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EXPANDED COGNITION, COMPLEX DYNAMIC SYSTEMS, AND DECISION-MAKING IN SPORTS

COGNIÇÃO EXPANDIDA, SISTEMAS DINÂMICOS COMPLEXOS E TOMADA DE DECISÃO NO ESPORTE

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Abstract
The understanding of cognition in sports has undergone a significant transformation in recent decades, shifting from internalist models based on information processing to extended perspectives that recognize the constitutive role of the environment, the body, and material and social tools in cognitive functioning. The concept of extended cognition, articulated with theories of complex dynamic systems and enactive and ecological approaches, offers a robust theoretical framework to understand action and decision-making in overly complex contexts such as sports. This article aims to examine in depth the theoretical and epistemological foundations of extended cognition applied to sports, emphasizing its interface with dynamic systems, cognition, metacognition, and regulation. This article discusses the implications of metacognition as a mechanism for monitoring and adaptive control, as well as its articulation with stability and metastability regimes in nonlinear systems. This work aims to establish a solid conceptual foundation for integrating extended cognition, complex dynamics, and regulatory processes, preparing the ground for a deeper examination of the emotional and decision-making dimensions in the second part of the study.
Keywords: Extended cognition; Sport; Complex dynamic systems; decision-making; Cognitive regulation.

Resumo
A compreensão da cognição no esporte sofreu uma transformação significativa nas últimas décadas, deslocando-se de modelos internalistas, fundamentados no processamento de informações, para perspectivas ampliadas que reconhecem o papel constitutivo do ambiente, do corpo e das ferramentas materiais e sociais no funcionamento cognitivo. O conceito de cognição expandida, articulado a teorias de sistemas dinâmicos complexos e às abordagens enativas e ecológicas, oferece um quadro teórico robusto para compreender a ação e a tomada de decisão em contextos de alta complexidade, como o esporte. Neste artigo, busca-se examinar em profundidade os fundamentos teóricos e epistemológicos da cognição expandida aplicada ao esporte, com ênfase em sua interface com sistemas dinâmicos, cognição, metacognição e regulação. São discutidas as implicações da metacognição como mecanismo de monitoramento e controle adaptativo, bem como a articulação com os regimes de estabilidade e metaestabilidade em sistemas não lineares. O objetivo é fornecer uma base conceitual sólida para integrar cognição expandida, dinâmica complexa e processos regulatórios, preparando terreno para a análise subsequente das dimensões emocionais e decisórias que serão exploradas em maior profundidade na segunda parte deste trabalho.

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Palavras-chave: Cognição expandida; Esporte; Sistemas dinâmicos complexos; tomada de decisão; Regulação cognitiva.

1 INTRODUCTION

The study of cognition applied to sports has historically been dominated by representationalist models centered on the computational metaphor of information processing. Within these models, the athlete is portrayed as an internal processor, receiving information from the environment, organizing it according to mental schemas, and producing motor responses. Although this approach provided important initial advances, it proved limited in the face of the complexity of sporting contexts, in which multiple biological, psychological, social, and material factors interact in a non-linear manner.

Since the late twentieth century, different theoretical frameworks - such as complex dynamic systems theory, the ecological approach, and the enactive perspective - have begun to challenge the internalist view of the mind and to emphasize the inseparability of cognition, body, and environment. Within this context, the concept of extended cognition (Clark; Chalmers, 1998; Clark, 2008; Hutchins, 1995) emerged as a paradigmatic milestone, proposing that cognitive processes can extend beyond neural and bodily boundaries, incorporating artifacts, tools, and social interactions as constitutive parts of the mind.

Wilson (2002) contends that cognition is not simply abstract symbolic processing isolated from our bodies and surroundings. In contrast to classical models of cognitive psychology and artificial intelligence, which treat perception and action as secondary, embodied cognition posits that the mind is deeply shaped by the body and its engagement with the world. Within this perspective, the author articulates six central theses of embodied cognition:

- Cognition is situated – Thought occurs in real contexts of direct interaction with the environment.
- Cognition is time-pressured – Decisions and reasoning take place under temporal constraints, in real time.
- We offload cognitive work onto the environment – The environment is used as support to reduce mental load.

