Beyond Biomechanics: Fighting Monkey and the Enactive Inference Approach to Health and Movement

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Abstract

Why do we exercise? To date, the most popular justification for movement has centered around physical health, typically operationalized through biomechanical outcomes such as muscular strength or cardiovascular capacity. This reductionist view produces narrow adaptations that leave individuals vulnerable to complexity in the real world, and ignores the embodied nature of our minds.

We present an alternative framework, drawing on insights from enactive cognitive science and the Active Inference Framework. Combining notions of the human as nested agents across scales, we recast health as competent problem solving across scales (from cellular to whole-organism) and spaces (anatomical, physiological, conceptual). Using an approach to movement informed by enactivism and active inference, we provide two examples of such an approach in practice. This reframing should allow for increased adaptability and expression across the human lifespan, and has implications in all domains of movement development.

Introduction

"*Experience shows the problem of the mind cannot be solved by attacking the citadel itself. — the mind is function of the body. — we must bring some stable foundation to argue from.*"
Charles Darwin (1836-44] 1987:564)

Current notions of exercise and movement neglect key dimensions of human experience, focusing narrowly on biomechanical outcomes while overlooking the richness of our embodied and embedded experience (Parviainen, 2015). Even at elite levels, professional athletes frequently train in ways that optimize performance at the expense of long-term wellbeing. The body is viewed as a resource to be utilized, rather than a core constituent of the self. The enactive inference approach to movement offers a corrective to this perspective.

We will begin by providing a short introduction to key principles from embodied cognition and active inference which serve as the foundation for the enactive inference approach. We discuss what it means for humans to be extended and embedded in an environment, the role of

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surprise-minimization, and the notion of our selves as being comprised of nested agents. We then propose to conceive of health as the ability to solve problems across different spaces.

Finally, we present the Fighting Monkey method, a specific instance of the enactive inference approach to movement, and discuss two activities to demonstrate the enactive inference approach in practice — a solo practice centered around the spine, and a partnered practice involving a ball on a string. With these examples, we suggest that movement based on enactive inference can be lively, playful, and effective at enhancing a broad range of capacities throughout our lifetime.

We hope for this perspective to benefit a wide range of people, including movement instructors, physiotherapists, athletes, and anyone interested in maintaining expressive, adaptable movement across their lifespan. For those seeking rehabilitation from injury, it offers novel pathways to recovery; for those already healthy, it provides an enriched conception of movement that cultivates adaptability and expression.

Active Inference, Embodied Cognition, and the Human

In this section, we describe certain key principles from embodied cognition and active inference that can help us understand humans and movement.

Embodied cognition, also referred to as enactivism, or 4E cognitive science, is a research tradition (Laudan, 1978) that arose as a response to both the cognitivist ("mind is a serial computer") and the connectionist ("mind is a distributed neural network") approaches to modeling the human mind (Varela et al., 2016; Thompson, 2010). In contrast to the cognitivist and connectionist approaches, embodied cognition emphasizes humans and their minds as essentially dynamic, embedded, and not separate from the body. We elaborate on this in the following section.

The Active Inference Framework (AIF) is a theoretical framework that characterizes living organisms as engaging in continuous loops of action and perception that collectively serve to minimize errors (Parr et al., 2022). "Error" here refers to the discrepancy between an organism's 'internal model' and the input from the environment. Examples include thermoregulation, where sufficient deviation from predicted input leads to physiological and behavioral change (Sterling, 2012), and spatial navigation, where an organism learning to navigate a maze updates its model in response to going down a dead end (Friston et al., 2015). This principle applies across all scales of biological organization, from cells to complex cognitive systems.

Although AIF and embodied cognition have historically been separate, Ramstead et al. have persuasively argued for deep complementarity between the embodied cognition approach and active inference (Ramstead et al., 2019). Roughly, AIF can be understood as the means by which a decision making policy is chosen, where the agent is still formulated in an embedded environment-agent system. We will borrow from their term and describe the following as the ‘enactive inference approach to movement’.

Key principles of the enactive inference approach to movement

Nested agency across scales. The human organism can be understood as a hierarchical system of semi-autonomous agents operating across scales and spaces (Levin, 2019). This extends beyond the view of an organism as single unified agent to acknowledge several distinct problem solving capacities throughout the body. “Agent” here we can loosely use to refer to a system that engages in action and perception feedback loops to maintain a range of states.

Organism-scale agency: At the whole-person level, we solve problems in conceptual, social, and physical space. A chess player operates within a conceptual spaces defined by 64 squares and six pieces with different rules for movement.

Organ system-scale agency: Below the whole-person, our organ systems solve problems without our conscious involvement. When we stand up, our circulatory system dynamically redirects blood flow to the head by constricting peripheral blood vessels and increasing heart rate.

