

Evaluating the Brain-Targeted Teaching Model as a Framework for Athletic Skill Development

By Iris Zhu & Eric Zhu

AUTHOR BIO

Iris Zhu is a student at Deerfield Academy with interests in neuroscience, psychology, and education. Her work on this project grew out of a curiosity about how the science of learning connects to physical performance.

Eric Zhu is a student at Blair Academy interested in sports science and the cognitive processes behind athletic skill. He is drawn to interdisciplinary questions that bridge the brain and the body.

ABSTRACT

Athletic performance depends heavily on the brain, yet the principles that govern athletic skill acquisition across the motor learning, sport psychology, and cognitive neuroscience literatures are seldom presented to coaches in a single organizing framework. This article is not a systematic review of athletic skill acquisition. It is an evaluation of a single framework, the Brain-Targeted Teaching (BTT) model assessed here as a coach-facing scaffold for organizing that body of research. Sources were selected on the basis of their relevance to one or more BTT components rather than through an exhaustive search of the field, and the evaluation asks how well each component is supported by existing evidence in motor learning, sport psychology, and cognitive neuroscience. The six BTT components - emotional climate and psychological safety; the physical training environment; learning design and cognitive load; mastery through deliberate practice; the application and transfer of skills under pressure; and evaluation through feedback - offer an accessible organizational model. Across these areas, principles such as emotional regulation, deliberate practice, attentional focus, and formative feedback draw on overlapping neural systems across classroom and athletic contexts. The evaluation finds the mapping strongest for learning design, mastery, and evaluation, and weakest for the physical environment component, where the classroom construct and its athletic parallel diverge substantially. The BTT model gives coaches and athlete development practitioners a way to understand the processes underlying athletic skill development, though its value here is organizational rather than empirically validated.

Keywords: Brain-Targeted Teaching; neuroeducation; motor learning; athletic skill development; cognitive load; deliberate practice

INTRODUCTION

The intersection of neuroscience and education has produced a rich body of scholarship over the past two decades. Neuroeducation researchers have demonstrated that effective instruction must account for the biological processes underlying attention, memory formation, emotional regulation, and motivation (Hardiman, 2012). At the same time, sports science has advanced its understanding of how athletes develop expertise through training protocols that emphasize repetition, feedback, and progressive challenge (Ericsson et al., 1993). While motor learning and cognitive sport psychology researchers have long drawn on neuroscience, much of this work is scattered across specialized literatures and is rarely consolidated into a single framework accessible to coaches and athlete development practitioners.

This disconnect is important because athletic performance is a cognitive endeavor. Every movement an athlete executes begins with neural processing: the brain must interpret sensory information, make decisions under time pressure, coordinate complex motor sequences, and regulate emotional states that can either enhance or impair performance (Walsh, 2014). When a basketball player reads a defender's body language and adjusts a pass in real time, or when a gymnast executes a complex routine from memory under competitive pressure, these actions depend on the same neural systems that underlie classroom learning, including working memory, attention networks, and the consolidation of knowledge through sleep and practice (Yarrow et al., 2009).

The Brain-Targeted Teaching (BTT) model, developed by Dr. Mariale Hardiman at Johns Hopkins University, offers a promising framework for consolidating this research. Originally designed as a pedagogical tool for K-12 educators, the BTT model provides a six-step instructional approach grounded in cognitive neuroscience research (Hardiman, 2012). These six components include establishing an emotional climate for learning, developing the physical learning environment, designing the learning experience with attention to cognitive load, teaching for mastery of content and skills, applying knowledge in novel contexts, and evaluating learning through meaningful assessment and feedback (Hardiman, 2025). Each component maps onto a substantial body of sport science and motor learning research, drawing on the same principles – cognitive load theory, deliberate practice, retrieval practice, attentional focus, and emotion regulation – that informed the model itself. Its value is its compactness of organization: it gathers principles that practitioners would otherwise need to assemble from several disciplinary streams.

BTT was selected over several alternative frameworks, and the reasons for that choice bear stating directly. Ecological dynamics and the constraints-led approach offer a well-developed account of how task and environmental constraints shape skill acquisition, but they speak primarily to practice design and say comparatively little about emotional climate or assessment. The Fitts and Posner stages of motor learning describe the trajectory a learner follows without prescribing what an instructor should do at each stage. The challenge point framework addresses the calibration of task difficulty to learner skill, and cognitive load theory addresses the management of working memory demands, but each covers a single link in the chain rather than the whole sequence from emotional readiness to evaluation. Self-determination theory accounts for motivational climate but not for instructional design. What distinguishes BTT is neither theoretical novelty nor empirical priority, since its constituent principles are drawn from these same literatures. It is rather that BTT is the only one of these frameworks that is

simultaneously practitioner-facing, sequenced as a usable procedure, and broad enough to span affective, environmental, instructional, and evaluative concerns in a single structure. That combination is what makes it a plausible candidate for the organizing role examined here, and it is also what this article sets out to evaluate rather than assume.

