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Periodization Paradigms in the 21st Century: Evidence-Led or Tradition-Driven?

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The planning and organization of athletic training have historically been much discussed and debated in the coaching and sports science literature. Various influential periodization theorists have devised, promoted, and substantiated particular training-planning models based on interpretation of the scientific evidence and individual beliefs and experiences. Superficially, these proposed planning models appear to differ substantially. However, at a deeper level, it can be suggested that such models share a deep-rooted cultural heritage underpinned by a common set of historically pervasive planning beliefs and assumptions. A concern with certain of these formative assumptions is that, although no longer scientifically justifiable, their shaping influence remains deeply embedded. In recent years substantial evidence has emerged demonstrating that training responses vary extensively, depending upon multiple underlying factors. Such findings challenge the appropriateness of applying generic methodologies, founded in overly simplistic rule-based decision making, to the planning problems posed by inherently complex biological systems. The purpose of this review is not to suggest a whole-scale rejection of periodization theories but to promote a refined awareness of their various strengths and weaknesses. Eminent periodization theorists—and their variously proposed periodization models—have contributed substantially to the evolution of training-planning practice. However, there is a logical line of reasoning suggesting an urgent need for periodization theories to be realigned with contemporary elite practice and modern scientific conceptual models. In concluding, it is recommended that increased emphasis be placed on the design and implementation of sensitive and responsive training systems that facilitate the guided emergence of customized context-specific training-planning solutions.

Keywords*:* emergent, biological complexity, athletic training, planning solutions

Periodization Theory: Origins and Legacy

Frederick Winslow Taylor is not a name often associated with athletic training planning. To recap some history: Taylor was the academically inclined factory supervisor who became the founding father of "scientific management," the first application of scientific principles to the production industry. Taylor's landmark 1911 publication *The Principles of Scientific Management*[1] combined the scientific knowledge of the day, his pioneering time-and-motion studies, and management's historical prejudice toward workers ("All we want of them is to obey the orders we give them") to construct the first great planning paradigm of the modern era.

Taylor's approach was typified by the belief that there was "one best way" to organize, manage, and plan production and that this "best" template could be uncovered through observation and analysis. Industrialists of the day readily embraced the intuitively appealing logic of Taylor's regimented paradigm. Henry Ford famously adapted Taylor's methodology to the automobile industry. In sociopolitical contexts, Taylor's influence was similarly widespread. Most notably his writings are cited as shaping the planning philosophies of Lenin, with many parallels between scientific management doctrine and later Soviet 5-year templates.[2]

This historical appeal can be attributed to a number of factors. First, when Taylor's methodology was applied to machine-shop environments, productivity improved. Second, the rigorous dissection and empiricization of the production problem resonated with a society awakening to the explanatory power of the scientific method. Third, the reduction of the planning problem to a set of formulaic "rules" and automatized solutions satisfied the deep-seated human attraction to simplicity and explanatory closure, tempering our innate aversion to uncertainty and ambiguity.[3,4]

The purpose of this diversion is solely to highlight that this historically pervasive ideology exerted a profound shaping influence on planning practice across

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domains. In relation to sports preparation this legacy is evident when comparing commonalities between industrial planning models and formative periodization concepts, both approaches seeking to control future outcomes through the decomposition of the overall process to a series of distinctly focused sequential units and subsequent arrangement of these units in a mathematically predetermined order. Thus, for example, when the historically influential Matveyev collated training records from the 1940s and 1950s it was perfectly logical that he interpreted these averaged data through the lens of pervading scientific conceptual models and applied his conclusions as per the generalized format of the culturally dominant planning paradigm.

Taylor's methodology enhanced productivity within simplistic engineering contexts; however, within broader industrial and sociopolitical domains the inefficiencies inherent when such logic was extrapolated to more complicated problems gradually became apparent. Today, governmental, military, and social planners are aware of the dangers presented by wide-sweeping assumptions and a failure to recognize the confounding far-reaching effects that minor, difficult to quantify, events may present to long-term project planning.