Cellular-scale agency: Problem solving continues at the cellular and molecular level. Cell replication requires careful coordination between cascades of enzymes and proteins, with mechanisms to detect and correct DNA replication errors.

These nested agents operate with relative autonomy yet remain integrated, creating a complex hierarchy of problem-solving processes that collectively constitute the moving human. Movement practices can target different levels of this hierarchy, from consciously learning new skills to implicitly training physiological systems to respond more effectively to changing demands.

Extended and embedded. The human mind does not reduce to a brain isolated from the body. Instead, the mind is fundamentally inseparable from its physical, social, and technological context (Stilwell & Harman, 2019; Clark & Chalmers, 1998; Varela et al. 2016). This includes several related dimensions:

Embodied: Cognitive processes fundamentally emerge out of interaction with the physical body. The nervous system connects everything from the gut to the heart to the muscle fibers in our toes. The neural network extends through the whole body, influencing and being influenced by brain activity (Critchley & Harrison, 2013). Cognition is not just “in the head”, but across the whole-organism and its environment.

Extended: Our cognitive processes often incorporate environmental elements as functional parts of the cognitive system itself (Clark & Chalmers, 1998). In sports, this is readily apparent: a basketball player's cognitive processes adapt specifically to the weight and bounce of the ball, while a hockey player's spatial awareness and decision-making become extended through the hockey stick, effectively changing how they perceive distances, opportunities, and threats. The stick or ball becomes, temporarily, part of the cognitive apparatus.

Embedded: Beyond extension, cognition is always situated within a specific environmental context that constrains and affords certain actions. The dimensions of the hockey field, the social relationship with teammates, memories associated with gameplay — all these features shape cognitive processes while remaining outside the cognitive system itself.

Dynamically self-creating. The person is not a static entity but rather a process in constant flux. While our cells are continuously recycled and our features change over time, there remains a continuity of self that we actively participate in maintaining. As living organisms, we engage in autopoiesis (Varela, 2025) — a continuous process of self-creation. This ongoing reorganization happens in response to environmental challenges and internal needs. In the context of exercise, this principle becomes evident when we consider how bodies adapt to specific stressors: a runner's cardiovascular system reorganizes to deliver oxygen more efficiently, while resistance training triggers reorganization of muscle tissue to generate greater force. Crucially, these adaptations aren't uniform but highly specific to the exact patterns of movement and challenge encountered. The organism doesn't merely respond passively but actively seeks out and creates the conditions for its own development, forming a dynamic stability rather than a fixed identity.

Action minimizes surprise. A core claim from the Free Energy Principle is that living systems work to minimize prediction error — the difference between expected and actual sensory inputs (Friston, 2010). This prediction error is formally quantified as variational free energy, and often termed “surprise” (related, though distinct from the colloquial meaning).

The Active Inference Framework extends this by suggesting there are two complementary ways organisms minimize prediction error: updating perception, and updating action.

Consider a novice learning to catch a ball: initially, prediction errors are large as their internal model fails to accurately anticipate the ball's trajectory, resulting in missed catches. With practice, improvement occurs through dual processes:

1. The practitioner updates their internal model to better predict flight paths based on the thrower's movements, ball spin, and environmental conditions (perceptual inference).
2. Simultaneously, they learn to position their body and hands to intercept the ball's path, effectively selecting actions that make sensory inputs conform to predictions (active inference).

Expert catchers demonstrate this at a refined level, making micro-adjustments based on subtle cues before the ball leaves the thrower’s hand. Understanding organisms in terms of these action-perception loops allows us to design movement practices that improve and refine our predictive models.

A new notion of health as agency

In contrast to common definitions of health as either the absence of disease, or else in reference to some normal population (Boorse, 1977), we want to propose the notion of *health as agency*. More specifically, we can understand health as *the problem solving competency across different scales and spaces*.

Drawing upon the notion of nested agency across scales, we can briefly distinguish between 'scale' and 'spaces' in which problem solving occurs (Levin, 2019). From the organism-scale to the cellular-scale, this gives us a vocabulary to reconceptualize physical dysfunction (as in sickle cell anemia) and psychological dysfunction (e.g. dissociative disorder) as a failure of competency at different scales.

"Spaces" here refers to distinct domains in which agents solve problems. These include anatomical, physiological, and cognitive space.

For a given task such as a wrestling takedown, the mover has to be able to sense their opponent's center of balance (ecological perception), coordinate and rearrange their limbs while maintaining appropriate tension (anatomical problem-solving), regulate breathing and energy expenditure (physiological problem-solving), and adapt tactics based on the opponent's responses (cognitive problem-solving). Each of these spaces presents distinct challenges that must be integrated for successful performance.

