied sport science support process (Boutcher & Rotella, 1987). Confusingly, however, proponents of implicit learning have

stated that these methods are impractical for sport coaching specifically. For instance, Poolton and Zachry (2007) explained that:

> the trouble with the initial implicit motor learning techniques [dual-task, errorless, and subliminal methods], however, was that they tended to be somewhat less than practical for a teaching or coaching environment . . . Obviously, using these methods in the practical arena would be at best a nuisance and at worst confusing and demotivating to learners (p. 69).

Further acknowledging these concerns, Gabbett and Masters (2011) contended "that it is simply not feasible for a performer to always employ the implicit motor learning paradigms that have been developed and validated in experimental laboratories" (p. 569). Consequently, these authors advocated downplaying verbal instructions and discouraging step-by-step processing of motor skills in the coaching context. Our point here is that whilst we agree, we are surprised to see so much continued effort aimed at implicit approaches more than 10 years following these statements directed toward sport coaches (e.g., Lola & Tzetzis, 2021; Zeniya & Tanaka, 2021).

Moreover, it is also apparent that these authors advocate using explicit methods, as Poolton and Zachry (2007) stated:

> Remember, the alternative motor learning techniques we have discussed [i.e., analogy] are technically explicit in nature but have certain implicit attributes. In this respect, introducing a skilled performer to a technique like an analogy or an external attentional focus strategy is actually just replacing one type of explicit learning technique with another, presumably more effective, explicit technique.

Further to this, Masters (2000) also conceded that coaching without explicit instruction is "unlikely to be viewed by the pupil as satisfactory" (p. 538) and that the use of analogies might help address this. On these specific points, we agree with the forthright analyses offered by Masters (2000), Poolton and Zachry (2007), and Gabbett and Masters (2011). Where we become confused, however, is how these points lead to and justify the continued use of implicit methods, its promotion to coaches, and the condemnation of explicit instructions. If, after 30 years and dozens of studies, the only acknowledged and practical basis of implicit learning for coaching rests on and requires analogy instruction, which evidence suggests is just very efficient explicit instruction (see Bobrownicki et al., 2015 for empirical demonstration), then the scientific support and practical relevance of implicit methods for sport coaching appear tenuous and insufficient to support its application.

Notably, recent theoretical advancements from a motoric perspective have explained that the content and modality of explicit instruction are vital in being able to successfully activate the desired motor representation from long-term memory (Carson & Collins, 2016). In short, not all explicit instruction is equally effective or disruptive to performance, learning, or

technical refinement. Poolton et al. (2006) seemed open to this idea when stating that it is the accumulation of verbal knowledge that disrupts motor skills and not an internal focus on the movement per se. Indeed, recent studies by Masters and colleagues (Malhotra, Poolton, Wilson, Omuro, & Masters, 2015; van Ginneken et al., 2017) have started differentiating between different types of movement reinvestment: movement self-consciousness (relating to conscious *monitoring*) and conscious motor processing (i.e., *controlling* movement mechanics). So far, developments on this front appear to be focused on what exactly differentiates between monitoring and controlling processes, but with laboratory results demonstrating some benefit for each at different phases (i.e., early or late) of practice. Although these developments are much welcomed and represent a significant change from the view that reinvestment is *always* negative, we would suggest that further examination in a manner that disregards the applied evidence and/or applied challenges will result in data and findings that only serve academic interests and, once again, limit the impact for sport coaches and athletes.

Reflecting on good coaching practice: is what remains relevant to coaches?

According to Poolton and Zachry (2007), "research attempts to provide answers and solutions, but it can never supplant the wisdom and judgement of a good practitioner" (p. 75). To this point, however, implicit learning research has not effectively considered or incorporated such applied expert wisdom or judgement. Our assessment of the literature to date, reconciled against our own understanding of applied coaching contexts, has led to the following conclusions for real-world coaching. First, despite recommendations for the minimisation or elimination of errors (i.e., errorless learning), it is advantageous to have an appropriate balance between successful and unsuccessful executions during the early acquisition phase of novices' learning (see Guadagnoli & Bertram, 2014). Second, being provided with simple and easily understood instructions benefits the later selection and execution of that movement (see Schempp, McCullick, St. Pierre, Woorons, You, & Clark, 2004). Third, not *over*loading working memory is beneficial for learning, either as a strategy, which focuses on the whole action or important components of the action (see Mullen & Hardy, 2010). Fourth, explicit learning is effective and practically appropriate in the applied setting when following these guidelines and implicit learning is, largely, not. Regrettably, as applied researchers, coaches, and coach educators with an interest in the translation of research into practice, the delayed arrival of these conclusions has been a frustrating, confusing and misrepresented journey that might have been avoided if researchers had adopted a pragmatic approach that

sought to understand "good" or even "best" coaching practice at the time and were more cautious in their conclusions given the limited data to support translation. Instead, it seems that the idea of implicit methods for motor learning was elevated to great heights – with a fundamental focus on developing theory – through comparison with poor coaching practice. Looking back, and forward, our suggestion is that it is better to develop and compare against what works rather than to push it to one side as a means to demonstrate (potential) innovation.

