1. Introduction

In this response article, I consider and react to some of the main issues and remarks made in the commentaries to my target article, ‘Towards a Grand Unified Theory of sports performance’. It was both reassuring and satisfying to receive two highly favourable reviews from the anonymous reviewers during the peer-review process. Although some of the commentators were somewhat less enthusiastic and supportive of my ideas, I am satisfied that the target article has broadly fulfilled its goal of stimulating critical discussion and provoking scholarly debate on what is an important contemporary topic. I hope this collection of articles will provide a useful resource for high-performance practitioners seeking to gain a more holistic understanding of sports performance and for academics aspiring to increase the impact and reach of their sports performance research. I thank the commentators, both for their considered contributions and for their patience whilst I prepared this response, and also the Editor, Peter Beek, for commissioning and coordinating this Special Issue of Human Movement Science.

2. Aim, motivation, and intention of the target article

Cobley, Sanders, Halaki, and O’Dwyer, in particular, were seemingly somewhat bewildered about what I was trying to achieve in the target article. From the outset, I would like to point out that the target article was only intended to be a proposal to the sports science community, hence why I purposefully entitled it “Towards a Grand Unified Theory …”. I am by no means claiming that the target article contains all the answers to the problems that continue to afflict contemporary applied sports science or that the theoretical approach described is some kind of panacea for the field that has regularly been criticised—as Williams and Ward did—for being descriptive, fragmented, and lacking theoretical rationale. As evidenced by previous target articles published in Human Movement Science (e.g., van Ingen Schenau, 1989), this format of article provides an excellent forum for open dialogue and I had hoped that the commentaries would collectively contribute to the development of the Grand Unified Theory (GUT) given the varied backgrounds and expertise of the commentators, and, together, consensus could be achieved or, at least, worked towards. Regrettably, however, it appears that I have only been partially successful at achieving this aim. Nevertheless, moving forwards, I hope the target article continues to stimulate discussion, both among and between academics and applied practitioners in high-performance sport—especially those who Cardinale insists are already engaging in interdisciplinary support work—and, in conjunction with the commentaries, will provide strategic direction to the field.

3. Originality of ideas – beyond Newell (1986)?

Despite acknowledging in the target article that many of the principles and concepts of the proposed GUT are not new, a number of commentaries criticised the ideas being conveyed for lacking originality. Cobley, Sanders, Halaki, and O’Dwyer contended that the proposed GUT was little more than Newell’s (1986) model of constraints reframed as a theory that contained no new theoretical...
concepts or provided any further explanations. Williams and Ward also remarked that the arguments made in the target article do not advance the field much further than those presented in previous decades, citing Davids, Handford, and Williams (1994) as a specific example. Before discussing these respective issues, it needs emphasising that the basis of the proposed GUT is just as much the formation and self-organisation of coordinative structures—as Lopez-Felip and Turvey correctly asserted—as it is Newell’s constraints framework.

There are, at least, two main advancements in the target article that appear to have gone unnoticed by these, and other, commentators. The first advancement is the extension of Newell’s (1986) model of constraints to the inter-individual level of analysis. Originally, this tripartite model was formulated to explain motor coordination in children performing both phylogenetic (‘natural’) and ontogenetic (‘cultural’) activities, which had previously required separate theoretical explanations (see Newell, 1989). As acknowledged in the introductory section of the target article, it has since been applied to various aspects of sport, including sports performance, but predominantly at the intra-individual level of analysis. The recent extrapolation of the coordinative structure concept to the inter-individual level of analysis (see Riley, Richardson, Shockley, & Ramenzoni, 2011; Araújo & Davids, 2016) has afforded the opportunity to broaden the scope of the constraints model and has enabled it to be applied to all levels of analysis—a key feature in fulfilling the requirements of a GUT.