This article uses each of the six BTT components as a heading under which to assemble and then assess relevant research from neuroscience, education, and sport science. The exercise is evaluative rather than exhaustive: sources were included because they bear on a BTT component, not because they represent a complete survey of athletic skill acquisition, and the aim is to judge how well each component holds up against that evidence. The aim is to put this dispersed evidence within reach of coaches and athlete development practitioners. Because this topic spans several fields and the goal is conceptual synthesis rather than (say) effect-size estimation, the review takes a structured narrative approach rather than offering a full systematic analysis. The review thus contributes to an interdisciplinary conversation about how understanding the brain can inform academic learning and physical performance alike.

THE BRAIN-TARGETED TEACHING MODEL: AN OVERVIEW

The BTT model emerged from Dr. Mariale Hardiman's work as both a school principal in Baltimore and a professor at Johns Hopkins University's School of Education. Recognizing a disconnect between neuroscience research findings and everyday classroom practice, Hardiman developed the structure as a practical bridge, translating complex scientific insights into an accessible, step-by-step pedagogical framework (Hardiman, 2012). The model has since been refined through years of research and professional development, with a second edition published in 2025 reflecting advances in the cognitive and learning sciences (Hardiman, 2025).

The BTT model consists of six interconnected learning targets. Brain Target 1 focuses on the emotional climate of the learning environment. Brain Target 2 concerns the physical learning environment, recognizing that sensory input from the surrounding space shapes attention and neural engagement. Brain Target 3 governs the design of the learning experience itself, incorporating principles of cognitive load theory, chunking, and the use of patterns and big-picture frameworks to help learners process information efficiently. Brain Target 4 emphasizes mastery through deliberate and repeated practice with targeted feedback. Brain Target 5 centers on applying knowledge to new contexts, fostering deeper understanding through transfer. Brain Target 6 addresses evaluation, framing assessment as an ongoing feedback loop that supports memory consolidation and learning refinement, rather than issuing a final judgment (Hardiman, 2012, 2025).

MAPPING THE FRAMEWORK

Table 1 previews the synthesis that follows. Each BTT component is shown alongside the corresponding body of sport science and motor learning research, with key supporting citations. The mapping illustrates the review's organizing logic: BTT supplies the structure, while the empirical content is drawn from primary research in neuroscience, motor learning, and sport psychology.

Table 1. Mapping the Six Brain-Targeted Teaching Components onto Athletic Training

BTT Component	Athletic Training Parallel	Supporting Evidence
1. Emotional Climate	Psychologically safe coaching that treats mistakes as learning opportunities and supports emotional regulation for optimal functioning	LeDoux (2000); Robazza et al. (2004); Bartholomew et al. (2011)
2. Physical Environment	Representative task design, sensory and proprioceptive training, and recovery and sleep that support motor memory consolidation	Pinder et al. (2011); Zech et al. (2010); Walker & Stickgold (2004); Mah et al. (2011)
3. Learning Design	Calibrating cognitive load of drills and chunking complex movement sequences into integrated motor programs	Sweller et al. (2011); Miller (1956); Pedrosa & Tavares (2025); Roetert et al. (2019); Lappi (2022)
4. Mastery and Practice	Deliberate practice with external-focus feedback that produces neural efficiency and automatic motor execution	Ericsson et al. (1993); Baker & Young (2014); Nakata et al. (2010); Wulf (2013); Zhu et al. (2022)
5. Application and Transfer	Practicing skills under simulated competitive pressure to guard against choking and to support transfer between contexts	Oppici & Panchuk (2022); Masters & Maxwell (2008); Gabbett et al. (2012)
6. Evaluation	Formative feedback loops using neurofeedback, neural monitoring, and guided video review rather than outcome metrics alone	Roediger & Butler (2011); Gruzelier (2014); Seidel-Marzi & Ragert (2020); Hughes & Bartlett (2002)

THEME 1: EMOTIONAL CLIMATE AND PSYCHOLOGICAL SAFETY

The first component of the BTT model emphasizes that learning begins with feeling safe, valued, and emotionally connected to the learning environment. Neuroscience research has demonstrated that the brain's emotional centers, particularly the amygdala, serve as gatekeepers for information processing. When a learner experiences anxiety, fear, or social threat, the amygdala activates stress responses that divert cognitive resources away from the prefrontal cortex, where higher-order thinking, decision-making, and working memory reside (LeDoux, 2000). Therefore, a stressed learner is less effective, regardless of whether the learning environment is a classroom or a training facility.