- The environment is part of the cognitive system – The most radical view: mind + body + environment constitute a single cognitive system. Wilson considers this thesis problematic, as it blurs the boundaries of what is meant by “cognition.”
- Cognition exists for action – The primary function of the mind is to guide motor and adaptive behavior.
- Offline cognition is body-based – Even when decoupled from the immediate environment (e.g., imagination, memory, abstract reasoning), cognition depends on sensorimotor simulations.

Subsequently, Allred (2020) revisited Wilson’s claims. The article does not dismiss Wilson’s six theses but shows that three of them - time-pressured cognition, the environment as part of cognition, and embodied offline cognition - prove limited or in need of revision. In contrast, the propositions that cognition is situated, that cognitive work is distributed into the environment, and that the mind exists for action remain compelling. The main contribution, therefore, lies in advancing a more balanced and integrative account of embodied cognition, bridging motor systems, executive functions, and abstract representations.

In sports, this perspective acquires particular relevance. Athletic performance results not only from technical skills or physiological capacities but also from the dynamic integration of perception, action, and cognitive and affective regulation, in constant coupling with the environment. Decision-making, far from being an exclusively internal process, emerges from distributed networks that include not only the brain but also the body, tools, contextual cues, and collective structures of interaction.

The present article seeks to examine in depth the application of extended cognition in sports, emphasizing its interface with complex dynamic systems, cognition, metacognition, and regulation. In the first part, the foundations of extended cognition and its relationship with dynamic systems will be discussed, along with an exploration of the role of metacognition and adaptive regulation. In the second part, attention will turn to the emotional, meta-emotional, and decision-making dimensions, integrating the theoretical framework advanced here with concrete implications for decision-making in sporting contexts.

2 EXTENDED COGNITION AND SPORT

The notion of extended cognition emerged in the philosophical and scientific debate on the mind in the late 1990s, particularly with the seminal article The Extended Mind (Clark; Chalmers, 1998). This perspective challenges the traditional conception that cognitive processes are confined to the brain or, more broadly, to the biological organism. For the authors, the mind can extend beyond the skin, encompassing tools, notes, technologies, and environments, provided that these elements play a functional role in the cognitive process.

This conceptual shift is consistent with already existing approaches such as situated cognition and embodied cognition (Varela; Thompson; Rosch, 2017; Gallagher, 2005; Noë, 2004) but goes further by emphasizing the idea of functional parity: if an external component performs the same function as an internal process, it should be considered part of cognition.

Traditionally, the study of cognition was centered on the brain as an isolated organ; however, the embodied cognition perspective highlighted the importance of integrating sensory stimuli, motor processing, and emotional experiences (Barsalou, 2008, 2010). Along these lines, the author developed the Perceptual Symbol Systems Theory, which proposes that the brain encodes multimodal experiences and subsequently reactivates them through simulation to guide cognition, resulting in the capacity to articulate brain, body, and environment into a single representational architecture. In other words, conceptual representations can be established from sensorimotor experience.

According to Wilson and Golonka (2013), the idea has been trivialized by approaches that reduce it to mere correlations between bodily and mental states. The authors move initially in the same direction as Barsalou, by proposing that cognition should be studied as the result of coupled perception–action systems that emerge in a situated and real-time manner to solve specific tasks. However, they diverge by pointing out that Barsalou’s approach remains restrictive, as it does not commit to replacing representation with the dynamic structure of interaction.

Willems and Francken (2012) criticize the way the literature tends to organize findings into a binary dichotomy between embodied and disembodied cognition. Such a simplistic opposition fails to capture experimental nuances and does not contribute to the formulation of refined hypotheses. For Farina (2021), embodied cognition is not merely a philosophical metaphor but a robust empirical program with concrete interdisciplinary applications. The author further argues that “a fully embodied perspective allows for the best of both worlds: explaining ecological cognition while preserving the usefulness of the brain and representations” (p. 84).

Wilson and Golonka (2013) establish four primary questions to assess embodied cognition:

1. What is the task to be solved?
2. What resources does the organism have access to in order to solve the task?
3. How can these resources be assembled to solve the task?
4. Does the organism in fact assemble and use these resources?

In the sporting domain, this perspective proves particularly fruitful, as it enables performance to be understood not as the product of an isolated mind but of a coupled system in which brain, body, environment, artifacts, and social interactions integrate into continuous flows of action and perception. This implies recognizing that an athlete’s cognitive strategies are co-constituted by environmental cues, collective interactions, and material conditions that shape practice.

