

# ENACTIVE MODE

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## Understanding the Foundations of the Enactive Mode in Cognitive Science

The **enactive mode** represents a significant paradigm shift in contemporary cognitive science, moving away from traditional models that view the mind as a passive processor of information. Historically, cognitive psychology was dominated by the representationalist view, which posits that the brain functions much like a computer, creating internal symbols to mirror the external world. In contrast, the enactive approach suggests that cognition is not something that happens "inside" the head, but rather something that emerges through the **dynamic interaction** between an organism and its environment. This perspective emphasizes that knowledge is not a static collection of facts stored in memory, but a continuous process of "bringing forth" a world through physical engagement and sensory-motor activity.

At its core, the **enactive mode** posits that an organism's perception is inextricably linked to its capacity for action. This means that we do not simply see an object and then decide how to act upon it; rather, our very perception of the object is shaped by the actions we are capable of performing. For instance, a chair is perceived not merely as a collection of physical properties like height and color, but as a "place for sitting." This action-oriented perception is the hallmark of enactive cognition, suggesting that our cognitive structures are built upon the foundation of our **physical embodiment** and the specific ways we navigate the spaces we inhabit. By focusing on the lived experience of the agent, the enactive mode provides a more holistic understanding of how intelligence operates in real-world settings.

Furthermore, the **enactive mode** challenges the traditional boundary between the subject and the object. In the representationalist framework, the observer and the observed are treated as distinct entities, with the mind acting as a bridge between them via internal models. However, enactive theory argues that the subject and environment are **co-constitutive**. Through physical action, the agent modifies the environment, and these environmental changes, in turn, reshape the agent's cognitive state. This reciprocal relationship suggests that cognition is a distributed process that involves the body, the brain, and the external world in a unified system. Consequently, the enactive mode has become a cornerstone for researchers seeking to understand how biological systems maintain their identity while remaining deeply coupled with their surroundings.

The academic interest in the **enactive mode** has surged in recent years as researchers in artificial intelligence, robotics, and human-computer interaction seek more robust frameworks for modeling intelligence. Traditional AI, built on symbolic logic, often struggles with the "frame problem" or the inability to handle the fluid, unpredictable nature of real-world environments. The enactive approach offers a solution by suggesting that intelligence does not require exhaustive internal maps if the agent can rely on **sensory-motor contingencies** to guide behavior. This shift from "thinking" to "doing" as the primary mode of cognition has profound implications for how we design everything from educational tools to complex autonomous systems, ensuring they are better

aligned with the natural ways humans and animals interact with reality.

## The Theoretical Genesis: Varela, Thompson, and Rosch

The formal introduction of the **enactive mode** is largely attributed to the seminal work of Francisco Varela, Evan Thompson, and Eleanor Rosch in their 1991 book, *The Embodied Mind: Cognitive Science and Human Experience*. In this groundbreaking text, the authors sought to bridge the gap between scientific cognitive psychology and the lived experience of human beings. They argued that the prevailing computational metaphors of the time failed to account for the **embodied nature** of the mind. By drawing on biological principles and Buddhist philosophy, they proposed that cognition is "enacted" rather than represented. This means that the world we inhabit is not a pre-given reality that we discover, but a world that we actively participate in creating through our biological and cultural history.

Varela and his colleagues introduced the concept of **autopoiesis**--the idea that living systems are self-producing and self-maintaining--to explain how cognition serves the needs of the organism. According to this view, an organism's "knowledge" is essentially its ability to maintain its own stability through effective action in its environment. The **enactive mode** thus treats cognition as a form of biological regulation. Instead of viewing the brain as a machine that processes inputs to produce outputs, the enactive view sees it as a component of a larger system dedicated to the survival and flourishing of the agent. This perspective redirected the focus of cognitive science toward the study of **autonomous agents** and their meaningful interactions with their ecological niches.

