# Naturalizing Free Will: Emergent Autonomy as Life's Tapestry

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**Abstract**

This paper naturalizes free will as emergent autonomy arising from biological organization and inherent indeterminacy. Critiquing classical determinism based on physical/informational limits (finite information vs. real numbers) and the distinction between creative and geometric time, we propose libertarian free will grounded in potentiality realism. Autonomy emerges from the interplay of organizational closure (self-maintenance), non-equilibrium thermodynamics, and the harnessing of ontic indeterminacy (objective potentialities) within the flow of creative time (duration). This framework synthesizes insights from systems biology, physics, and process philosophy. We outline the philosophical basis (emergence, potentiality realism), scientific principles (thermodynamics, dynamics in creative time), biological realization (minimal agency, materiality), and a model of choice involving downward constraint and emergent sourcehood. The paper addresses neural implementation, reinterprets Libet-style findings, and defends against standard objections (luck, manipulation, exclusion). It offers a coherent, empirically-grounded research program for understanding freedom as a natural phenomenon rooted in life's unique organization unfolding in creative time. (200 words)

**Keywords:** Free Will, Emergent Autonomy, Ontic Indeterminacy, Creative Time, Potentiality Realism, Organizational Closure.

## 1. Introduction: The Quest for Naturalized Freedom

The capacity for purposeful choice among genuine alternatives—commonly termed free will—presents a profound challenge to a scientific worldview often perceived as deterministic. Understanding how seemingly goal-directed actions, observed across the spectrum of life from bacteria navigating chemical gradients (chemotaxis) to humans deliberating complex decisions, can arise from underlying physical and chemical processes is a central question in both philosophy and science. This paper explores the possibility of naturalizing free will by conceptualizing it as **emergent autonomy**: a capacity rooted in the unique organization of life itself, an organization that unfolds dynamically in real, lived time (Mascolo & Kallio, 2019; Moore, 2023). Foundational work by thinkers like Kauffman & Clayton (2006) on emergence and organization provides crucial groundwork for such an approach.

Addressing this demands more than examining biological mechanisms; it requires establishing a coherent philosophical and scientific foundation. This involves clarifying ontological commitments, reconsidering causality, critically evaluating physical determinism, and appreciating the fundamental nature of time itself. A key distinction, explored further below, is between **geometric time**—the parameter of deterministic physics—and **creative time**, the time associated with the actualization of potentialities and the emergence of novelty in an indeterministic universe (Gisin, 2016; Del Santo & Gisin, 2024a). Recognizing the unknowns, empirical challenges, and limitations of current science, this paper proposes a framework for emergent autonomy. It aims not at definitive proof, but at constructing a scientifically plausible and conceptually coherent pathway for how freedom could naturally arise. By moving beyond inherited conceptual constraints, such as simplistic reductionism and the conflation of time with space or mathematical idealizations with physical reality, we seek to offer the most reasonable scientific hypothesis based on current knowledge, while remaining open to future revision (Popper, 1959).

We propose a form of **naturalist, emergentist libertarianism**, building upon insights from systems biology, non-equilibrium thermodynamics, process philosophy, and critiques of physical determinism. This view argues that autonomy arises from biological self-organization harnessing objective physical openness (**ontic indeterminacy**) within the flow of **creative time**, or **duration (durée)**, as conceptualized by Bergson (1889) and echoed in Gisin's distinction (2016). This stance emphasizes the reality and causal efficacy of emergent organizational properties, aligning with perspectives suggesting that life involves phenomena "beyond physics" in the sense that biological organization introduces new causal powers not reducible to physics alone (Kauffman, 2019; drawing upon Kauffman & Clayton, 2006). Section 2 establishes the philosophical groundwork. Section 3 critiques determinism, introducing ontic indeterminacy and the crucial distinction between creative duration and geometric time. Section 4 outlines scientific principles enabling autonomy within creative time. Section 5 explores biological realization. Section 6 synthesizes the emergent autonomy framework. Section 7 discusses neural implementation. Section 8 engages in philosophical dialogue. Section 9 concludes with limitations and a research roadmap.