In this sense, Araújo *et al*. (2019) emphasize that sports cognition is not primarily based on internal inferences or isolated mental processes but on the interaction between whole-body action and perception within the performance environment. Cappuccio (2015) adds that many athletic skills should be understood as non-conceptual and pre-linguistic capacities that do not necessarily depend on rules or priori models but are normatively shaped by the motor system and perceptual contingencies of executive control in real-world interactions.

Furthermore, extended cognition in sports connects directly to the theory of distributed cognition (Hutchins, 1995; Sutton *et al.*, 2010), which holds that cognitive processes can be shared and distributed across multiple agents and artifacts. This view resonates with sports practice, in which collective decision-making, team coordination, and communication systems function as extensions of the individual mind. Voigt *et al.* (2023) highlights that, rather than treating action solely as the product of decision-making, it must be recognized as an integral and informative part of the decision-making process.

At the same time, the ability to monitor and adjust one’s own mental processes - what we call metacognition - has gained increasing prominence as a determining factor for making rapid and accurate decisions in highly complex competitive contexts (Araújo; Davids; Hristovsky, 2006). Interactively, the role of emotions in the preparation and execution of movements has become increasingly evident. Emotional states such as anxiety and confidence interact with cognitive processes and can modulate both performance and motor learning. This recognition has led to the study of metaemotion, understood as the ability to reflect upon and regulate one's own affective states (Gross, 2002).

Indeed, the adoption of the complex dynamic systems perspective, in articulation with the concept of embodied cognition, connects the individual's internal dynamics with contextual pressures. As Balagué *et al*. (2013, p. 5) point out, "complex systems can behave in a simple manner because their interactive components can form large coalitions of cooperative elements that reduce the dimensionality of behavior."

The explanation of performance phenomena from a dynamic standpoint is enriched by concepts drawn from dynamic systems theory, particularly stability and metastability - principles that help explain how athletes are able to maintain consistent patterns of action while simultaneously adapting to unforeseen situations (Kelso, 1995).

2.1 Complex Dynamic Systems and Self-Organization

The theory of complex dynamic systems (Kelso, 1995; Juarrero, 1999; Thelen; Smith, 1994) offers a theoretical framework that complements extended cognition by describing the mechanisms through which patterns of behavior emerge in nonlinear systems. These systems are characterized by the interaction of multiple components across distinct levels, by sensitivity to initial conditions, and by the emergence of global properties that cannot be reduced to the sum of their parts.

In the sporting context, dynamic systems provide a means of understanding how patterns of motor coordination, collective strategies, and decision-making emerge from the interaction of individual, environmental, and social factors. Concepts such as attractors, stability, instability, and metastability are fundamental to explaining how relatively stable behaviors can be maintained under certain conditions, yet rapidly reorganized when new demands arise.

The notion of metastability (Kelso; Tognoli, 2014; Tognoli; Kelso, 2014) is particularly relevant. Unlike rigid stability or total chaos, metastability is characterized by a critical dynamic regime in which multiple solutions remain active, and the system sustains a state of adaptive flexibility. This allows athletic performance to combine consistency with creativity, ensuring both the repetition of functional patterns and openness to innovative solutions.

2.2 Cognition, Metacognition, and Adaptive Regulation

If extended cognition and dynamic systems provide the theoretical foundations for understanding athletic performance, metacognition (Flavell, 1979; Dunlosky; Metcalfe, 2009; Nelson; Narens, 1990) adds a fundamental layer of self-regulation. Metacognition refers to the ability to monitor, evaluate, and regulate one's own cognitive processes, playing an essential role in learning, strategic planning, and adaptation under conditions of uncertainty.

In sports, metacognition should not be understood solely as an individual introspective process, but rather as part of an expanded network of regulation. This means that cognitive regulation does not occur only "within the mind," but is supported by external feedback, interactions with other agents, and environmental cues that function as metacognitive resources.

Moreover, metacognition connects to the notion of executive functions (Miyake *et al*., 2000; Diamond, 2013), which include working memory, cognitive flexibility, and inhibitory control. These functions are essential for adjusting strategies, redefining goals, and modulating decision thresholds, particularly in dynamic and high-pressure contexts. Contemporary literature also suggests that metacognitive processes are closely related to markers of confidence, error, and uncertainty, playing a crucial role in calibrating decisions under complex conditions (Fleming; Dolan, 2012; Shadlen; Kiani, 2013).