One of the key contributions of Varela et al. was the emphasis on **sensory-motor coupling**. They argued that perception consists of perceptually guided action. To understand how a creature perceives the world, one must understand how that creature moves. For example, the way a bat perceives its environment through echolocation is fundamentally different from the way a human perceives it through vision, not just because of the sensory organs involved, but because of the different **action possibilities** available to each. The enactive mode suggests that our cognitive categories are derived from these patterns of interaction. This theoretical foundation provided a rigorous alternative to the "computer metaphor" of the mind, laying the groundwork for what is now known as **embodied cognition**.

The impact of *The Embodied Mind* cannot be overstated, as it provided a common language for philosophers, biologists, and computer scientists to discuss the nature of intelligence. It moved the discourse away from abstract logic and toward the **phenomenology of experience**. By asserting that "the mind is not in the head," Varela and his co-authors invited a radical rethinking of the locus of cognition. This theoretical genesis remains the primary touchstone for all subsequent research into the **enactive mode**, serving as the philosophical bedrock for modern attempts to create

systems that truly "understand" their environment through physical presence and active participation.

## Phenomenological Roots: The Influence of Maurice Merleau-Ponty

While the term "enactive" gained prominence in the late 20th century, its philosophical roots extend back to the phenomenological tradition, most notably the work of **Maurice Merleau-Ponty**. In his masterwork, *Phenomenology of Perception* (1962), Merleau-Ponty argued against the Cartesian dualism that separated the mind from the body. He proposed that the body is not just an object in the world, but the very medium through which we have a world. According to Merleau-Ponty, **knowledge is acquired** through physical action, and our primary way of relating to reality is through "body-subjectivity." This idea is central to the **enactive mode**, as it posits that our consciousness is fundamentally "incarnate" and situated.

Merleau-Ponty introduced the concept of the **intentional arc**, which describes the tight connection between our past experiences, our current bodily state, and the possibilities for future action. He suggested that when we learn a skill--such as typing or playing an instrument--the knowledge does not reside in our intellectual memory but in our "body-schema." The body "understands" the environment in a way that precedes conscious thought. This **pre-reflective awareness** is a critical component of the enactive mode, as it explains how we navigate complex environments with ease and fluidity without needing to constantly perform mental calculations. For Merleau-Ponty, the subject and the object are locked in a "chiasm" or a dynamic intertwining where each defines the other.

The enactive approach adopts Merleau-Ponty's view that **physical action** is a form of understanding. When we reach for a cup, our hand automatically shapes itself to match the cup's contours before we even touch it. This "motor intentionality" demonstrates that our bodies are constantly "interrogating" the environment. The **enactive mode** formalizes this philosophical insight by integrating it into cognitive models that prioritize movement and interaction. By recognizing that we "know" the world by being in it and acting upon it, researchers can move beyond the limitations of purely intellectualist theories of mind that ignore the vital role of the **living body**.

Furthermore, Merleau-Ponty's work emphasizes the **subjective quality** of experience, which is often neglected in traditional cognitive science. The enactive mode seeks to honor this subjectivity by exploring how meaning is generated from the perspective of the agent. In this view, the world is not a collection of neutral objects, but a field of **affordances**--opportunities for action. A cliff is not just a geological formation; it is "fall-off-able" or "climbable." By grounding cognition in these phenomenological realities, the enactive mode provides a much richer and more accurate account of how human beings and other animals actually experience and make sense of their lives.

## Contrasting Enactive Mode with Traditional Representationalism

To fully appreciate the **enactive mode**, one must understand the "representationalist" paradigm it seeks to replace. Traditional cognitivism views the mind as a system that manipulates **symbolic representations**. In this model, the senses provide raw data, which the brain then transforms into internal maps or models. These models are used to plan actions, which are then executed by the body. This "sandwich" model of cognition--where perception and action are merely the bread surrounding the "meat" of central processing--assumes that the mind can operate independently of the body's physical state or the immediate environmental context.