The question explored in this review is whether periodization philosophies have sufficiently evolved beyond this culturally pervasive planning heritage to adequately assimilate advances in scientific insight and conceptual understanding. Are periodization philosophies best understood as "the methodical, scientific procedures to help athletes achieve high levels of training and performance" previously asserted[5(p150)] or as the legacy of an outdated and scientifically naïve world view?

What Is Periodization?

Contemporary discussion is hampered by the absence of a universally accepted formal definition of *periodization*. The term was originally employed to describe programs taking the form of predetermined sequential chains of specifically focused training periods. However, today the term is frequently indiscriminately employed to describe any form of training plan, regardless of structure. The archetypal periodized model, exemplified by the writings of Matveyev,[6] was typified by a progressive segmented transition from high to low volume, and low to high intensity, accompanied by a simultaneous reduction in training variation as competitive peak approached. Since the first English translation of Matveyev's influential 1981 *Fundamentals of Sports Training,*[6] various authors have proposed novel periodized designs—for example, nonlinear,[7] block,[8] fractal,[9] and conjugate sequence.[10] Although these models differ in terms of structure and supporting rationale, there is an evident common set of shared assumptions underpinning such approaches:

- Established time frames exist for the development and retention of specific fitness adaptations.[7,11,12]
- Various fitness attributes are best developed in a sequential hierarchy (eg, strength before power, endurance before speed).[7,8,12]
- Idealized training structures, time frames, and progression schemes can be generalized across athletic subgroups.[7,8,11–14]

Inevitably arising from these premises are 2 implicit assumptions:

- Biological adaptation to a given training intervention follows a predictable course.
- Appropriate future training can be adequately forecast.

Scientific Support for Periodization Principles

The *science of periodization* is a frequently encountered phrase in exercise-science and coaching domains, with many studies commonly cited as evidencing periodization's superiority as a training organizational means. For example, in review of 15 studies of meso-cycle length (7–24 wk), 13 studies concluded that periodized training provided statistically superior performance improvements when compared with constant-repetition programs.[15] A similar review concluded that periodized strength training led to enhanced outcomes, in a variety of performance measures, in comparison with nonperiodized models.[16] A meta-analysis comparing periodized and nonperiodized strength-training programs concluded that periodized structures were more effective for males and females, individuals of varying training backgrounds, and a range of age groups.[17] A rare study failing to support superiority of periodized regimes found no difference in efficacy between undulating-periodized and nonperiodized groups when volume and intensity were equalized over a short-term period.[18] Similarly, a study employing elderly untrained participants concluded that fixed-repetition strength training was as effective in developing strength as a periodized program.[19]

Thus, the preponderance of published literature suggests that periodized structures provide enhanced benefits when compared with nonperiodized counterparts. Occasional studies have failed to demonstrate such superiority. However, such investigations have been typified by

- Subjects of low initial fitness
- Short time frames of investigation

When we reflect on these conclusions, there appears a subtle point of interpretation that is frequently overlooked. In essence, due to complicating logistical constraints, experimental designs have compared interventions regularly varying training parameters with interventions with minimal, or no, variation. Accordingly, what such studies have demonstrated is that variation is a critical aspect of effective training, *not* that periodization methodologies are an optimal means of providing variation. This may seem a semantic distinction. However, as already noted, periodized approaches are characterized by a set of shared assumptions, and although the evidence does support the need for regular training variation, other core tenets of periodization philosophy are neither supported nor refuted. Accordingly, a legitimate concern is that habitual mention of the science of periodization, and habitual uncritical acceptance of such studies as proof of the superiority of periodized structures, creates the illusion that periodized methodologies have been empirically validated. This is not the case.