Research in sport psychology has established that anxiety and emotional dysregulation are among the most significant barriers to optimal athletic performance (Robazza et al., 2004). The concept of competitive anxiety shows that athletes who cannot manage their emotional states experience degraded performance, impaired decision-making, and increased injury risk (Hanton et al., 2008).

The BTT's emotional climate target is clear: just as students learn best when they feel psychologically safe, athletes train and perform best when their emotional environment supports focus, confidence, and engagement rather than fear and self-doubt. Coaches who create psychologically safe training environments, where mistakes are treated as learning opportunities rather than failures, foster the same conditions that Hardiman identifies as foundational for brain-based learning (Hardiman, 2012). In contrast, coaching styles characterized by harsh criticism, public shaming, or authoritarian control can trigger the very stress responses that impair neural processing and learning (Bartholomew et al., 2011).

THEME 2: THE PHYSICAL TRAINING ENVIRONMENT

The second brain target of the BTT model recognizes that the physical environment in which learning occurs shapes neural engagement, attention, and memory. Classroom research has shown that factors such as lighting, color, temperature, noise level, opportunities for movement, and visual stimulation all influence how the brain processes and retains information (Hardiman, 2012). The framework encourages educators to design learning spaces that optimize sensory input, minimize distractions, and promote engagement through environmental and multisensory stimulation.

The design of training conditions influences how effectively athletes learn and consolidate skills. Research in ecological dynamics and motor learning has emphasized the importance of representative task design, in which training environments are structured to preserve the perceptual-motor couplings that athletes will encounter in actual competition (Pinder et al., 2011). This approach aligns directly with BTT's emphasis on creating environments that engage the brain's natural processing systems.

Sensory training also has emerged as a relevant area of research. Because the sensory and perceptual systems that athletes rely on remain modifiable through experience rather than fixed in adulthood, the sensory characteristics of the training environment are themselves a target for design (Voss et al., 2017). Similarly, proprioceptive training, which targets the body's sense of its own position in space, has been shown to improve balance, coordination, and neuromuscular control (Zech et al., 2010).

This emphasis on environmental design also resonates with research on training periodization and recovery. As Hardiman advocates for learning spaces that balance stimulation with cognitive rest, sports scientists have recognized that the structure of training sessions directly affects the brain's ability to consolidate motor memories (Walker & Stickgold, 2004). Sleep has been identified as a critical period for the neural consolidation of motor skills, with studies demonstrating that athletes who sleep well after practice show significantly greater improvements than those who do not (Mah et al., 2011).

THEME 3: LEARNING DESIGN, COGNITIVE LOAD, AND STRUCTURED PRACTICE

The third brain target turns to learning design itself — the use of patterns and big-picture frameworks and the strategic organization of information, all aligned with how the brain naturally processes and stores knowledge (Hardiman, 2012). This target draws on cognitive load theory (CLT), which posits that working memory has a limited capacity for processing new information and that instructional design should minimize extraneous cognitive demands while maximizing learning efficiency (Sweller et al., 2011).

The application of CLT to sports training has received increasing attention in recent years. A 2025 study introduced the Cognitive Load Scale (CLS), a five-level framework designed to help football coaches classify and adapt to the cognitive demands of training drills by manipulating task constraints such as space, color rules, attentional shifts, and memory load (Pedrosa & Tavares, 2025). This framework directly applies CLT principles to athletic training design, echoing BTT's emphasis on structuring learning experiences so the brain can process information efficiently rather than being overwhelmed.

Chunking is also relevant to both classroom learning and athletic skill acquisition. Miller's (1956) classic finding that working memory can hold seven items has been extended by sport researchers who study how expert athletes organize complex movement sequences into larger and more manageable units. For example, research on tennis has shown that skilled players chunk serve sequences, shot selections, and tactical patterns into integrated motor programs that can be executed with minimal conscious effort (Roetert et al., 2019). Similarly, studies of motorsport athletes have shown that expert drivers chunk complex track sections into egocentric spatial representations, enabling predictive processing that reduces the cognitive demands of high-speed navigation (Lappi, 2022). BTT's emphasis on designing learning experiences that scaffold this chunking process offers coaches a model for sequencing athletic drills to optimize cognitive processing.