The **enactive mode** rejects this separation, arguing that representationalism creates an unnecessary "explanatory gap." If the mind only deals with internal symbols, how do these symbols ever acquire real-world meaning? This is known as the **symbol grounding problem**. Enactive theorists argue that meaning is not found in abstract symbols, but in the **active engagement** of the organism with its surroundings. By eliminating the need for complex internal representations for every action, the enactive approach offers a more parsimonious and biologically plausible explanation for cognitive behavior. Instead of "computing" a world, the agent "enacts" it through continuous feedback loops of movement and sensation.

Another key distinction lies in how each approach handles **environmental complexity**. Representational systems require immense computational power to update internal models whenever the environment changes. This often leads to "brittleness" in AI systems. The **enactive mode**, however, suggests that the environment itself can serve as its own best model. By remaining in constant physical contact with the world, an agent can respond to changes in real-time without needing to re-calculate an entire internal map. This **dynamic relationship** allows for greater flexibility and adaptability, as the agent's "knowledge" is always current and relevant to the task at hand.

Finally, the contrast between these two modes extends to the **nature of intelligence** itself. Representationalism tends to value "disembodied" intelligence, such as the ability to play chess or solve mathematical equations. The **enactive mode**, conversely, values "situated" intelligence, such as the ability to navigate a crowded street or use a tool effectively. It suggests that the most fundamental forms of cognition are those that allow us to interact with the physical world. By prioritizing **interaction over representation**, the enactive mode aligns cognitive science with the realities of biological evolution, where the primary function of the nervous system is to coordinate action rather than to contemplate abstract truths.

## The Role of Physical Action in Knowledge Acquisition

In the **enactive mode**, physical action is not merely a consequence of knowledge but the primary

vehicle for its acquisition. This concept is often described through the lens of **sensory-motor contingencies**--the regularities that govern how sensory input changes as a result of movement. For example, when an individual moves closer to an object, that object occupies a larger portion of their visual field. By mastering these contingencies, the agent learns the spatial properties of the world. Therefore, **knowledge acquisition** is essentially the process of refining one's ability to predict and control the sensory consequences of one's actions.

This approach has significant implications for how we understand learning and development. From an enactive perspective, a child does not learn about the world by being told facts, but by **grasping, tasting, and moving** through it. Each physical interaction provides a piece of the cognitive puzzle, building a repertoire of "know-how" that forms the basis for later, more abstract "know-that." The **enactive mode** suggests that even the most complex intellectual skills are ultimately rooted in these basic motor patterns. Consequently, education and training systems that incorporate **hands-on interaction** are often more effective because they align with the natural enactive processes of the human brain.

Furthermore, the **enactive mode** emphasizes that knowledge is always "situated." This means that what we know is deeply tied to the context in which we learned it and the tools we used. When a person uses a hammer, the hammer effectively becomes an extension of their body, and their "knowledge" of the hammer is found in the fluid way they use it to drive a nail. This **extension of the self** through physical action illustrates how cognition spills over the boundaries of the skin. Knowledge is not a "thing" we possess, but a "way of acting" that we manifest in specific environments. This makes the enactive mode a powerful tool for analyzing **human-tool interaction** and expert performance.

The emphasis on action also highlights the **interpretive nature** of cognition. Every action is a choice that reflects the agent's goals and perspective. By acting on the world, we "interrogate" it, forcing it to reveal certain properties while ignoring others. This means that the **enactive mode** is inherently participatory. We do not discover a world that exists independently of us; we participate in the "co-creation" of our lived reality. This view transforms our understanding of knowledge from a passive mirror of reality into an **active exploration** of the possibilities for existence, making the role of the physical body indispensable to the life of the mind.

## Implications for the Design of Cognitive Systems

The transition toward the **enactive mode** has profound implications for the design of **cognitive systems**, including artificial intelligence, robotics, and user interfaces. Traditionally, systems were designed to process data and provide outputs, often creating a barrier between the user's physical intent and the system's response. An enactive approach, however, suggests that **physical interaction** should be the primary consideration in the design process. By creating systems that

respond to the user's natural movements and gestures, designers can create more **efficient and effective** cognitive environments that feel like an extension of the human body rather than a foreign tool.