## 2. Philosophical Foundations: Weaving Ontology, Epistemology, and Causality

To understand how freedom might arise naturally, we must clarify the philosophical lens through which we view reality, knowledge, and causation.

### 2.1 Scientific Ontology, Epistemology, and Emergence

This framework adopts a **Scientific Ontology**: claims about "what exists" are grounded in scientific evidence and models, critically informed by a post-Kantian awareness of epistemological limits. We must distinguish between **Entities**—phenomena abstracted and conceptualized from the observer's perspective, becoming objects of scientific discourse—and **Noumena**—things-in-themselves, independent of observation. Science, by its nature, deals with Entities, constructing models based on observation, abstraction, and interaction. The aim is to describe the observable world adequately, acknowledging that our models are representations, not perfect mirrors.

Central to this ontology is **Ontological Emergence**: the appearance of genuinely new entities, properties, and causal powers at higher levels of organization (Kauffman & Clayton, 2006; Clayton & Davies, 2006). This novelty arises because higher-level organization imposes **enabling** constraints on lower-level components, channeling their behavior in ways impossible without that specific organization (Kauffman & Clayton, 2006; Ellis, 2023). The focus is on the causal efficacy and relative autonomy of organized wholes. This view is further supported by **Potentiality Realism**, which posits that objective potentialities (propensities) are fundamental elements of reality alongside actual properties, providing a basis for indeterminism (Del Santo & Gisin, 2023a).

This directly challenges **strong reductionism**, which often asserts that the whole is "nothing but" the sum of its parts. Such a view faces a logical circularity: 1) The whole is nothing but the collection of its constituent parts. 2) A part is defined as that which constitutes the whole. This circularity dissolves when we recognize that "part" and "whole" are defined relative to an observer's perspective and the level of organization being considered. Emergentism emphasizes that the organization itself is real and causally efficacious.

Furthermore, reductionism, despite its anti-dualist stance, often implicitly adopts a form of Cartesian dualism. By assuming a neutral, disembodied observer processing information without affecting or being part of the physical system being observed, it treats information processing as if it were non-physical, echoing the classic mind/matter divide. A consistent naturalism must integrate the observer and the act of observation within the physical, temporal world.

### 2.2 Rethinking Causality: Beyond Mechanism

Causality here signifies functional dependencies and regular relationships within our descriptive models, moving beyond older metaphysical notions of necessary connection (criticized by Hume and Russell, 1913). Understanding complex biological systems requires incorporating a richer, multi-causal perspective, potentially drawing insights from Aristotle's four causes interpreted naturalistically. The scientific revolution tended to exclude formal causes (organizational principle) and final causes (purpose or function), focusing on efficient triggers and material constituents. This exclusion created challenges for biology. Later developments, like cybernetics (Wiener, 1948) and systems biology, helped reintroduce concepts related to formal and final causation. This framework embraces this richer perspective, arguing that understanding autonomous agents requires considering how organizational structure (formal cause) and the goal of self-maintenance (final cause, naturalized as biological normativity) shape processes over time, alongside efficient triggers and material constituents (Ellis, 2023; Emmeche et al., 2000). Downward constraint (Sec 6.1) often operates via these formal and material factors shaping temporal dynamics. In an indeterministic framework, causality is understood not as necessary determination but potentially through propensities – objective tendencies for certain effects given specific conditions (Del Santo & Gisin, 2023a).

### 2.3 Creative Duration vs. Geometric Time

A crucial philosophical foundation, often overlooked by physicalism, is the nature of time itself. Henri Bergson (1889) drew a fundamental distinction between:

* **Real Duration (Durée) / Creative Time:** Lived, experienced time; a continuous, qualitative, heterogeneous flow, indivisible, inherently linked to memory and consciousness. It is the very process of becoming, the unfolding of novelty and the actualization of potentialities. It cannot be adequately represented by a static line. This aligns with Gisin's (2016) concept of "creative time" where genuinely new information arises due to indeterministic events.
* **Spatialized Time / Geometric Time:** Abstract, conceptual time used by science and language; conceived as homogeneous, infinitely divisible into discrete instants, measurable like points on a line. It is, in essence, space used as a model for time. This corresponds to Gisin's (2016) "geometric time," the parameter of deterministic evolution where nothing fundamentally new happens.