2.3 Emotion and Metaemotion in Sports Cognition

Contemporary approaches reject the dichotomy between cognition and emotion, recognizing them as deeply interdependent dimensions. Neuroscientific models of cognitive-emotional integration (Pessoa, 2013; Pessoa, 2022) argue that affective processes modulate perception, attention, and action selection, and decisively influencing performance in sports contexts.

Emotion is viewed both as a personal experience and as a practical tool for shaping behavior (Adolphs, 2013; Barrett, 2017). In sports, emotional states modulate the availability of affordances (Gibson, 1979; Withagen *et al*., 2012), responsiveness to environmental cues, and sensitivity to contextual fluctuations.

Metaemotion (Gottman; Katz; Hoover, 1996) adds a reflective dimension, designating the ability to monitor and regulate emotions in real time. This process involves both awareness of emotional states and the implementation of regulatory strategies (Gross, 1998; Gross; Thompson, 2007). In sports practice, metaemotion is linked to self-regulation, supporting the functional stability of the dynamic system under pressure while preserving the flexibility that characterizes metastability (Kelso; Tognoli, 2014).

The literature on emotion regulation (Lane *et al*., 2012; Hanin, 2007) demonstrates that athletes employ instrumental strategies to modulate their affective states and optimize performance. These processes, however, are not exclusively internal: they emerge in coupled contexts, supported by social interactions, bodily routines, and regulatory artifacts, consistent with extended cognition.

2.4 Stability, Metastability, and Critical Regimes

Applying dynamic systems theory to sports requires an understanding of the relationship between stability and metastability. Stability refers to the maintenance of functional patterns under relatively constant conditions, ensuring consistency and predictability (Thelen; Smith, 1994; Riley; Turvey, 2002). Metastability, in contrast, is characterized as a critical regime of coexistence among multiple attractors, in which the system remains sensitive to small variations and capable of rapidly transitioning between different coordination patterns (Kelso, 1995; Tognoli; Kelso, 2014).

In sports, metastability underpins adaptability, allowing the system to remain functionally coherent while maintaining openness to the emergence of novel solutions. This dynamic is central to decision-making, as it ensures that multiple options remain active until additional information reorganizes the decision field (Spivey, 2007).

Functional plasticity in metastable regimes connects with contemporary notions of cognitive flexibility (Miyake *et al*., 2000; Diamond, 2013) and adaptive heuristics

(Gigerenzer; Gaissmaier, 2011). Optimal performance results from the articulation between consistency (stability) and innovation (metastability), in a dynamic that reflects the balance between exploration and exploitation of possibilities (Pezzulo; Cisek, 2016).

2.5 Decision-Making as a Dynamic Process

Decision-making in sports should be understood as a time-dependent, nonlinear, and situated process. Evidence accumulation models (Smith; Ratcliff, 2004; Gold; Shadlen, 2007) show that decisions are progressively constructed under conditions of uncertainty, while ecological approaches emphasize the selection of *affordances* within perception–action coupling (Fajen; Riley; Turvey, 2009; Araújo; Davids; Hristovski, 2006).

Csurilla and Sterbenz (2022) demonstrate that uncertainty is not merely an inevitable condition but a structuring factor of sport, with distinct and often paradoxical effects on fans, athletes, and organizations. The authors emphasize that uncertainty operates on three levels: spectator, athlete, and system.

The literature indicates that athletes rely on fast heuristics in high-pressure contexts (Raab, 2012; Raab; Gigerenzer, 2007), reducing processing complexity without compromising effectiveness. Such heuristics do not operate in isolation but in synergy with metacognitive and metaemotional mechanisms, which calibrate confidence, response thresholds, and emotional regulation (Fleming; Dolan, 2012; Gross; Thompson, 2007).

Accordingly, decision-making should be conceived as an emergent event of a dynamic system in which stability, metastability, and regulation continuously interact. This process highlights the distributed and extended nature of cognition, insofar as decisions are not the exclusive products of neural activity but of an integrated network that includes the body, environment, and sociotechnical structures (Clark, 2015; Hutchins, 1995; Sutton *et al*., 2010).