One of the key goals in designing enactive systems is to maximize **intuition**. As suggested by Löw (2017), enactive interfaces should be designed to leverage the user's existing sensory-motor skills. This means that the "learning curve" for a new system can be drastically reduced if the interaction patterns mimic the way humans interact with physical objects. For example, touchscreens and gesture-based controls are more "enactive" than command-line interfaces because they tap into our **innate spatial abilities**. The objective is to create a "transparent" interface where the user can focus entirely on the task at hand, with the technology receding into the background of their awareness.

Moreover, the **enactive mode** encourages designers to consider the **coupling** between the system and the environment. A truly enactive cognitive system does not just sit in a vacuum; it is designed to be situated in a specific physical context. This leads to the development of "affordance-based" design, where the system provides clear visual or tactile cues that suggest how it should be used. By aligning the system's capabilities with the **physical affordances** of the environment, designers can ensure that the interaction is both natural and meaningful. This approach is particularly vital in high-stakes environments, such as surgical robotics or aviation, where the speed and accuracy of the **user-environment interaction** are critical.

The design of these systems also necessitates a shift in how we evaluate "intelligence." In an enactive framework, an intelligent system is not one that can store the most data, but one that can **interact most successfully** with its surroundings. This has led to the rise of "soft robotics" and "situated AI," which prioritize flexibility and real-time responsiveness over brute-force calculation. By focusing on the **dynamics of interaction**, designers can create cognitive systems that are more resilient, adaptable, and better suited to the complexities of the human world. The **enactive mode** thus provides a roadmap for the next generation of technology, where the digital and physical worlds are seamlessly integrated.

## Personalization and Individual Characteristics in Enactive Interfaces

A significant advantage of the **enactive mode** in system design is its focus on the **individual characteristics** of the user. Because enactive cognition is grounded in the body, it follows that different bodies will "enact" different worlds. Gutierrez et al. (2016) argue that enactive interfaces must be highly personalized to account for the unique **physical abilities**, preferences, and histories of each user. For a system to be truly effective, it cannot rely on a "one-size-fits-all" model of interaction. Instead, it must be flexible enough to adapt to the specific ways an individual moves and perceives their environment, creating a **tailored cognitive experience**.

This focus on personalization is particularly important for **assistive technologies** and rehabilitation. For individuals with motor impairments, the "normal" sensory-motor contingencies are disrupted. An enactive interface can be designed to map the user's remaining physical capabilities to new forms of action, effectively "re-embodiment" the user within a digital or robotic system. By taking into account the user's **unique physical constraints**, designers can create tools that empower individuals to interact with the world in ways that were previously impossible. This application of the **enactive mode** demonstrates its potential to improve quality of life by honoring the diversity of human embodiment.

Beyond physical ability, personalization also involves the user's **cognitive preferences** and emotional state. The enactive approach recognizes that our mood and intentions shape our perception. A system that is "aware" of the user's current state can adjust its interface to be more or less demanding, thereby optimizing the **cognitive load**. For example, a personalized enactive system might provide more tactile feedback when it senses the user is distracted or provide a simplified interaction set for a beginner. This **dynamic adaptation** ensures that the system remains aligned with the user's evolving needs, fostering a deeper sense of agency and "flow" during the interaction.

Furthermore, the **enactive mode** suggests that personalization should be an ongoing process. As users interact with a system, they develop new skills and habits. A well-designed enactive interface should "grow" with the user, evolving its interaction patterns to match the user's increasing expertise. This creates a **co-evolutionary relationship** between the human and the machine. By prioritizing the user's individual journey, the enactive approach moves away from rigid, static software and toward **organic cognitive partners** that enhance human potential through personalized, action-oriented engagement.

## Challenges in the Practical Implementation of Enactive Systems

Despite the theoretical elegance and potential benefits of the **enactive mode**, its practical implementation faces several significant challenges. One of the primary hurdles is the **difficulty of design**. Creating an interface that is both intuitive and effective requires a deep understanding of human biomechanics, psychology, and environmental physics. Designers must go beyond traditional UI/UX principles to consider how every movement translates into a meaningful cognitive outcome. As Cheng et al. (2019) point out, the complexity of **mapping physical actions** to digital functions often leads to systems that are either too simplistic to be useful or too complex to be intuitive.