Next steps

Given the widespread promotion of implicit learning for elite athletes and coaches over the past three decades, the need for critical examination of these approaches specifically *for coaching* has now become vital. As we have laid out above, despite the advocation of implicit strategies, the research has focused on the psychological processes and mechanisms that underlie motor learning, specifically in early and short-term learning scenarios, rather than the translational aspects that will be relevant for sport coaches and athletes. In short, the implicit motor learning approaches, which researchers have acknowledged are impractical to administer, have been translated beyond the research evidence and its implications.

Although the initial inspiration for implicit learning was intriguing and worthy of investigation, if there is relevance and value for implicit learning in sport coaching in the present day, scholars in this area will urgently need to address the cited issues and acknowledge more real-world concerns (see Bobrownicki et al., 2015). This might include written responses to articles such as this (e.g., to clarify misunderstandings, to identify areas of common ground or potential collaboration, or to rebut) or empirical work that directly addresses the known issues and challenges in this area (which have been discussed here and previously in cognate areas of sport science). A continuation of the status quo – where criticisms are not addressed or remain unacknowledged – is not in the interest of applied practitioners who will want to understand how, why, and when to either apply or avoid implicit methods.

As part of addressing these issues, scholars will need to take heed of the principles put forward by Bobrownicki, Carson, MacPherson, and Collins (2022) to carefully select and design comparison groups in order to maximise translation to applied contexts. In particular, the recommendations regarding the types of comparison groups to include (e.g., no treatment, placebo/alternative task, variable delivery, and active treatment/best practice) and key factors when designing these (e.g., real-world relevance, timing, cognitive loading, physical loading, athlete understanding, and epistemology) will be paramount to enhance validity, ensure interpretability

of the findings, and address the acknowledged challenges in this research area. In addition, scholars should be clearer about the aims of any research (e.g., *for* sport, *through* sport or *of* sport) and, depending on these aims, exercise more caution about extrapolating to real-world contexts that may go beyond the research findings.

Interestingly, in the peer-review process for this article, which challenged our thinking and helped to refine and strengthen our arguments, previews of the potential critical debate and examination that is needed in the literature began to emerge, which the reviewers encouraged us to convey to the readership. For instance, there was discussion of the appropriate timescale and skill level for applying implicit methods. In our reading, implicit learning has been presented as a long-term developmental strategy (i.e., across entire developmental pathways from beginner to expert), but one reviewer questioned this interpretation, stating that there was uncertainty "when or where it has been advised that the method be used for those seeking lifelong engagement within a performance domain". As (a) experts are prominently mentioned across the literature (e.g., Gabbett & Masters, 2011; Masters, 1992; Poolton & Zachry, 2007), (b) choking and reinvestment are phenomena primarily associated with skilled performance (as reinvestment disrupts automaticity of experts; Cooke, Kavussanu, McIntyre, Boardley, & Ring, 2011), and (c) skill learning/refinement is a continuous process for athletes (Carson & Collins, 2011), if implicit learning is not a long-term strategy, then we feel this represents a critical area for revision, clarification, and/or debate in the literature to avoid confusion and to enhance understanding. In the review process, there was similar scholarly debate regarding analogy instruction and its classification as either an implicit or explicit method with it put forward that "even if an explicit instruction is used, who is to say that it cannot result in the promotion of implicit learning". Again, if implicit learning, which is noted for its impracticality, can be promoted via explicit methods, then there is an urgent need to clarify or reconsider the value of implicit methods for real-world sport going forward.

Alongside such scholarly discussions and contentions, there were also areas for potential alignment identified with reviewers offering more nuanced and measured assessments of implicit learning. For us, these nuanced perspectives better reflect the complex reality of real-world sport, which will be rooted in coaches' professional judgement and decision making (PJDM, Abraham & Collins, 2011; Martindale & Collins, 2005). For instance, one of the reviewers commented, "it is impossible to maintain such an [implicit] approach over extended periods of time – both implicit and explicit knowledge will accrue. Fundamentally, the approach just suggests that the ratio of explicit to implicit can, and perhaps should, be altered". Rather than pitting implicit methods versus explicit methods,

which we feel cannot be supported by the current evidence, such nuanced perspectives – which acknowledge and seek to better understand the purpose, contribution, and balance of different learning methods (e.g., implicit *and* explicit) and their associated knowledge – would represent a meaningful step forward.