THEME 4: MASTERY THROUGH DELIBERATE PRACTICE

Under the fourth brain target, durable learning requires not just exposure to information but sustained, purposeful practice with targeted feedback. This target aligns with deliberate practice: it refers to activities designed to improve performance with informative feedback and are individualized to address the learner's specific weaknesses (Ericsson et al., 1993). Ericsson and colleagues' (1993) research demonstrated that the amount of time spent in deliberate practice is one of the strongest predictors of expert performance across a wide range of domains, including music, chess, and athletics.

A comprehensive review by Baker and Young (2014) evaluated the evidence for deliberate practice in sport skill acquisition and confirmed that elite athletes consistently accumulate more hours of focused, effortful training. However, the review also noted that, in sport, individualized solitary practice is often difficult to implement because athletes typically train in group settings under the direction of a coach. From a neuroscience perspective, extended deliberate practice is associated with significant changes in brain structure and function. Neuroimaging studies have shown that expert athletes exhibit greater neural efficiency than novices, meaning their brains achieve the same or better performance

outcomes while activating fewer neural resources. Research using functional near-infrared spectroscopy (fNIRS) and electroencephalography (EEG) has shown that skilled athletes exhibit more efficient cortical activation patterns, with less activity in regions linked to conscious control and more in areas supporting automatic motor execution (Nakata et al., 2010). These findings are consistent with BTT's emphasis on practice-driven mastery: as learners move from conscious processing to automatic performance, the neural signature of their skill changes in measurable ways. Studies also suggest that feedback directing athletes' attention to movement effects (external focus) is more effective than attention to the movements themselves (Wulf, 2013), and that elaborated feedback produces stronger instructor-learner neural synchronization and better learning transfer than simple correctness feedback (Zhu et al., 2022).

THEME 5: APPLICATION AND TRANSFER UNDER PRESSURE

The fifth component of the BTT model addresses the ability to apply what has been learned in one context to unfamiliar situations. In classroom settings, this means students should be able to use concepts learned in one lesson to solve problems they have never encountered before, demonstrating that their understanding goes beyond memorization to genuine comprehension and flexible application (Hardiman, 2012).

In athletic contexts, transfer manifests in two primary forms: the ability to execute practiced skills under the novel pressures of competition, and the ability to transfer skills or perceptual-motor capacities from one sport or training context to another. Both forms of transfer are relevant to athlete development and have been the subject of considerable research. A systematic review by Oppici and Panchuk (2022) examined the evidence for specific and general transfer of perceptual-motor skills between sports, finding that while specific transfer (such as from practice drills to competitive performance in the same sport) is well-supported, general transfer (from one sport to an entirely different one) is more complex and depends on the degree of overlap in the perceptual-motor demands of the two activities.

Performing under pressure is an important transfer challenge in sport: athletes may execute skills flawlessly in practice yet struggle in competition, a phenomenon known as “choking,” in which competitive pressure reverses automatic processing back to conscious, step-by-step motor control (Masters & Maxwell, 2008). This dechunking process disrupts the fluid execution of well-learned skills and is associated with degraded performance. From a BTT perspective, athletes must also practice applying skills under conditions that simulate competitive demands, including cognitive distractions, time pressure, and emotional arousal. Whether ordinary training actually reproduces those demands cannot be assumed. Comparing a season of microtechnology data from professional rugby league training sessions with data from competitive matches, Gabbett et al. (2012) found that typical training activities did not reproduce the intensity profile of match play, which suggests that practice does not prepare athletes for competitive conditions simply by involving the same skills. These approaches align with BTT's target for learning activities that require students to apply knowledge in real-world situations rather than recalling information in controlled settings.

THEME 6: EVALUATION AND FEEDBACK LOOPS

Evaluation, the sixth and final target, is reframed from summative judgment to a formative process of ongoing feedback and reflection. Hardiman (2012) argues that assessment should function as a feedback loop, helping learners adjust their approach and consolidate understanding. Neuroscience research shows that retrieval practice strengthens memory traces by reinforcing the neural pathways activated during recall (Roediger & Butler, 2011).