Managing Training Variation

The presented evidence suggests that variation is a necessary component of effective training planning. Supporting this perspective, other research suggests that elevated training monotony—which may be broadly perceived as a lack of variation[20]—leads to increased incidence of overtraining syndromes,[21] poor performance, and frequency of banal infections.[22] Conversely, reductions in monotony have been associated with increased incidence of personal-best performances,[22] and monotony indexes have been advocated as beneficial training-regulation tools in elite rowing[23] and sprinting.[24]

A cursory glance at this literature suggests that variation is always "good," and the repetitive application of a unidirectional training stressor is always "bad." However, there are obvious logical qualifiers to be overlaid on such conclusions. First, if stimuli are excessively varied—if the performer's adaptive energy is too thinly dispersed among multiple training targets—then it seems sensible to assume that progress will be very slow, or nonexistent. Second, periodic reduction in variation, facilitating a concentrated focus on a narrow band of training targets, may serve to induce rapid development of these prioritized attributes.

Two related inferences emerge:

- Training variation is a critical component of long-term planning, *but* if adaptive energy is too widely distributed, gains may be excessively diluted.
- Repetitive application of a unidimensional training stress may induce rapid improvements in a limited range of targets, *but* if such concentrated focus is unduly prolonged the athlete will be exposed to the negative effects of unremitting monotony.

In Summary

Over a given time course, there is an apparent dynamic balance to be negotiated between (a) the variation and novelty required to offset diminishing training returns arising from excess training habituation and (b) the concentrated focus required to progress already well-developed fitness attributes. Although all periodized methodologies provide formats for modulating focus and variation, there is no direct evidence enabling us to discern between the worths of these various schemes.

Each eminent periodization theorist has proposed, based on personal perspective and interpretation of the available evidence, a "best" design scheme for providing variation over a given time frame. Although each theorist has robustly outlined a rational argument supporting his individual stance (while occasionally criticizing those of his peers),[8,25,26] it should be recognized that the evidence offered in support of such templates is sparse and circumstantial. The scarcity of evidence, coupled with an eagerness to formulize a coherent planning approach, may have facilitated the overinterpretation of a very limited evidence base.

A Realignment With Biological Reality

Given the logistical difficulties inherent when investigating such a multidimensional phenomenon, it would be unfair to criticize periodization theories based solely on a lack of specific evidence. However, there is another, less commonly considered, line of reasoning questioning the conceptual logic underpinning periodization philosophy.

A unifying thread resonating throughout the periodization literature is the quintessentially mechanistic logic employed to derive formulaic solutions to training-planning problems. Periodization philosophy hinges on the presumption that biological adaptation to future training is largely predictable and follows a determinable pattern. A logical extension of such a rationalization is that appropriate interventions can be adequately planned in advance through a straightforward process of deduction and prediction. Although this perspective is understandable in the light of historical conceptual frameworks, contemporary insights do not support such simplistic modeling of biological function.

Consider the findings of the Heritage Family Study, a large-population multicenter trial resulting in over 120 separate publications, investigating the role of genotype in mediating exercise response. As an example, training-induced changes to maximal oxygen uptake (VO_{2max}) were established to vary extensively in response to identical exercise prescriptions. The average increase in VO_{2max} was 19%. However, 5% of participants had little or no change in VO_{2max}, and 5% had an increase of 40% to >50%, despite all being subjected to a similar training stimulus.[27]

Similar diversity of interindividual responses has been reported after strength-focused interventions. For example, when 585 young men and women strength-trained for 12 weeks the average strength gain was 54%. However, the magnitudes of individual gains were distributed between 0 and 250%, with changes to cross-sectional area of targeted muscles ranging from –2% to 59%.[28] Furthermore, evidence suggests that initial status, acute response, and chronic development of trained attributes

