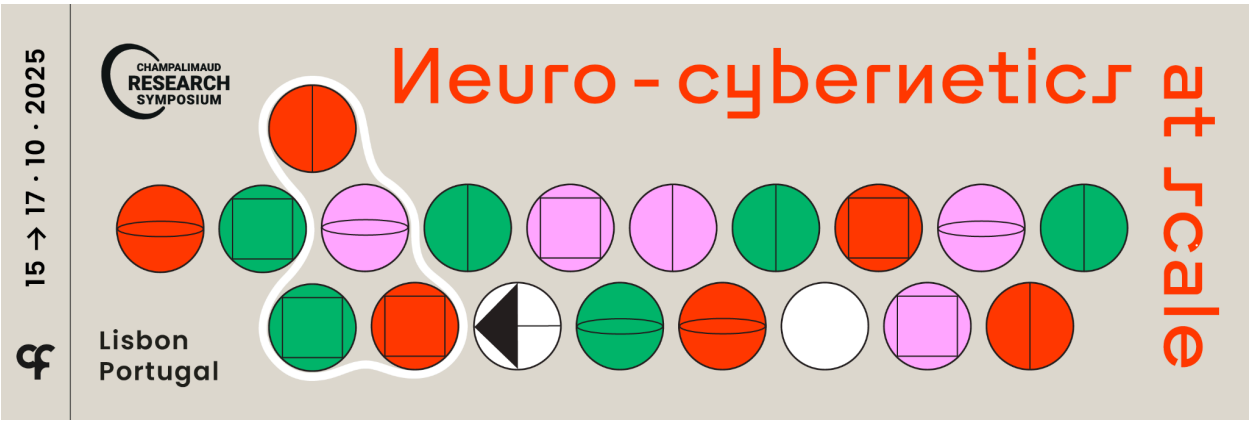

A normative dynamical theory of intuitive human reasoning

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Humans routinely solve complex, high-dimensional problems with efficiency, often relying on intuitive reasoning that yields near-optimal solutions with minimal deliberation. This suggests an inference mechanism that is fast, directed, yet capable of implicitly evaluating long-range, multi-step action sequences.

Early cognitive theories, notably those of H. Simon [1], framed human reasoning as heuristic-guided search over symbolic representations. These accounts emphasized meta-cognitive strategies for navigating large problem spaces. While foundational, such models were limited to static symbolic operations and overlooked the dynamical nature of cognitive processes.

We introduce a normative framework in which key meta-cognitive principles emerge from a sub-symbolic, dynamical inference process, formalized within fully specified Markov Decision Processes. Our model generalizes Simon's means–ends analysis as the core unifying perspective by replacing explicit forward models with an implicit representation of global problem structure, guiding inference through gradient-based policy optimization that converges to globally optimal solutions.

This architecture gives rise to hallmark traits of human reasoning as emergent properties of optimization dynamics, including hierarchical abstraction, forward-backward search, and least commitment—e.g., selectively refining policies at sub-goals while avoiding premature full-plan specification. The inference process is inherently parallel and supports flexible adaptation through second-order mechanisms such as situational focusing or preconditioning.

We show that model predictions align with empirical observations in tasks involving spatial navigation, physical reasoning, and puzzle-solving, capturing both behavioral outcomes and the process-level dynamics underlying intuitive human reasoning through a single unifying normative principle.

Intuitive Reasoning, Dynamical Systems