In sports, evaluation has centered on performance metrics such as speed, accuracy, distance, and win-loss records. While these outcome measures provide important information, they represent only a partial picture of an athlete's learning and development. The BTT model's emphasis on formative and process-oriented assessment suggests that athletic evaluation should also incorporate measures of cognitive and perceptual-motor development. For example, neurofeedback training (NFT) has emerged as a tool for assessing and developing the neural components of athletic performance. Studies have shown that NFT protocols targeting specific brainwave patterns can improve balance in judo athletes (Maszczyk et al., 2018), enhance focus in archers (Landers et al., 1991), and support anxiety regulation across multiple sports (Gruzelier, 2014).

The concept of performance analytics has also expanded to include cognitive and neural metrics alongside traditional physical measures. Researchers have proposed that techniques such as fNIRS and EEG for monitoring brain activity during sport-specific tasks should be integrated into routine performance assessment (Seidel-Marzi & Ragert, 2020). These tools could provide coaches and athletes with real-time information about neural efficiency, attentional focus, and emotional regulation.

Video analysis and reflective practice are two more evaluation strategies that fit well with BTT principles. Research has shown that athletes who review video of their own performance, particularly when guided by a coach or structured reflection protocol, show greater improvements in technique and tactical awareness than those who rely solely on live feedback (Hughes & Bartlett, 2002). This engages the brain's self-monitoring systems and encourages reflective, self-directed learning, which BTT sees as key to deep understanding and long-term retention.

DISCUSSION

The review shows that each component of the Brain-Targeted Teaching model has a meaningful counterpart in sports training, drawing on primary research that predates the BTT model and, in many cases, was foundational to its development. The emotional climate of the training environment shapes the brain's readiness to learn and perform. The physical training environment provides the sensory context that the brain uses to encode and retrieve motor memories. The design of structured practice determines how efficiently the brain processes and organizes new information. Deliberate and feedback-rich practice drives the neural changes that underlie mastery and expertise. Transfer activities prepare athletes to apply their skills flexibly under pressure, while formative evaluation provides the feedback loops that the brain needs to refine and consolidate learning.

The BTT model's strength lies in how it organizes interconnected parts into a single learning system. This model offers a compact, accessible structure that gathers these principles in one place, which is especially valuable in sports, where the relevant evidence is often fragmented across motor learning, sport psychology, neuroscience, and skill acquisition and is rarely encountered together by coaches in the field (Williams & Ford, 2008).

IMPLICATIONS FOR PRACTICE

Taken together, the six areas reviewed above point to several practical ideas for coaches and training programs. Coaches can treat the emotional climate of training as seriously as its physical content, framing mistakes as information rather than failure (Bartholomew et al., 2011). Practice can be designed so that its cognitive load matches what athletes can handle, with complex skills broken into manageable chunks (Sweller et al., 2011). Feedback can be structured to direct attention outward, toward the effects of a movement rather than the movement itself (Wulf, 2013). And evaluation can be reframed as an ongoing feedback loop, using tools like guided video review rather than relying only on win-loss records (Hughes & Bartlett, 2002). None of these ideas requires expensive technology; they mostly require thinking about training as a brain-based learning process.

LIMITATIONS AND FUTURE DIRECTIONS

Several limitations bear noting. The BTT model was designed for classroom learning, and its role in this review is organizational rather than empirical, as its validation as a learning intervention in athletic contexts has not been established. Most of the cited evidence also comes from adult or elite athletes, and more research is needed to understand how these principles apply to youth athletes, whose brains are still developing. Because the review is conceptual rather than experimental, it can show that the parallels are plausible and well-supported, but it cannot by itself demonstrate that a BTT-based program improves athletic learning. Future research should test the model directly through controlled studies that implement BTT-based training with athletes and measure outcomes across cognitive and performance dimensions.

A further and more fundamental limitation concerns the logic of the mapping itself. BTT was built out of cognitive load theory, deliberate practice, retrieval practice, attentional focus, and emotion regulation, and those same principles are load-bearing in the motor learning and sport psychology literatures. Finding that each BTT component has a counterpart in sport science is therefore partly guaranteed by construction rather than discovered, and a correspondence of this kind cannot on its own establish that the framework is the right one for athletic contexts. The mapping would be informative only where it could have failed, and it is worth being explicit about where it comes closest to doing so. Brain Target 2 is the weakest case. In its original formulation the physical environment target concerns classroom conditions such as lighting, color, acoustics, and the arrangement of space, whereas the athletic material assembled under it here concerns representative task design, proprioceptive training, and sleep-dependent consolidation. These are substantively different constructs, and grouping them under one heading reflects the organizing scheme more than any shared mechanism. Brain Target 5 is similarly strained, since transfer in the classroom sense of applying a concept to an unfamiliar problem is not obviously the same phenomenon as the reinvestment of conscious control that produces choking under competitive pressure. A stronger test of the framework would specify in advance what pattern of evidence

SCHOLARLY DEBUT

— by Scholarly Review

Fall 2026

would count against it, and future work applying BTT to athletic settings should state such criteria before rather than after the mapping is carried out.