The second advancement in the target article is the promotion of the constraints model as a basis for increasing interdisciplinary collaboration within and among high-performance practitioners and researchers conducting applied sports science studies, and the explicit identification of key physiological and psychological variables affecting sports performance within the constraints framework. Following a comprehensive review of the ‘natural-physical’ approach to motor behaviour, Davids et al. (1994) made a similar recommendation to the sports science community about the opportunity for interdisciplinary research, but their proposals only made fleeting reference to Newell’s (1986) model of constraints. Additionally, they tended to focus on potential links between biomechanics and motor learning/control—as others have before (e.g., Dillman, 1989; Gregor, Broker, & Ryan, 1992) and since (e.g., Bartlett, 1997; Glazier, Wheat, Pease, & Bartlett, 2006), albeit not necessarily with the same rationale—whereas the GUT outlined in the target article aspires to incorporate all subdisciplines. Although Sands has argued to the contrary (see Section 8), very few, if any, previous attempts have been made in the literature over the past few decades to unite and unify the subdisciplines of sports science using such rigorous underpinning science.

4. Characteristics, criteria, and application of GUTs

There was some conjecture in the commentaries about what constitutes a GUT and whether the approach outlined in the target article fulfilled the qualifying criteria. It was this difference of opinion and/or interpretation that perhaps led Williams and Ward to proclaim that they had “... no great confidence that a unifying theory of sports performance is something that is even achievable” (Williams & Ward, 2017)—a viewpoint shared by Hackfort. Williams and Ward had earlier claimed that “... while the approach may have some utility as a descriptive and illustrative framework, ultimately, it falls considerably short of the type of unifying theory proposed by Glazier (2017). It does not satisfy some of the basic criteria required by the scientific community to constitute a theory” (Williams & Ward, 2017). Cobley, Sanders, Halaki, and O’Dwyer also argued that the GUT “... does not adhere to criteria for being grand or unified” (Cobley, Sanders, Halaki, & O’Dwyer, 2017).

Although there were some inconsistencies, the commentators identified several key deficiencies with the proposed approach that they believed prevented it from fulfilling the requirements of a GUT. First, it was argued that the proposed approach does not enable testable hypotheses to be postulated (Williams and Ward; Rein, Perl, and Memmert) and, therefore, is not falsifiable (Williams and Ward). Second, it was claimed that the proposed approach does not provide any information about underlying causal mechanisms (Williams and Ward; Rein, Perl, and Memmert), has no explanatory power (Williams and Ward), and cannot be used to make predictions about future behaviours (Williams and Ward). Finally, it was asserted that the proposed approach does not incorporate multiple theories from other disciplines to make a bigger collective (Cobley, Sanders, Halaki, and O’Dwyer).

Taken at face value, these concerns appear to be legitimate and may be perceived to represent significant impediments to the proposed approach attaining GUT status. However, on closer inspection of the generally accepted characteristics and criteria of a GUT (e.g., Fawcett, 2005; Ayres, 2008; Davidoff, Dixon-Woods, Leviton, & Michie, 2015)—many of which were covered in Footnote 1 of the target article—most of these putatively disqualifying issues are actually commensurate with those required for a GUT. To recap, GUTs are not designed with the express purpose of generating hypotheses nor are they meant to be falsifiable. Rather, GUTs are intended to provide a broad, overarching explanation for a discipline or body of knowledge and a foundation on which to develop mid-range and micro theories, which display many of the hallmark features that some of the commentaries incorrectly associate with a GUT.

To be clear, the GUT label is not extravagant or pretentious as Hackfort implied and, just because GUTs do not lead directly to the generation of hypotheses or experimentation, it does not mean they are merely a “... sophisticated form of storytelling” (Sands, 2017) as Sands insinuated. I somewhat agree with the proposal of Rein, Perl, and Memmert that the constraints model—and, by elaboration, the proposed GUT—should be regarded more as a phenomenological framework. Indeed, GUTs by their nature are phenomenological, rather than structural, in that they deal in abstract laws and principles rather than dedicated structures and mechanisms (see Beek, Peper, & Stegeman, 1995, for further discussion of the key distinctions between phenomenological and structural approaches). Criticism has been directed previously at the phenomenology of dynamical systems and constraints-based approaches (e.g., Carson & Riek, 1998; Rosenbaum, 1998), and Summers (1998), in particular, raised concerns regarding the apparent lack of clarity about where constraints come from, which ones are relevant, and how they interact. However, whilst these are clearly important and valid
issues, they become less conspicuous if expressed in the context of a GUT.