Some tasks require more competence than others. Tasks that are more passive, such as watching a video of a baseball game, are usually seen as easier than more active tasks, such as hitting a baseball. We can consider these along an axis of complexity, where tasks at one end require very little competence across spaces and scales (e.g. getting a massage) and tasks at the other end that require immense competence (e.g. balancing on one leg while dodging a rapidly moving ball).

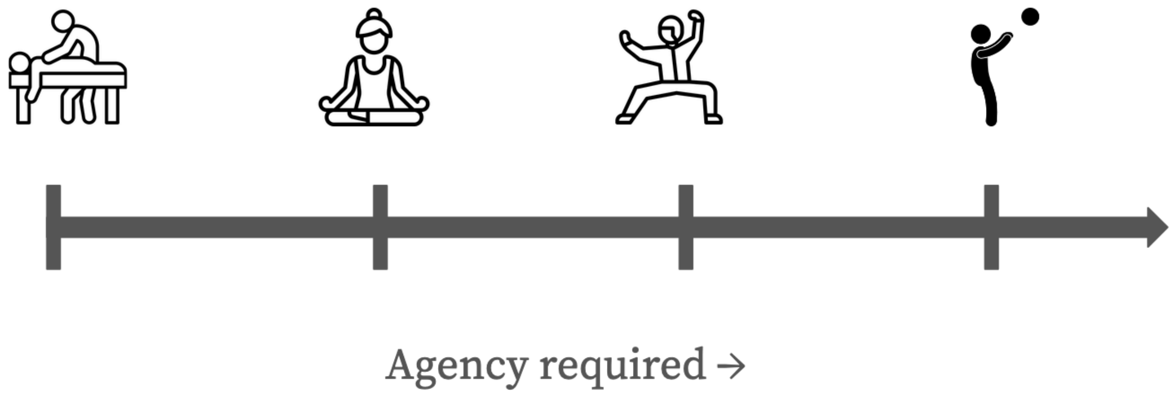

Fig 2. Axis of complexity. We can organize 'tasks' in increasing levels of complexity at the scale of the organism and the space of anatomy. At the lowest level is the passive reception of a treatment, such as a massage. One level above this requires participation of the mover, but is restricted to static positions, such as a plank, or meditation asana within yoga. Another level of complexity is added with moving (but still fixed-step) forms, as with Tai Chi. Yet another can be added with open-exploration, potentially involving an environmental tool such as a ball.

Fighting Monkey Method as Agency Increasing Practice

The Fighting Monkey Method, as conceived by Jozef Frucek and Linda Kapetanea, aims broadly to increase movement agency of its practitioners. It does this by specifying tasks of varying complexity across a wide range of spaces. These tasks can be separated into forms that are self led (known as "Zero Forms Practice"), or those in interaction with an environment (known as "Movement Situations"). Each task is also made more demanding so as to require more agency from the practitioner.

Zero Forms: Spinal Exploration

Fighting Monkey's spinal explorations demonstrate a self-led movement that moves along the axis of complexity. In its simplest form, the practitioner stands with feet hip-width apart, and raises arms overhead in alignment with the spine. The alignment is kept as the practitioner folds their body forward, hinging at the hips, maintaining a continuous line from pelvis to fingertip. After touching the ground, the mover rises up, maintaining length through the spine and concludes with a gentle backbend with arms at hips (See Fig 2.).

After comprehending this basic pattern, practitioners explore variations while preserving the principle of communication between joints. Examples of variations include altering hand positions (straight palms, fists, perpendicular palms), changing orientation of folding and rising (diagonally left or right), vary speed and rhythm. practitioners are then encouraged to freely improvise, using the basic movement pattern as a template for novel movement.

Maintaining the principle of joint-level communication provides a constraint that the practitioner's physiology has to solve problems around. The active exploration foregrounds the edge of competency and therefore also the boundary of self. The instructions are given with particular emphasis on our autopoetic nature, and the dynamically improvised nature of our boundaries.