CONCLUSION

This review has used the BTT model as an organizing scaffold for evidence drawn from neuroscience, education, and sport science. Each of the six BTT components finds clear and well-supported counterparts in the sport literature, and gathering them under a single, compact framework gives coaches and athlete development practitioners a way into a body of evidence that is otherwise distributed across several disciplinary literatures. It also sets the stage for future empirical work that would test whether the model offers insights into more effective, engaging, and responsive approaches to the complex cognitive demands of athletic performance.

REFERENCES

- Baker, J., & Young, B. (2014). 20 years later: Deliberate practice and the development of expertise in sport. *International Review of Sport and Exercise Psychology*, 7(1), 135-157. <https://doi.org/10.1080/1750984x.2014.896024>
- Bartholomew, K. J., Ntoumanis, N., Ryan, R. M., Bosch, J. A., & Thøgersen-Ntoumani, C. (2011). Self-determination theory and diminished functioning: The role of interpersonal control and psychological need thwarting. *Personality and Social Psychology Bulletin*, 37(11), 1459-1473. <https://doi.org/10.1177/0146167211413125>
- Ericsson, K. A., Krampe, R. T., & Tesch-Römer, C. (1993). The role of deliberate practice in the acquisition of expert performance. *Psychological Review*, 100(3), 363-406. <https://doi.org/10.1037/0033-295X.100.3.363>
- Gabbett, T. J., Jenkins, D. G., & Abernethy, B. (2012). Physical demands of professional rugby league training and competition using microtechnology. *Journal of Science and Medicine in Sport*, 15(1), 80-86. <https://doi.org/10.1016/j.jsams.2011.07.004>
- Gruzelier, J. H. (2014). EEG-neurofeedback for optimising performance. I: A review of cognitive and affective outcome in healthy participants. *Neuroscience and Biobehavioral Reviews*, 44, 124-141. <https://doi.org/10.1016/j.neubiorev.2013.09.015>
- Hanton, S., Neil, R., & Mellalieu, S. D. (2008). Recent developments in competitive anxiety direction and competition stress research. *International Review of Sport and Exercise Psychology*, 1(1), 45-57. <https://doi.org/10.1080/17509840701827445>
- Hardiman, M. M. (2012). *The brain-targeted teaching model for 21st-century schools*. Corwin Press.
- Hardiman, M. M. (2025). *The brain-targeted teaching model: A framework for joyful learning and leading* (2nd ed.). Corwin Press.
- Hughes, M., & Bartlett, R. M. (2002). The use of performance indicators in performance analysis. *Journal of Sports Sciences*, 20(10), 739-754. <https://doi.org/10.1080/026404102320675602>
- Landers, D. M., Petruzzello, S. J., Salazar, W., Crews, D. J., Kubitz, K. A., Gannon, T. L., & Han, M. (1991). The influence of electrocortical biofeedback on performance in pre-elite archers. *Medicine and Science in Sports and Exercise*, 23(1), 123-129.
- Lappi, O. (2022). Egocentric chunking in the predictive brain: A cognitive basis of expert performance in high-speed sports. *Frontiers in Human Neuroscience*, 16, Article 822887. <https://doi.org/10.3389/fnhum.2022.822887>
- LeDoux, J. E. (2000). Emotion circuits in the brain. *Annual Review of Neuroscience*, 23(1), 155-184. <https://doi.org/10.1146/annurev.neuro.23.1.155>
- Mah, C. D., Mah, K. E., Kezirian, E. J., & Dement, W. C. (2011). The effects of sleep extension on the athletic performance of collegiate basketball players. *Sleep*, 34(7), 943-950. <https://doi.org/10.5665/SLEEP.1132>
- Masters, R. S. W., & Maxwell, J. P. (2008). The theory of reinvestment. *International Review of Sport and Exercise Psychology*, 1(2), 160-183. <https://doi.org/10.1080/17509840802287218>
- Maszczyk, A., Gołaś, A., Pietraszewski, P., Kowalczyk, M., Cięszczyk, P., Kochanowicz, A., Smółka, W., & Zając, A. (2018). Neurofeedback for the enhancement of dynamic balance of judokas. *Biology of Sport*, 35(1), 99-102. <https://doi.org/10.5114/biol sport.2018.71488>
- Miller, G. A. (1956). The magical number seven, plus or minus two: Some limits on our capacity for processing information. *Psychological Review*, 63(2), 81-97. <https://doi.org/10.1037/h0043158>