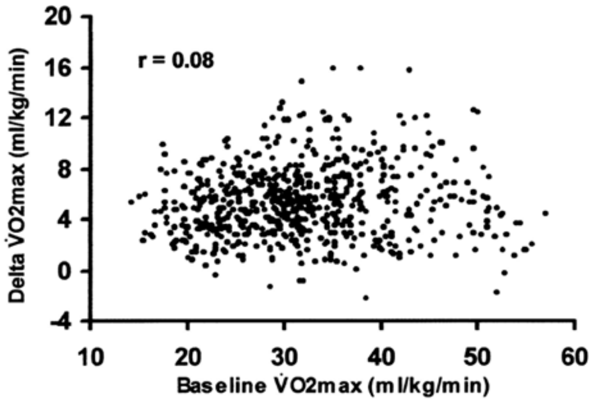

Figure 1 — Relationship between baseline maximal O_2 uptake (VO_{2max}) and change (Delta) in VO_{2max} in 633 subjects in the Heritage Family Study. ©American Physiological Society. Reproduced with permission from Skinner JS et al. *J Appl Physiol*. 2001;90:1770–1776.

are regulated by differing molecular pathways and gene networks, implying that preexisting levels of strength and/or endurance are not reliably indicative of how either attribute will respond to future training.[28,29]

Other evidence supports extensive interindividual variation among elite athletes. For example, an investigation employing professional rugby players established that a standard weight-training session resulted in a range of differing hormonal responses among a homogeneous group of players.[30] In a related study, individual testosterone responses to 4 different weight-training protocols were determined. Players then trained for 3 weeks using the protocol that elicited either their maximum or their minimum response before crossing over to the opposing protocol for a subsequent 3 weeks. All players demonstrated significant gains in strength measures subsequent to the protocol that elicited their maximum testosterone response. In contrast, when they trained using the protocol that induced their minimal response, either no change or a significant decline in strength measures resulted,[31] hence suggesting that had all players performed any arbitrarily selected session some would have benefited substantially whereas others executing the same protocol would have made little or no gains.

As further complication, consider the variety of factors demonstrated to affect release characteristics of a single member of the family of interacting androgenic hormones. Testosterone release has been noted to modulate in response to time of day, week, and month; cycles of light and dark[32,33]; ratings of work satisfaction; motivational and assertiveness levels[34]; and training stress.[35] In addition, consider the influence exerted by environmental and lifestyle factors on biological responses. For example, a wide range of imposed stressors—emotional, dietary, social, sleep, academic—have been demonstrated to variously down-regulate the immune system, dampen adaptive response, and negatively affect motor coordination, cognitive performance, mood, metabolism, and hormonal health,[36–40] consequently reducing performance[41] and elevating injury risk.[42]

Integration of these various evidence-led strands suggests that the adaptive response to imposed interventions emerges consequent to the complex interactions between a broad spectrum of inherited predispositions and chronically and acutely varying biopsychosocial factors. This includes, as suggested by the presented evidence,

- Training-loading parameters
- Epigenetic predispositions
- Legacy of previous stress exposures (including training history)
- Transient biological, psychological, and emotional states
- Transient social and environmental variables

By extension, we may conclude that

- Individual athletes will respond differently, *to one another,* to identical training sessions.
- Identical sessions performed by an individual will always elicit a unique training response, *for that athlete,* depending on transient functional states of component subsystems.
- Group-based patterns and observations may be highly misleading when generalized to individuals.
- It is highly improbable that there are "best" patterns, time frames, or progression and/or loading schemes validly applicable across training contexts.

Mechanistic Modeling of a Complex Reality

Critically, it should be acknowledged that many of our historical training conceptions are founded on the premise that responses are substantially predictable, in other words, that a known training input leads to an expected adaptive output. This may be the case when considering the "averaged" responses of a specific population to a given intervention. However, as illustrated, individual variation typically oscillates widely about such group-based means, thereby suggesting a growing disconnect between periodization ideologies that assume predictability and stability of time frames and progression schemes and the evidenced reality of biological complexity.[43,44]

The functioning of complex biological systems is characterized by deeply entangled interdependencies between component subsystems, by sensitive dependence to initial conditions and subsequently introduced "noise," and by the inherently unpredictable chain of consequences that may be initiated by any imposed action. Applied perturbations may be absorbed, distributed, and dissipated, for little or no discernible change in system functioning. Alternatively, when system states are delicately poised, finely balanced between stability and dysfunction, then a single minor event, or the ripples of seemingly innocuous interacting events, may reverberate through system components, being progressively amplified until eventually manifesting as major behavioral bifurcation.