Another major challenge involves the **unpredictability of the environment**. Because enactive systems rely on the constant interaction between the user and their surroundings, they are highly sensitive to external variables that may be difficult to control or predict. In a lab setting, an enactive

interface might work perfectly, but in the "noisy" real world, environmental interference can disrupt the **sensory-motor loop**. Ensuring that the intended outcomes are consistently achieved requires robust error-correction mechanisms and a level of environmental sensing that is technically demanding and expensive to implement. This makes the **scalability** of enactive systems a persistent concern for developers.

The issue of **control and agency** also poses a challenge. In an enactive system, the boundary between the user's action and the system's response is blurred. While this "coupling" is a goal of the enactive mode, it can sometimes lead to a sense of "loss of control" if the system's responses do not perfectly align with the user's expectations. If the **feedback loops** are even slightly delayed or misinterpreted, the user may experience frustration or "cybersickness" (in the case of VR/AR). Balancing the **fluidity of interaction** with the need for precise, predictable control is a delicate task that requires sophisticated algorithmic development and extensive user testing.

Finally, there are **methodological challenges** in researching the enactive mode. Because cognition is seen as a distributed, dynamic process, it is difficult to measure using traditional "input-output" metrics. Researchers must develop new ways to quantify the **quality of interaction** and the "meaningfulness" of an enactive experience. This often requires longitudinal studies and qualitative data that are harder to generalize than standard cognitive tests. Despite these obstacles, the push toward **enactive systems** continues, driven by the belief that the current limitations are technical hurdles rather than fundamental flaws in the theory. Overcoming these challenges will require a multidisciplinary effort that integrates engineering, neuroscience, and philosophy.

## Future Directions: Scaling the Enactive Mode

As the field of cognitive science evolves, a major focus for future research will be **scaling the enactive mode** to account for higher-level cognitive functions. While the enactive approach is highly successful at explaining "low-level" tasks like navigation and object manipulation, some critics argue that it struggles to explain "high-level" tasks like abstract reasoning, mathematical calculation, or linguistic communication. The challenge for future enactive theorists is to demonstrate how these **complex mental activities** are also rooted in embodied action and sensory-motor contingencies. This involves exploring the concept of "mental simulation," where the agent "re-enacts" actions internally to solve problems.

The integration of the **enactive mode** with **social cognition** is another promising area of exploration. This involves looking at "participatory sense-making," where meaning is generated through the coordinated actions of two or more individuals. Just as an individual enacts a world through their own body, a group of people can enact a shared social reality through their **collective interactions**. Research into how the enactive mode applies to teamwork, cultural rituals, and

language acquisition could provide a more grounded understanding of social life, moving away from "theory of mind" models that rely on internalizing the mental states of others.

Technologically, the future of the **enactive mode** lies in the development of more sophisticated **haptic and bio-sensing** technologies. As we develop sensors that can more accurately track muscle tension, eye movement, and even neural activity, we can create interfaces that are even more deeply coupled with the human body. These "next-generation" enactive systems will likely blur the line between **biological and artificial intelligence**, leading to the creation of "extended minds" that operate across multiple platforms. The goal is to reach a state of **seamless embodiment**, where technology does not just assist the user but becomes a natural part of their cognitive ecology.

In conclusion, the **enactive mode** offers a compelling and comprehensive framework for understanding the nature of the mind. By prioritizing **physical action**, embodiment, and environmental interaction, it provides a much-needed alternative to the limitations of representationalism. While significant challenges remain in the implementation and scaling of this approach, its implications for the design of **cognitive systems** are transformative. As we continue to explore the depths of the enactive mode, we move closer to a science of the mind that truly reflects the richness, complexity, and **active nature** of human experience, ensuring that our future technologies are as dynamic and embodied as we are.

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