-
- Nakata, H., Yoshie, M., Miura, A., & Kudo, K. (2010). Characteristics of the athletes' brain: Evidence from neurophysiology and neuroimaging. *Brain Research Reviews*, 62(2), 197-211. <https://doi.org/10.1016/j.brainresrev.2009.11.006>
- Oppici, L., & Panchuk, D. (2022). Specific and general transfer of perceptual-motor skills and learning between sports: A systematic review. *Psychology of Sport and Exercise*, 59, Article 102118. <https://doi.org/10.1016/j.psychsport.2021.102118>
- Pedrosa, R., & Tavares, R. (2025). Training spatial intelligence in football through the cognitive load scale. *Frontiers in Sports and Active Living*, 7. <https://doi.org/10.3389/fspor.2025.1628561>
- Pinder, R. A., Davids, K., Renshaw, I., & Araújo, D. (2011). Representative learning design and functionality of research and practice in sport. *Journal of Sport and Exercise Psychology*, 33(1), 146-155.
- Robazza, C., Pellizzari, M., & Hanin, Y. (2004). Emotion self-regulation and athletic performance: An application of the IZOF model. *Psychology of Sport and Exercise*, 5(4), 379-404.
- Roediger, H. L., & Butler, A. C. (2011). The critical role of retrieval practice in long-term retention. *Trends in Cognitive Sciences*, 15(1), 20-27. <https://doi.org/10.1016/j.tics.2010.09.003>
- Roetert, E. P., Woods, R. B., Knudson, D., & Brown, S. W. (2019, April). Applying the concept of chunking to tennis. *ITF Coaching Review*, 27(77), 10-15. <https://doi.org/10.52383/itfcoaching.v27i77.105>
- Seidel-Marzi, O., & Ragert, P. (2020). Neurodiagnostics in sports: Investigating the athlete's brain to augment performance and sport-specific skills. *Frontiers in Human Neuroscience*, 14, Article 133. <https://doi.org/10.3389/fnhum.2020.00133>
- Sweller, J., Ayres, P., & Kalyuga, S. (2011). Cognitive load theory. Springer. <https://doi.org/10.1007/978-1-4419-8126-4>
- Voss, P., Thomas, M. E., Cisneros-Franco, J. M., & de Villers-Sidani, É. (2017). Dynamic brains and the changing rules of neuroplasticity: Implications for learning and recovery. *Frontiers in Psychology*, 8, Article 1657. <https://doi.org/10.3389/fpsyg.2017.01657>
- Walker, M. P., & Stickgold, R. (2004). Sleep-dependent learning and memory consolidation. *Neuron*, 44(1), 121-133. <https://doi.org/10.1016/j.neuron.2004.08.031>
- Walsh, V. (2014). Is sport the brain's biggest challenge? *Current Biology*, 24(18), R859-R860. <https://doi.org/10.1016/j.cub.2014.08.003>
- Williams, A. M., & Ford, P. R. (2008). Expertise and expert performance in sport. *International Review of Sport and Exercise Psychology*, 1(1), 4-18. <https://doi.org/10.1080/17509840701836867>
- Wulf, G. (2013). Attentional focus and motor learning: A review of 15 years. *International Review of Sport and Exercise Psychology*, 6(1), 77-104. <https://doi.org/10.1080/1750984X.2012.723728>
- Yarrow, K., Brown, P., & Krakauer, J. W. (2009). Inside the brain of an elite athlete: The neural processes that support high achievement in sports. *Nature Reviews Neuroscience*, 10(8), 585-596. <https://doi.org/10.1038/nrn2672>
- Zech, A., Hübscher, M., Vogt, L., Banzer, W., Hänsel, F., & Pfeifer, K. (2010). Balance training for neuromuscular control and performance enhancement: A systematic review. *Journal of Athletic Training*, 45(4), 392-403. <https://doi.org/10.4085/1062-6050-45.4.392>
- Zhu, Y., Leong, V., Hou, Y., Zhang, D., Pan, Y., & Hu, Y. (2022). Instructor-learner neural synchronization during elaborated feedback predicts learning transfer. *Journal of Educational Psychology*, 114(6), 1427-1441. <https://doi.org/10.1037/edu0000707>