As we cannot adequately assess the transient functional states of component subsystems or unravel the dynamically changing relationships between these subsystems, a defining characteristic of biological systems is that future behavior is impossible to accurately predict,[44,45] and the consequences of future training interventions, impossible to reliably project.

In the face of such complexity, the available training-organizational studies must be recognized as inevitably simplistic and capable of providing only the most rudimentary of insights. Although empirical studies investigating the effects of various training interventions are an invaluable necessity—in terms of unraveling generalized responses to specific interventions—the limitations inherent when such isolated context-specific findings are used to substantiate elite planning philosophies should be acknowledged. Eminent periodization theorists have constructed rational, logical arguments supporting personal perspectives. However, when the task is multifaceted and inherently complex, when discerning evidence is sparse, when sensitive comparison between training structures is not logistically feasible, then multiple coherent narratives rationalizing any given set of observations can be readily constructed.

As illustration, peer-reviewed publications have been cited as demonstrating the superiority of block periodization over more traditional designs.[46] Consider: Eleven days of high-intensity intervals are interjected into regular training patterns. Result: The experimental group improves tested parameters more than the control group continuing habituated training.[47] Conclusion: Principles of block periodization are supported. But is such interpretation a logical inference or a conclusion violating the principle of parsimony, the fundamental scientific dictate urging the acceptance of only the most frugal explanation best fitting factual observations? Is the most economical rationalization of these results that (a) block periodization represents a superior planning methodology or (b) interjecting training novelty into habituated patterns may lead to sudden performance improvements? Certainly, (b) appears a more prudent conclusion. Furthermore, (b) being true does not entail that (a) is true. Regular variation and/or periods of high-intensity training are not unique to any particular periodization philosophy and appear to be a hallmark of elite programs regardless of the stated methodology employed.

The presented evidence illustrates the extreme context specificity arising when individual biological systems, each with unique genetic predispositions and "stress" histories, interact with unique training, psychosocial, and environmental variables. Such extreme context specificity highlights 2 logical fallacies evident in the periodization literature:

- The assumption that averaged group-based trends accurately reflect likely individual responses
- The assumption that planning methodologies of celebrated high achievers—by definition extreme outliers—can be generalized and extrapolated to other elite individuals

Emergent Solutions to Complex Problems

Although the assumption of training generalizability is alluring, in the light of biological complexity this allure is revealed as illusory. More appropriately, the preparation process may be conceptualized as a guided exploration through an unknown and constantly shifting terrain. Each "preparation terrain" presents a unique navigational challenge, thus requiring a unique route map to optimally guide toward program objectives. When moving through unknown territory, having a map may provide the illusion of certainty and control. However, while having a map may be reassuring, previously used maps, inevitably of differing terrains, are inherently inaccurate. A more reliable and direct means of arriving at your destination is consistent triangulation between expectations, outcomes, and objectives.

Such reasoning suggests a shift from the historical ideal of preordained "best" training structures toward a philosophy characterized by an adaptive readiness to respond to emerging "information." From this perspective, effective planning may be perceived as the implementation of sensitive and responsive learning systems designed to enable the early detection of emerging threats and opportunities.

How such systems are designed and implemented sensibly depends on context-specific parameters such as coaching preferences, experience of the athlete, logistical limitations, and applicability of available technologies and metrics. There are certain impositions constraining the boundaries of the preparation plan: the competitive schedule, performance needs analysis, and long- and short-term goal setting. Sensibly, a broad framework should be outlined and starting points, checkpoints, and endpoints agreed on. However, within this sparse planning skeleton, training evolution may be most productively driven by emerging information continually contextualized against program constraints and objectives.

Many assessment and monitoring tools—both objective and subjective—are available and represented in the literature, with many sure to follow as technological innovation continues to drive improvements in capabilities and accessibility.