3 DISCUSSION

The integration of extended cognition, complex dynamic systems, and regulation offers a paradigmatic shift for sports studies. Performance is no longer interpreted as the product of isolated individual capacities but is instead understood as an emergent phenomenon constituted in the relationship between subject and environment.

The concepts of stability and metastability provide a dynamic framework for explaining how patterns of action can be maintained and simultaneously reorganized under pressure. Metacognition and metaemotion function as regulatory mechanisms, enabling athletes to monitor their cognitive and affective states and to adjust strategies in real time. These processes are not isolated but are part of extended cognition, in which tools, social interactions, and environmental affordances are constitutive of decision-making.

From a practical standpoint, this approach suggests that sports interventions should consider not only technical training but also the cultivation of metacognitive and metaemotional competencies, as well as the promotion of environments that foster metastable adaptability. From a theoretical perspective, it reinforces the need to abandon reductionist models and to adopt systemic, distributed, and ecological perspectives for understanding cognition in sport.

4 FINAL CONSIDERATIONS

This article sought to articulate the application of extended cognition in sport with the concepts of complex dynamic systems, metacognition, emotion, metaemotion, stability, metastability, and decision-making. The central argument is that sports performance should be understood as the result of distributed, situated, and emergent processes in which the body, environment, artifacts, and social interactions play constitutive roles.

The analysis demonstrated that extended cognition provides the epistemological framework; dynamic systems explain the mechanisms of self-organization; metacognition and metaemotion ensure adaptive regulation; and the dynamic between stability and metastability enables both consistency and innovation in decision-making.

It is essential to explore integrative methodologies that capture the complexity of these processes, combining neurocognitive measures, dynamic analyses, and ecological approaches. In doing so, it will be possible to advance the understanding of sports cognition as a genuinely complex and extended phenomenon.

REFERENCES

ADOLPHS, R. The biology of fear. **Current Biology**, v. 23, n. 2, p. R79-R93, 2013. DOI: https://doi.org/10.1016/j.cub.2012.11.055.

ARAÚJO, D. et al. Ecological cognition: Expert decision-making behavior in sport. **International Review of Sport and Exercise Psychology**, v. 12, n. 1, p. 1-25, 2019. DOI: https://doi.org/10.1080/1750984X.2017.1349826.

ARAÚJO, D.; DAVIDS, K.; HRISTOVSKI, R. The ecological dynamics of decision making in sport. **Psychology of Sport and Exercise**, v. 7, n. 6, p. 653-676, 2006. DOI: https://doi.org/10.1016/j.psychsport.2006.07.002.

BALAGUÉ, N.; TORRENTS, C.; HRISTOVSKI, R.; DAVIDS, K.; ARAÚJO, D. Overview of complex systems in sport. **Journal of Systems Science and Complexity**, v. 26, p. 4-13, 2013. DOI: https://doi.org/10.1007/s11424-013-2285-0.

BARRETT, L. F. **How emotions are made**: The secret life of the brain. New York: Houghton Mifflin Harcourt, 2018.

BARSALOU, L. W. Grounded cognition. **Annual Review of Psychology**, v. 59, p. 617-645, 2008. DOI: https://doi.org/10.1146/annurev.psych.59.103006.093639.

BARSALOU, L. W. Grounded cognition: Past, present, and future. **Topics in Cognitive Science**, v. 2, n. 4, p. 716-724, 2010. DOI: https://doi.org/10.1111/j.1756-8765.2010.01115.x.

CAPPUCCIO, M. L. Introduction: When embodied cognition and sport psychology team-up. **Phenomenology and the Cognitive Sciences**, v. 14, p. 213-225, 2015. DOI: https://doi.org/10.1007/s11097-015-9415-1.

CLARK, A. **Supersizing the mind**: Embodiment, action, and cognitive extension. Oxford: Oxford University Press, 2008.

CLARK, A. **Surfing uncertainty**: Prediction, action, and the embodied mind. Oxford: Oxford University Press, 2015.

CLARK, A.; CHALMERS, D. J. The extended mind. **Analysis,** v. 58, n. 1, p. 7-19, 1998. DOI: https://doi.org/10.1093/analys/58.1.7.

CSURILLA, G.; STERBENZ, T. The presence of uncertainty in sport—A literature review. **Studia Universitatis Babeș-Bolyai**, Educatio Artis Gymnasticae, v. 67, n. 1, p. 19-30, 2022. DOI: https://doi.org/10.24193/subbeag.67(1).02.