Table 2. Sources Included in the Review

#	Author(s) (Year)	Field	Role in This Review
1	Hardiman (2012, 2025)	Education / Neuroeducation	Source of the Brain-Targeted Teaching model and its six components; the organizing framework for the whole review.
2	LeDoux (2000)	Neuroscience	Explains how the amygdala diverts cognitive resources under threat; supports the emotional climate theme.
3	Robazza et al. (2004)	Sport psychology	Links emotional regulation to optimal athletic functioning (IZOF); supports the emotional climate theme.
4	Bartholomew et al. (2011)	Sport psychology	Shows how controlling coaching styles thwart needs and trigger stress; supports the emotional climate theme.
5	Hanton et al. (2008)	Sport psychology	Reviews competitive anxiety and its effect on performance and decision-making; supports the emotional climate theme.
6	Pinder et al. (2011)	Sport science	Representative learning design that preserves game-relevant couplings; supports the physical environment theme.
7	Zech et al. (2010)	Sport science	Evidence on proprioceptive and balance training; supports the physical environment theme.
8	Walker & Stickgold (2004)	Neuroscience	Sleep-dependent motor memory consolidation; supports the physical environment theme.
9	Mah et al. (2011)	Sport science	Sleep extension improves athletic performance; supports the physical environment theme.
10	Sweller et al. (2011)	Education / Cognitive psychology	Cognitive load theory; foundation for the learning design theme.
11	Miller (1956)	Cognitive psychology	Classic working memory limit; basis for chunking in the learning design theme.
12	Pedrosa & Tavares (2025)	Sport science	Cognitive Load Scale for football drills; direct application of CLT in the learning design theme.
13	Roetert et al. (2019)	Sport science	Chunking of tennis sequences into motor programs; supports the learning design theme.

SCHOLARLY DEBUT

by Scholarly Review

Fall 2026

#	Author(s) (Year)	Field	Role in This Review
14	Lappi (2022)	Cognitive neuroscience	Egocentric chunking in high-speed sport; supports the learning design theme.
15	Ericsson et al. (1993)	Cognitive psychology	Foundational deliberate practice research; basis for the mastery theme.
16	Baker & Young (2014)	Sport science	Review of deliberate practice in sport; supports the mastery theme.
17	Nakata et al. (2010)	Neuroscience	Neural efficiency in expert athletes via fNIRS/EEG; supports the mastery and evaluation themes.
18	Wulf (2013)	Sport science	External-focus feedback in motor learning; supports the mastery theme.
19	Zhu et al. (2022)	Educational psychology	Elaborated feedback and instructor-learner neural synchronization; supports the mastery theme.
20	Oppici & Panchuk (2022)	Sport science	Systematic review of specific vs. general transfer; supports the transfer theme.
21	Masters & Maxwell (2008)	Sport psychology	Theory of reinvestment and choking under pressure; supports the transfer theme.
22	Gabbett et al. (2012)	Sport science	Documents a gap between the demands of routine training and those of competition; supports the transfer theme.
23	Roediger & Butler (2011)	Cognitive psychology	Retrieval practice strengthens memory; supports the evaluation theme.
24	Maszczyk et al. (2018)	Sport science	Neurofeedback improves balance in judo athletes; supports the evaluation theme.
25	Landers et al. (1991)	Sport science	EEG biofeedback improves archery performance; supports the evaluation theme.
26	Gruzelier (2014)	Neuroscience	Review of EEG-neurofeedback for performance; supports the evaluation theme.
27	Seidel-Marzi & Ragert (2020)	Neuroscience	Neurodiagnostics (fNIRS/EEG) in sport; supports the evaluation theme.
28	Hughes & Bartlett (2002)	Sport science	Performance indicators and video analysis; supports the evaluation theme.

SCHOLARLY DEBUT

by Scholarly Review

Fall 2026

#	Author(s) (Year)	Field	Role in This Review
29	Walsh (2014)	Neuroscience	Frames sport as a major challenge for the brain; used in the introduction.
30	Yarrow et al. (2009)	Neuroscience	Neural processes behind elite athletic performance; used in the introduction.
31	Williams & Ford (2008)	Sport science	Notes fragmentation of expertise research; supports the discussion.
32	Voss et al. (2017)	Neuroscience	Neuroplasticity and the role of vision in learning; supports the physical environment theme.