The hallmarks of such information-driven learning processes may sensibly include

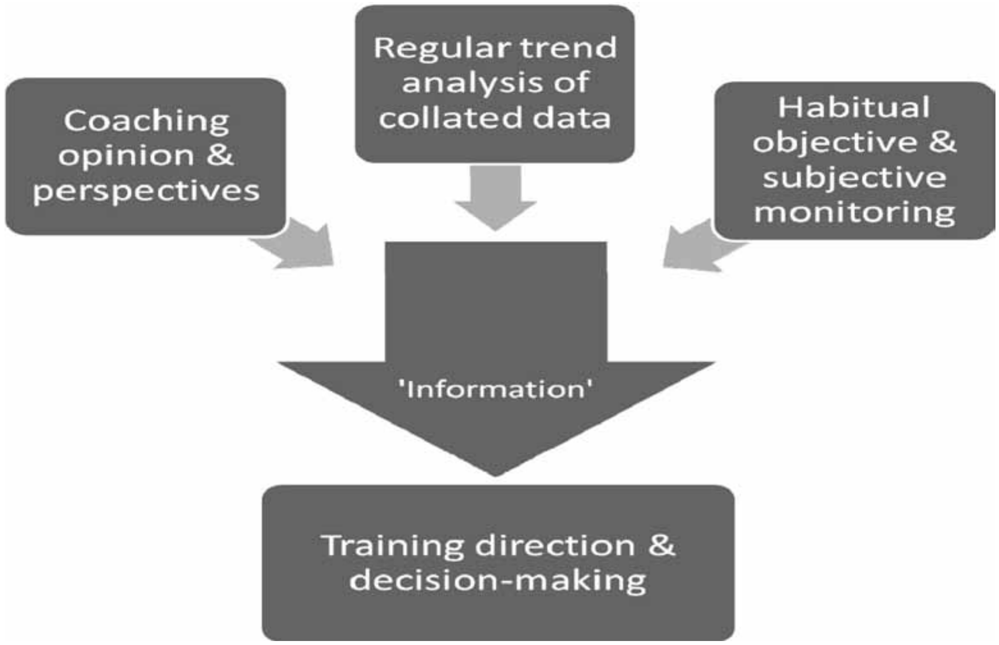

Figure 2 — Sources of training decision-making "information."

- Development, and ongoing refinement, of long-term sensitive monitoring and tracking systems
- Cultivation of performer-generated feedback and feed-forward contribution
- Trend analysis of collated data
- Critical evaluation of projections against outcomes
- Regular review, refinement, and redirection

Critically, the quality of planning decision making is founded on 2 cornerstones:

- A conceptual model—against which experiences, observations, data, and decisions are contextualized—that is optimally reflective of the complex nature of the preparation task
- The effective management of emerging information

This line of reasoning is not intended as an assault on the historical value of periodization philosophy or the substantial contributions made by eminent theorists. However, in light of the converging evidence, I suggest that periodization dictates are understood as hypothetical tradition-driven assumptions rather than, as commonly presented, evidence-led constructs. This does not imply that plans are unimportant but that our perception of what constitutes effective planning should be reevaluated. Similarly, the presented rationale should not be interpreted as suggesting a false dichotomy, an either/or choice between preformed periodized structures and more emergent information-driven training systems. Ultimately, there is a dynamic tension to be negotiated between structural rigidity and responsive adaptability. The need for "flexibility," necessary deviation from the chosen path, is often noted in the periodization literature but is not discussed in any depth. This lack of attention, in the midst of a heavy focus on predetermined training structures, imparts the impression that deviation is sometimes necessary but generally unwelcome. Conversely, the perspective materializing from this reframing suggests that

- Deviation from the preplanned path is desirable, should be actively sought, and the training management system designed to facilitate, rather than suppress, consistent modulation.
- A crucial component of effective training processes is the systematic capture and review of pertinent data that are then employed to drive future direction.