DIAMOND, A. Executive functions. **Annual Review of Psychology**, v. 64, p. 135-168, 2013. DOI: https://doi.org/10.1146/annurev-psych-113011-143750.

DUNLOSKY, J.; METCALFE, J. **Metacognition**. Thousand Oaks: Sage, 2009.

FAJEN, B.; RILEY, M.; TURVEY, M. T. Information, affordances, and the control of action in sport. **International Journal of Sport Psychology**, v. 40, n. 1, p. 79-107, 2009.

FARINA, M. Embodied cognition: Dimensions, domains and applications. **Adaptive Behavior**, v. 29, n. 1, p. 73-88, 2021. DOI: https://doi.org/10.1177/1059712320912963.

FLAVELL, J. H. Metacognition and cognitive monitoring: A new area of cognitive-developmental inquiry. **American Psychologist**, v. 34, n. 10, p. 906-911, 1979. DOI: https://doi.org/10.1037/0003-066X.34.10.906.

FLEMING, S. M.; DOLAN, R. J. The neural basis of metacognitive ability. **Philosophical Transactions of the Royal Society:** Biological Sciences, v. 367, n. 1594, p. 1338-1349, 2012. DOI: https://doi.org/10.1098/rstb.2011.0417.

GALLAGHER, S. **How the body shapes the mind**. Oxford: Oxford University Press, 2005.

GIBSON, J. J. **The ecological approach to visual perception**. Boston: Houghton Mifflin, 1979.

GIGERENZER, G.; GAISSMAIER, W. Heuristic decision making. **Annual Review of Psychology**, v. 62, p. 451-482, 2011. DOI: https://doi.org/10.1146/annurev-psych-120709-145346.

GOLD, J. I.; SHADLEN, M. N. The neural basis of decision making. **Annual Review of Neuroscience**, v. 30, p. 535-574, 2007. DOI: https://doi.org/10.1146/annurev.neuro.29.051605.113038.

GOTTMAN, J. M.; KATZ, L. F.; HOOVER, C. **Meta-emotion**: How families communicate emotionally. Mahwah: Lawrence Erlbaum Associates, 1996.

GROSS, J. J. The emerging field of emotion regulation: An integrative review. **Review of General Psychology**, v. 2, n. 3, p. 271-299, 1998. DOI: https://doi.org/10.1037/1089-2680.2.3.271.

GROSS, J. J.; THOMPSON, R. A. Emotion regulation: Conceptual foundations. In: GROSS, J. J. (org.). **Handbook of emotion regulation**. New York: Guilford, 2007. p. 3-24.

HANIN, Y. L. Emotions in sport: Current issues and perspectives. In: TENENBAUM, G.; EKLUND, R. C. (org.). **Handbook of sport psychology**. 3. ed. Hoboken: Wiley, 2007. p. 31-58.

HUTCHINS, E. **Cognition in the wild**. Cambridge, MA: MIT Press, 1995.

JUARRERO, A. **Dynamics in action**: Intentional behavior as a complex system. Cambridge, MA: MIT Press, 1999.

KELSO, J. A. S. **Dynamic patterns**: The self-organization of brain and behavior. Cambridge, MA: MIT Press, 1995.

KELSO, J. A.; TOGNOLI, E. Toward a complementary neuroscience: Metastable coordination dynamics of the brain. **Chaos and Complexity Letters**, v. 1, p. 141-162, 2017.

LANE, A. M. et al. Instrumental emotion regulation in sport: Relationships between beliefs about emotion and emotion regulation strategies used by athletes. **Scandinavian Journal of Medicine & Science in Sports**, v. 21, n. 6, p. e445-e451, 2011. DOI: https://doi.org/10.1111/j.1600-0838.2011.01364.x.

MIYAKE, A. et al. The unity and diversity of executive functions and their contributions to complex "frontal lobe" tasks. **Cognitive Psychology**, v. 41, n. 1, p. 49-100, 2000. DOI: https://doi.org/10.1006/cogp.1999.0734.

NELSON, T. O. Metamemory: A theoretical framework and new findings. In: BESSON, T. (org.). **Psychology of learning and motivation**. Cambridge: Academic Press, 1990. p. 125-173. DOI: https://doi.org/10.1016/S0079-7421(08)60053-5.