5. Multidisciplinary, interdisciplinary, or transdisciplinary?

The majority of the commentaries were in agreement with the target article that adopting an interdisciplinary approach would likely facilitate collaboration and make a significant contribution to a more holistic understanding of sports performance—a viewpoint shared recently by Buckers et al. (2016) and Ibáñez-Gijón et al. (2017). Hackfort, however, was somewhat more sceptical, not so much about the utility and application of adopting an interdisciplinary approach, but more about whether the proposed GUT affords an interdisciplinary approach—or even a multidisciplinary or transdisciplinary approach, for that matter. He argued: "... multidisciplinary is no option for Glazier, but the characteristics of either interdisciplinary or transdisciplinary are not reflected in his approach and construction. My impression is that he is striving for transdisciplinarity but he refers to interdisciplinarity" (Hackfort, 2017).

One explanation for Hackfort’s pessimistic assessment is how he defines the terms multidisciplinary, interdisciplinary, and transdisciplinary, which seem to be somewhat at odds with the accepted definitions that feature in the literature (e.g., see Burwitz, Moore, & Wilkinson, 1994; Freedson, 2009). To recop, multidisciplinary and interdisciplinary approaches both involve input of knowledge and/or methods from two or more subdisciplines, but, importantly, the former involves the subdisciplines working in parallel whereas the latter necessitates the subdisciplines working integratively. The term transdisciplinary has seldom featured in the sports science literature and, when it has (e.g., Abernethy et al., 2013), it has tended to be used interchangeably with interdisciplinary. Beyond sports science, there have been some efforts to distinguish between the two terms (e.g., Rosenfield, 1992), but these attempts have lacked consistency and have only contributed to the ambiguity. So, whilst Hackfort may have a point depending on which set of definitions are being used, the discussion serves little purpose in terms of developing a GUT for sports performance and remains largely an issue of semantics.

6. Scope of application

The target article was very clearly focused on proposing a GUT of sports performance. However, Williams and Ward made multiple references—at least seven by my reckoning—to the need to develop theory that has wider societal application. Although a noble aspiration that may have some merit—or perhaps a strategic ploy to increase the likelihood of acquiring grant funding that Cardinale correctly identified as being inaccessible and woefully lacking in sports science—it is, nevertheless, beyond the intended scope and remit of the proposed GUT. I would suggest that the complex, multi-faceted, topic of sports performance poses sufficient “common problems or questions” and enough of a “shared agenda” to warrant the pursuit of interdisciplinary research—expedited and supported by a thoughtfully constructed GUT—even if Williams and Ward do not.

Cardinale bemoaned the proposed GUT for having “no consideration of genomics advancements … not only related to the identification of performance traits but also to the adaptability of individuals to different training paradigms” (Cardinale, 2017). He is correct in that the proposed GUT does not make explicit reference to recent advancements in genomics but, then again, it was not intended to. What it does provide, however, is an indication of how genetic constraints impact on sports performance, albeit without providing a material description of those constraints (see Section 4). It is these genetic constraints, alongside other organismic constraints (e.g., musculoskeletal architecture), that determine the preferred modes of coordination and control or ‘intrinsic dynamics’ of each individual (Kelso, 1995; see also Kostrubiec, Zanone, Fuchs, & Kelso, 2012), which, in large part, dictate their relatively unique performance predispositions and capabilities. Furthermore, although the proposed GUT was devised specifically to account for the relatively short timescales of sports performance, it does have application to relatively longer developmental timescales typically associated with training responses. Interested readers are directed to Baker and Davids (2006), and Davids and Baker (2007), for reviews on the influence of genetic constraints on training responses and other aspects of sports performance.

7. Interfacing (perceptual) information and (movement) dynamics

Cardinale remarked that the “... ability to learn and read the situations” (Cardinale, 2017) should be included as psychological constraints in the proposed GUT and, in so doing, indirectly drew attention to the importance of attuning to perceptual information, not only in decision making, but also motor learning (see Araújo & Davids, 2011). His recommendation was supported by more formal proposals from Seifert, Araižo, Komar, and Davids, who promoted their ‘ecological dynamics’ approach (see Section 8), and, more particularly, Lopez-Felipe and Turvey, who recommended a ‘functional semantics’ based on the concepts of dexterity (Latash & Turvey, 1996) and affordances (Gibson, 1979) to help explain the formation and self-organisation of coordinative structures with respect to perceptual information at the intra- and inter-individual levels of analysis.