Many, perhaps most, elite coaches already integrate aspects of this approach in their practical work. However, there remains an evident dissonance between the reality of elite practice, the reality of contemporary biological models, and the theoretical positions habitually forwarded in the periodization literature.

Moving Forward

Einstein once remarked that everything should be made as simple as possible, but not simpler. Periodization philosophies have reduced the complexity of the planning task through the assembly of superficially logical

Table 1 Sample Information Capture and Tracking Options

Quantifying training stress	Sample metrics
Pretraining readiness	Perceived readiness rating
	Objective readiness measure (using habituated exercise tracking)
	Psychomotor speed
	Heart-rate variability
In-training variables	Empirical descriptors (load, sets, reps, recoveries, etc)
	Intensity rating (rating of perceived exertion per effort, set, or session)
	Technical execution (quality rating)
Assessing accumulative stress	Recovery-Stress Questionnaire for Athletes
	Profile of Mood State
	Recovery-cue
	Daily Analysis of Life Demands for Athletes[48]
	Heart-rate variability
	Monotony (weekly average load/SD)
	Strain (mean weekly load/monotony)
	Residual muscle-fatigue rating
	Training load (rating of perceived exertion × training time)
	Total Quality Recovery
	Category Ratio Pain Scale

sets of assumptions, rules, and guidelines to construct formulaic solutions to training-organizational tasks. From this perspective, periodization templates offer a useful service. However, this usefulness comes at a cost. The downside emerges when such oversimplifications become enshrined in practice, elevated to the status of unquestioned dogma, and are perceived as validated truths rather than grossly generalized, frequently misleading approximations. The result is a belief-based planning paradigm gradually becoming ever more disconnected from contemporary science and elite practice.

Arguments against such a reframing are immediately obvious. Why depart from planning paradigms that have clearly worked in the past? Such criticism is understandable but flawed. Within performance environments a commonly forwarded argument, opposing innovation, is an appeal to the weight of history, to point to celebrated champions who scaled great heights using conventionally pervasive methodologies. However, despite its persuasive power, such a rationale presents a damaging logical inconsistency. An unbiased evaluation of the worth of any training scheme requires that both successes and "failures" be factored into analysis. As such, the highlighting of isolated high-achieving exemplars to confirm the superiority of any planning scheme while neglecting to consider those who conformed to a similar framework yet "failed" is a fundamentally lopsided, albeit attractive, argument. Furthermore, the training plan is but one facet of the multidimensional "performance" phenomenon. Did the planning methodology contribute to, or detract from, the exceptional performances of an exceptional performer? Would a different plan have led to greater achievement, a longer career, less injury or illness? Our inability to run counterfactual alternative-reality iterations originating from common initial conditions renders such arguments irresolvable. Instead, we must rely on critical reflection, informed by evidence, contextualized against conceptual understanding, and cleared of presumption. Ultimately, historical prevalence is not supporting evidence.

Appeals to coaching experience are similarly instinctively persuasive. However, in complex environments, an appreciation of the uniquely tangled web of circumstances underpinning observable behaviors should caution against the presumption that previously successful strategies will prove similarly successful in the future. The history of every complex planning domain—medical, political, military, financial—is replete with examples of experts who assumed that previous success bestowed an ability to forecast the future consequences of imposed actions—a confidence directly contravening a substantial evidence base.[3,4,45,49]

A more legitimate concern relates to the lack of perceptive, validated monitoring tools. It should be acknowledged that no single assessment, or battery of assessments, is likely to be universally applicable across domains or groups of individuals (as previously noted[50]). In the absence of ready-made solutions, the design of an efficient training process may be considered an exploratory, slowly evolving, meticulously documented, single-subject trial-and-error experiment.

An appreciation of both the philosophical origins underpinning cultural planning convention and the nature of biological complexity may caution against reliance on generalized rule-based planning and automatized training decision making—a reliance that ultimately constrains our vision of available training strategies, impedes critical thinking, and suppresses coaching creativity.

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