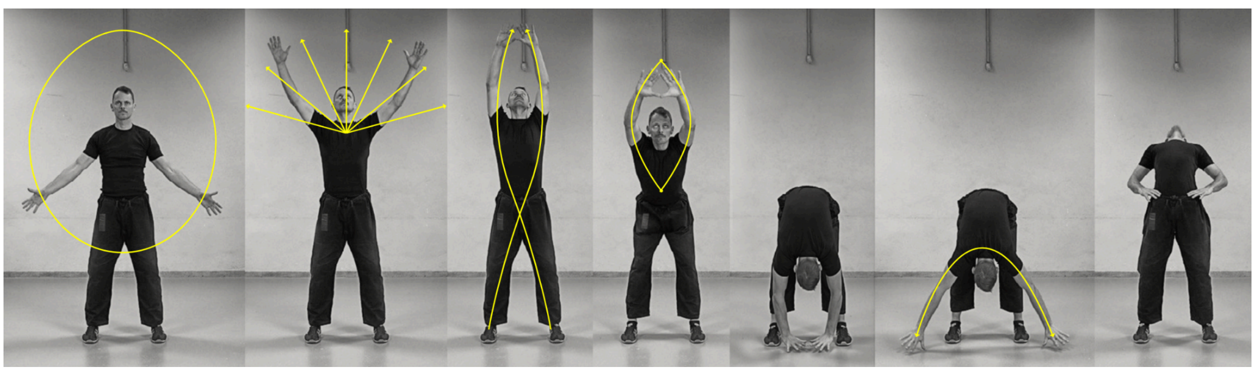

Fig 3. An illustration of the Spinal Pull by Jozef Frucek. Taken with permission from the Zero Forms: Spine programme.

It is important to emphasize that a task-variant requiring more agency is not *better* than another requiring less agency. The appropriate level will always depend on the context of the practitioner. For someone with spinal degeneration, entirely passive treatment may be the only available (and therefore appropriate) option. For a young athlete, introducing a progressively complex movement situation may aid in the development of agency.

Movement Situation: Practice Ball

We have just demonstrated an instance of moving along the axis of agency for mostly self led tasks. Now we can provide an example that includes environmental interaction, highlighting how the enactive inference approach to movement incorporates external elements into perception-action loops.

In the Fighting Monkey method, tools are often added to create dynamic problem spaces. The practice ball — a soft yellow ball attached to an elastic string — is a one such versatile tool. It can be swung, thrown, watched, or dodged, providing a playful landscape of affordances for exploring movement. Below, we demonstrate four variants of practice ball interactions that increase in complexity.

Fig. 3 Four movement situations using the practice ball. Photos taken with permission from May 2025 Manhattan Fighting Monkey workshop with participants.

Variant I: Back watching. Practitioner lies on their back while continuously tracking the ball with their gaze as it moves through space.

Variant II: Tracking while standing. Practitioner keeps two feet in same position on ground and continues to watch the ball. This adds greater demands on maintaining stability while rotating torso, neck, and eyes to follow the movement of the ball.

Variant III: Dynamic tracking. Practitioner now rises and falls to maintain visual contact and a similar distance with the ball through space. The additional degrees of freedom require increasingly complex coordination across joints and space.

Variant IV: Dodging. The ball is now bounced towards the practitioner at various heights, in an unpredictable way as the practitioner evades while staying in roughly the same space. The time constraint of the ball, and its unpredictable trajectory require an even greater degree of problem solving in anatomical and physiological space.

These two tasks — spinal explorations and playing with the practice ball — represent a small sample from the vast possibility space of the enactive inference approach to movement. While superficially resembling conventional “progressive overload” in exercise science, this approach fundamentally differs in its theoretical foundations. Rather than simply increasing intensity within a particular domain (heavier weights, faster speeds), the enactive inference approach deliberately expands and contracts problem spaces practitioners must navigate.

Agency development across multiple spaces — anatomical, physiological, cognitive — requires constraints that challenge prediction at various levels and continued novelty, so new movement patterns have to constantly arise. The relation between self and environment, what Varela refers to as ‘structural coupling’ (Varela, 2025) is deliberately shifted, forcing active exploration and reorganization of the coupling pattern (as when the rules of engagement with the practice ball change). The experience of the participants is one of challenge, confusion, exhileration.

The framework offers rich possibilities for application across movement disciplines, from dance to martial arts to rehabilitation. While the full experience cannot be conveyed through text alone, we hope these examples demonstrate how such a practice may be used to develop competency across scales and spaces and enrich our process of self-creation.

Contributions

In this article, we articulated an alternative to the biomedical view of health and the closely associated biomechanical view of exercise. Through drawing on the literature around embodied cognition and active inference, we introduced the notions of extended and embedded minds, nested agency across scales, surprise minimization, and dynamic self-creation in the context of movement. After proposing one view of health as problem-solving competency across spaces and scales. Drawing on FM, we provided two concrete examples of the enactive inference approach to movement.

In an era of health crises — from chronic disease to mental health challenges — our interventions are deeply informed by our conceptual frameworks. By expanding how we conceive of health and movement, we hope provide to provide new conceptual tools for the reader, be they movers, teachers, healers. We believe such conception can address not only the afflictions of unease but honor deep meaning and the beautiful complexity of embodied human experience.

Conflict of interest statement

The authors declare the following potential conflicts of interest: Jozef Frucek is the co-founder of the Fighting Monkey Practice and derives financial income from teaching workshops, courses, and selling online educational content related to the method described in this paper. Max Shen has participated in Fighting Monkey workshops but has received no financial compensation, sponsorship, or funding related to this work. This manuscript was conceived and written independently, without financial support or commissioned input from Fighting Monkey or any associated organizations.

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