I agree with Seifert, Araižo, Komar, and Davids and Lopez-Felipe and Turvey about the need to better understand how individuals pickup and use perceptual information to guide their actions during sports performance. I also cannot disagree with their proposals that affordances, as reviewed by Fajen, Riley, and Turvey (2008), offer a basis for gaining greater insight into the reciprocal relations between perception and action (i.e., information-movement coupling), especially given the substantial theoretical contributions that some of these commentators have made to the literature. However, I would respectfully suggest that affordances are still somewhat esoteric and that prudence is required when evaluating empirical data that purportedly confirm their existence and role in sports performance. For example, Lopez-Felipe and Turvey made reference to the importance of visual gaze and body orientation of the midfielder attempting to make a pass in Figure 1 of their commentary, but yet studies of affordance pickup and usage in sport have rarely examined these facets and instead have typically relied on positional data from which to make inferences (e.g., Passos, Cordovil, Fernandes, & Barreiros, 2012). Furthermore, the literature appears to be dominated by
rather dogmatic accounts of interpersonal coordination where affordances have been used as the default explanation without giving due consideration to other possibilities.

8. Alternative theoretical approaches

Sands stated, and Hackfort inferred, that there are better alternative theoretical frameworks than the GUT proposed in the target article. Sands made reference to an unnamed theoretical model putatively acquired from Eastern European sports scientists based on the “... physical, technical, tactical, psychological, and theoretical hierarchy of athlete development” (Sands, 2017). However, from the information provided, the approach seems to have a different emphasis and appears to be based more on logic than any scientifically rigorous theory. Unfortunately, since no supporting references were provided, further examination of this approach—and verification of Sands’ claim that it is superior to the proposed GUT—is not possible.

Hackfort championed an approach called ‘action-theory’, which he and his German colleagues have been developing for at least the past 30 years and have published widely on, oftentimes in their native language. The focus of action-theory seems to have predominantly been psychological (e.g., Schack & Hackfort, 2007; Nitsch & Hackfort, 2016) and, although its person-environment-task constellation draws some strong parallels, at least superficially, to the organism, environment, and task constraint distinction made in the proposed GUT, closer inspection of the literature reveals substantial differences in emphasis and theoretical basis. Specifically, it appears that the origins of action-theory are firmly rooted in cognitive science—Schack and Hackfort (2007), for example, made multiple references to concepts such as internal representations, action plans, and mental structures—and, therefore, it presumably shares many of the well-documented problems associated with information processing theory and other computational approaches to motor control. Although, admittedly, I only have a very rudimentary understanding of action-theory, it is difficult to envisage it being as all-encompassing as the proposed GUT, although Hackfort and his colleagues (e.g., Nitsch, 2009) would probably argue to the contrary.

Seifert, Araújo, Komar, and Davids stated that “… it might be more suitable to postulate a Grand Unified Theory of sports performance at the level of ecological dynamics instead of a component level of the framework (i.e., the constraints-led approach with its application in dynamical systems)” (Seifert, Araújo, Komar, & Davids, 2017) before outlining three main pillars that they suggested make it richer than the proposed GUT. Although I am empathetic to some of their suggestions, I am ambivalent about others and question whether ecological dynamics really offers that much different to the GUT outlined in the target article. As its name implies, ecological dynamics is essentially the conjunction of principles and concepts of dynamical systems theory and ecological psychology, and one of its perceived virtues seems to be that it offers a more explicit role for perceptual information. But, is this sufficient rationale to warrant a ‘new’ theory or is it simply a new take on an existing theory? A core concept of ecological dynamics is affordances (see also Section 7), but since Gibson (1982) suggested that “Affordances do not cause behaviour but constrain or control it” (p. 411), could affordances not just be interpreted as another type of (informational) constraint, as intimated in Footnote 5 of the target article (see also Riccio & Stoffregen, 1988)? Could ecological dynamics and the constraints-based approach, therefore, not just be viewed as one and the same thing, especially since most, if not all, the other pillars of ecological dynamics described by Seifert, Araújo, Komar, and Davids have been previously associated with the constraints-based approach (e.g., Davids, Button, & Bennett, 2008)?