NOË, A. **Action in perception**. Cambridge, MA: MIT Press, 2004.

PESSOA, L. **The cognitive-emotional brain**: From interactions to integration. Cambridge, MA: MIT Press, 2013.

PESSOA, L. **The entangled brain**. Cambridge, MA: MIT Press, 2022.

PEZZULO, G.; CISEK, P. Navigating the affordance landscape: Feedback control as a process model of behavior and cognition. **Trends in Cognitive Sciences**, v. 20, n. 6, p. 414-424, 2016. DOI: https://doi.org/10.1016/j.tics.2016.03.013.

RAAB, M. Simple heuristics in sports. **International Review of Sport and Exercise Psychology**, v. 5, n. 2, p. 104-120, 2012. DOI: https://doi.org/10.1080/1750984X.2012.654810.

RAAB, M.; ARAÚJO, D. Embodied cognition with and without mental representations: The case of embodied choices in sports. **Frontiers in Psychology**, v. 10, art. 1825, 2019. DOI: https://doi.org/10.3389/fpsyg.2019.01825.

RAAB, M.; GIGERENZER, G. Intelligence as smart heuristics. In: TENENBAUM, G.; EKLUND, R. C. (org.). **Handbook of sport psychology**. 3. ed. Hoboken: Wiley, 2007. p. 558-575.

RILEY, M. A.; TURVEY, M. T. Variability and determinism in motor behavior. **Journal of Motor Behavior,** v. 34, n. 2, p. 99-125, 2002. DOI: https://doi.org/10.1080/00222890209601934.

SHADLEN, M. N.; KIANI, R. Decision making as a window on cognition. **Neuron,** v. 80, n. 3, p. 791-806, 2013. DOI: https://doi.org/10.1016/j.neuron.2013.10.047.

SMITH, P. L.; RATCLIFF, R. Psychology and neurobiology of simple decisions. **Trends in Neurosciences**, v. 27, n. 3, p. 161-168, 2004. DOI: https://doi.org/10.1016/j.tins.2004.01.006.

SPIVEY, M. J. **The continuity of mind**. Oxford: Oxford University Press, 2007.

SUTTON, J.; HARRIS, C. B.; KEIL, P. G.; BARNIER, A. J. The psychology of memory, extended cognition, and socially distributed remembering. **Phenomenology and the Cognitive Sciences**, v. 9, p. 521-560, 2010. DOI: https://doi.org/10.1007/s11097-010-9182-y.

THELEN, E.; SMITH, L. B. **A dynamic systems approach to the development of cognition and action.** Cambridge, MA: MIT Press, 1994.

TOGNOLI, E.; KELSO, J. A. S. The metastable brain. **Neuron**, v. 81, n. 1, p. 35-48, 2014. DOI: https://doi.org/10.1016/j.neuron.2013.12.022.

VARELA, F. J.; THOMPSON, E.; ROSCH, E. **The embodied mind:** Cognitive science and human experience. Rev. ed. Cambridge, MA: MIT Press, 2017.

VOIGT, L. et al. Advancing judgment and decision-making research in sport psychology by using the body as an informant in embodied choices. **Asian Journal of Sport and Exercise Psychology**, v. 3, n. 1, p. 47-56, 2023. DOI: https://doi.org/10.1016/j.ajsep.2022.09.006.

WILLEMS, R. M.; FRANCKEN, J. C. Embodied cognition: Taking the next step. **Frontiers in Psychology**, v. 3, art. 582, 2012. DOI: https://doi.org/10.3389/fpsyg.2012.00582.

WILSON, A. D.; GOLONKA, S. Embodied cognition is not what you think it is. **Frontiers in Psychology**, v. 4, art. 58, 2013. DOI: https://doi.org/10.3389/fpsyg.2013.00058.

WILSON, M. Six views of embodied cognition. **Psychonomic Bulletin & Review**, v. 9, n. 4, p. 625-636, 2002. DOI: https://doi.org/10.3758/BF03196322.

WITHAGEN, R.; DE POOLE, I.; ARAÚJO, D.; PEPPING, G.-J. Affordances can invite behavior: Reconsidering the relationship between affordances and agency. **New Ideas in Psychology**, v. 30, n. 2, p. 250-258, 2012. DOI: https://doi.org/10.1016/j.newideapsych.2011.12.003.