Despite this optimism, however, the wider field is not yet at this stage, as the language and terminology used in the literature (e.g., "analogy *versus* explicit instructions", Lam et al., 2009b; explicit instructions can be "neither effortless nor efficient", van Duijn, Crocket, & Masters, 2020) do not present these approaches as tools to be deployed as appropriate by the coach, but as *competing* approaches where one (i.e., explicit) leads to choking under pressure and the other (i.e., implicit) robustness against such choking. For instance, when Masters (2000) stated that "the weight of evidence available at the present time suggests that there are benefits if motor skills can be learned implicitly" (p. 538), this, to us, is a recommendation to use implicit methods *rather* than explicit methods and, as such, requires reconsideration.

Nevertheless, if scholars can and do pursue a more nuanced, PJDM-informed approach going forward, which explores and is open to the potential contributions of both explicit and implicit learning strategies for sport, they might also consider more diverse methods for investigating and understanding their utility and relevance (see Bobrownicki et al., 2019, Bobrownicki, Carson, MacPherson, & Collins, 2023). In this regard, there has been limited consideration of the effects of these methods on psychological factors such as motivation, enjoyment, confidence, or adherence, which will be relevant to and informative for applied practitioners beyond performance outcome and movement measures. Indeed, a recent study with elite divers suggested athlete preferences for explicit instructions – as these instructions were perceived to enhance confidence and to help in coping with sport-related anxiety (Henderson, Bloom, & Alexander, 2022) – and could provide a meaningful starting point for more nuanced research that better accounts for real-world coaching and athletic environments.

Conclusion

Our main aim in this paper has been to critically explore theory, application, and practice relating to implicit methods for sport coaching. Despite merit in the initial idea, the myriad issues pertaining to ecological challenges, contentious methodological choices, and inequitable comparisons to real-world practice mean that the available implicit methods are currently impractical and offer limited utility for sport coaching at this time. Despite being translated beyond the evidence, implicit coaching has persisted as a prominent construct and remained in the foremost consciousness

of scholars and practitioners (e.g., the development of a coaching fraamework for the Irish Rugby Football Union, Smith et al., 2022). Concerningly, the actual learning effects of implicit learning do not themselves appear to persist for nearly as long and the preferred delivery method of implicit coaching is – apparently unironically – via explicit instruction.

The application of scientific principles within practice requires careful consideration and criticality by coaches in order to provide and maintain a "cutting edge" advantage for performers (e.g., Stoszkowski, MacNamara, Collins, & Hodgkinson, 2021). Occasionally, novel or non-mainstream ideas can be presented within research that have yet to undergo rigorous amounts of testing to be certain of any practical benefit. Here, both coaches and support scientists must be extra thorough in their thinking *if* they are to have sufficient confidence that such a new idea will assist their performer. Whether or not a decision is made to adopt a change in practice immediately, some of these ideas are eventually better understood, developed through research, and proven through practice with a strong translational evidence base to support ongoing use with performers. Examples include motor imagery (e.g., Guillot & Collet, 2008) or pre-performance routines (e.g., Rupprecht, Tran, & Gröpel, 2021). Given these circumstances, it is important for coach education bodies to advocate an understanding of *why* these ideas work, so that coaches can optimally deploy them with the right performer, at the right time and in the right way. In other instances, however, further research can demonstrate that what *might* have seemed a good/reasonable/interesting idea at one time, ultimately turns out to offer limited benefits to coaching practice. On this latter point, for coaches and support personnel, it is important to know not only what works but also to formally recognise what does not within the coaching literature. This is especially true when ideas and practices prevail within education programmes and/or are publicised on social media as valuable and effective coaching tools without the requisite evidence to support their application. Despite the positive press, however, and similar to other common, yet ill-supported approaches (e.g., discovery learning and the notion of learning styles; Mayer, 2004; Pashler, McDaniel, Rohrer, & Bjork, 2009), we posit that there are numerous theoretical, methodological and practical concerns that might significantly limit the apparent usefulness of implicit learning for real-world coaching practice that coaches will want to carefully consider. If researchers and practitioners in implicit learning are to establish and justify its relevance and utility for sport coaching, they will urgently need to address the significant methodological and practical issues set forth in this paper and more pragmatically consider the role and contribution of implicit methods for sport coaching within a PJDM toolbox.

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Interests to declare

None

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