9. Process versus outcome: measurement, analysis, and research design considerations

Williams and Ward stated that “… many aspects of performance in dynamic, open sports … are impossible to quantify other than via broad outcome measures such as win-loss margins” (Williams & Ward, 2017) before posing the following statement question: “If you can’t measure sports performance in a universal or holistic manner, how can one hope to develop a Grand Unifying Theory that predicts performance?” (p. Williams & Ward, 2017). Notwithstanding the differences of opinion as to what constitutes a GUT (see Section 3), there seems to be some confusion about what is meant by ‘sports performance’ as Hackfort, too, argued “… there is a lack of a comprehensive and consensual definition of performance” and “… the differentiation of process and result/course and outcome performance … are missing” (Hackfort, 2017).

I believe the distinction between sports performance (i.e., the outcome) and coordination and control (i.e., the processes that determine the outcome) has been adequately addressed in Footnotes 2–4 of the target article and no further elaboration will be provided here. Furthermore, regarding Williams and Ward’s concerns about measuring sports performance in a “universal or holistic manner”, I suspect they are actually referring, not only to the measurement of performance outcome and associated key performance indicators/parameters, but also the processes of coordination and control at the intra- and inter-individual levels of analysis that determine the performance outcome, and the various physiological and psychological constraints that shape coordination and control. As stated in Section 4 of the target article, I agree that this task presents a considerable challenge for sports scientists, but Williams and Ward’s comment that sports performance is “impossible to quantify” is, at best, misguided and does not acknowledge the tremendous advancements in motion tracking and wearable performance monitoring technologies over the past couple of years that Button and Croft (2017) alluded to, or the innovative theoretical and empirical developments that Rein, Perl and Memmert (2017) briefly touched on, in their respective commentaries (see also Davids et al., 2014; Passos, Davids, & Chow, 2016; Passos, Araujo, & Volossovitch, 2017, for recent summaries of this work).

Cardinale, like many other sports scientists who have worked in high-performance sport (e.g., Sands, McNeal, & Stone, 2005; Sands, 2008), drew attention to problems associated with studying elite athletes (e.g., small sample sizes, lack of experimental control, instrumentation challenges, etc.) and the difficulties surrounding publishing research findings in academic journals. Although I can empathise with his frustrations, the issues highlighted are perhaps not as significant or as insurmountable as he and
many other sports scientists believe. For example, regarding small sample sizes, a strong case has been made over recent decades—in large part, because of the rise to prominence of dynamical systems theory—for a shift towards the adoption of idiographic (individual-based), rather than more traditional nomothetic (group-based), research designs (e.g., Bates, 1996; Bates, James, & Dufek, 2004; Button, Davids, & Schöllhorn, 2006). An individual-based approach is justified because of the often considerable inter-individual variability that exists in sports performance (e.g., ‘signature’ techniques), which tends to get masked when averaging data across individuals in a group-based design (see also Neyroud, Kayser, & Place, 2016, for a similar observation in psychology). As demonstrated by Button and Croft, the adoption of an individual-based approach yielded other, arguably more insightful, information than the group-based analysis in their water safety project and they appeared to have had little trouble publishing their findings in reputable academic journals.

10. Concluding remarks

In contrast to Cobley, Sanders, Halaki, and O’Dwyer, I suggest that the proposed GUT can be used to provide a broad, overarching explanation of sports performance and a basis for narrower, more focused, mid-range and micro theory development. Owing to its practical focus, I do not anticipate the proposed GUT being “… confined to the realm of intellectual debates …” (Cardinale, 2017) as Cardinale forewarned. However, based on some of the commentaries, and also my personal experience in applied sports science, the principles and concepts underpinning the proposed GUT do not appear to be widely understood either within high-performance sport or academia, contrary to the assertions of Williams and Ward. As correctly identified by Button and Croft, many sports scientists have been slow to recognise how sports behaviours emerge from a wide range of interacting constraints and are typically reticent to explore alternative, more progressive, theoretical and experimental paradigms that may better elucidate sports performance. It is my hope that the articles comprising this Special Issue of Human Movement Science will give greater exposure to the principles and concepts of the proposed GUT and provide the impetus and inspiration for sports scientists to explore beyond more traditional approaches, which have only yielded limited insights and understanding to date.

References