Reductionism and classical determinism rely entirely on geometric time, treating moments as points on a line and processes as traversals of pre-existing trajectories. This spatialization ignores the qualitative flow, creativity, inherent indivisibility, and unpredictability of creative duration, leading to paradoxes (like Zeno's) and an inability to grasp genuine change, novelty, and freedom (Bergson, 1889, Chap. II & Conclusion; Bergson, 1922, Chap. III; Gisin, 2016; Del Santo & Gisin, 2024a). Furthermore, Bergson argued that attempts to quantify qualitative states (like the intensity of feeling) by treating them as magnitudes on a scale fundamentally misrepresent their nature, which is a **qualitative multiplicity**—an interpenetration of states within duration—rather than a **quantitative multiplicity** (discrete, spatial units) (Bergson, 1889, Chap. I & II).

**Key Takeaways:** A naturalistic account of free will requires a scientific ontology acknowledging emergence, potentiality realism, epistemological limits, and the observer's role. Causality must be understood broadly, incorporating organizational factors and potentially propensities. Critically, we must distinguish creative duration (lived, qualitative, continuous, creative) from geometric time (abstract, quantitative, discrete), recognizing that reductionism's reliance on the latter fundamentally misses the essence of becoming, agency, and freedom.

## 3. Shattering Clocks: Challenging Determinism & Embracing Openness

The primary obstacle to naturalizing libertarian freedom is classical determinism, often conflated with predictability. This section argues this view is untenable based on limitations within classical physics, quantum mechanics, information theory, and the nature of time itself. It reframes indeterminacy not as a problem, but as a positive feature—a space of possibility within creative time enabling choice.

### 3.1 The Crumbling Clockwork: Flaws in Determinism

The Laplacian vision of a perfectly predictable universe, given complete knowledge of initial conditions and laws, fails on multiple grounds:

1. **Mathematical Idealization & Infinite Precision:** Classical determinism rests on the metaphysical presupposition of "infinite precision"—that every physical quantity corresponds to a mathematical real number with infinite decimal places (Del Santo, 2021; Gisin, 2019a, 2019b). This is physically problematic (Born, 1969). Real numbers (with few exceptions) contain infinite information, which is physically implausible for finite regions of space (Gisin, 2019a; Del Santo & Gisin, 2019). Treating mathematical continua and infinite precision as physically real is challenged by interpretations suggesting physical quantities carry only **finite information** (Gisin, 2019a, 2020; Del Santo & Gisin, 2019). Gisin and Del Santo propose replacing real numbers with **Finite Information Quantities (FIQs)** and advocate for **Potentiality Realism**, where objective potentialities (propensities) are fundamental, reconciling realism with indeterminism (Del Santo & Gisin, 2019, 2023a). Even within Newtonian mechanics, unique solutions are not guaranteed if force functions are not Lipschitz continuous, and collisions introduce singularities requiring extra-dynamical assumptions (Del Santo, 2021). The mathematical real numbers used in deterministic models are effectively "hidden variables" that contain infinite, unphysical information (Gisin, 2019b).
2. **Physical Information Limits:** Fundamental physics prohibits the acquisition and processing of infinite information required by the Laplacian ideal.
	* **Landauer's principle** dictates a minimum energy cost (kBTln(2)) for irreversibly erasing one bit of information (Landauer, 1961, 1996). Processing infinite information would require infinite energy, violating conservation laws (Del Santo, 2021).
	* The **Bekenstein bound** posits a universal limit on the entropy (and thus information) containable within a finite region of space with finite energy (Bekenstein, 1973, 1981). Infinite information density is physically impossible (Del Santo, 2021).
	* Together, these principles render the Demon's computational task physically impossible (Gisin, 2014).
3. **Complexity, Scale & Non-Ergodicity:** Applying deterministic laws directly to complex macroscopic systems is often intractable (Kastner, 2016; Ellis, 2016; Del Santo, 2021). Furthermore, as Kauffman (2000, 2019) argues, the universe above the level of atoms, particularly the biosphere, is profoundly **non-ergodic**: it cannot explore all possible complex combinations within its history. This implies that biological evolution and complex system dynamics are not simply exploring a pre-defined state space but are constantly creating novel, unpredictable possibilities in the **"adjacent possible"**, fundamentally challenging predictability and strict determinism (Kauffman, 2019, pp. 3-4, Chap. 4). This creative unfolding aligns with the concept of creative time.
4. **Chaos Theory:** Even if laws are deterministic, sensitivity to initial conditions in non-linear systems (chaos) makes long-term prediction practically impossible. Tiny uncertainties in initial conditions grow exponentially, rendering precise prediction unattainable (Atmanspacher, 1999). Crucially, if initial conditions only possess finite information (as argued by Gisin & Del Santo), then the future evolution of chaotic systems becomes *ontologically* indeterminate, not just epistemically unpredictable (Gisin, 2019a; Del Santo, 2021).
5. **Quantum Mechanics & Ontic Indeterminacy:** Heisenberg's uncertainty principle (ΔxΔp ≥ ħ/2, ΔEΔt ≥ ħ/2) imposes a fundamental limit on the simultaneous precision with which conjugate variables can be known. This is widely interpreted not merely as an epistemic limit but reflects an **ontic indeterminacy** in nature itself (Del Santo, 2021). The experimental violation of Bell's inequalities further supports the rejection of local hidden variables and affirms the inherently probabilistic and potentially non-local nature of quantum reality (Del Santo, 2021; Del Santo & Gisin, 2023a). The features often considered uniquely quantum, like the measurement problem, might actually stem from indeterminism itself, applicable even classically (Del Santo & Gisin, 2024b).
6. **Operational Closure & Epistemic Opacity:** The self-maintaining nature of autonomous systems creates inherent epistemic opacity (Maturana & Varela, 1980; Moreno & Mossio, 2015; Von Foerster, 2003). Even if underlying laws were deterministic, the internal dynamics unfolding in creative time are not fully predictable from an external viewpoint due to the system's self-referential organization.
7. **The Illusion of Geometric Time:** As argued previously (Sec 2.3), the deterministic picture relies fundamentally on geometric (spatialized) time. It treats the future as already laid out, merely waiting to be traversed or calculated. This ignores the creative unfolding, the continuous generation of novelty, and the inherent unpredictability characteristic of creative duration (Bergson, 1889; Gisin, 2016; Del Santo & Gisin, 2024a). Determinism is an artifact of substituting a static, geometric representation for the dynamic reality of creative time.

### 3.2 Rethinking Prediction: Operational vs. Ontological

Given these profound challenges, the classical notion of prediction as reflecting ontological determinism must be revised. We distinguish:

* **Ontological Determinism:** The metaphysical claim that the future is uniquely fixed by the past and the laws of nature.
* **Epistemic Predictability:** Our ability to calculate or foresee future states based on models and data.

The failure of Laplacian prediction does not automatically disprove ontological determinism (though quantum mechanics, information limits, and the critique of infinite precision strongly challenge it), but it forces us to reconsider prediction. Instead of revealing a pre-determined future (ontological claim), prediction is the **operational** act of calculating future states with sufficient accuracy for a specific purpose, given available data and models (Del Santo, 2021). We predict simple systems not necessarily because their future is ontologically fixed, but because our models (using geometric time) are good enough. We fail to predict chaotic systems long-term potentially because the notion of a single, fixed future state calculable from present data (requiring infinite precision) is an inappropriate idealization, especially given finite information limits (Gisin, 2019a). The success of a deterministic model operationally does not equate to ontological truth (Del Santo, 2021, Azhidahak analogy). Prediction (operational) is possible to varying degrees, but the world itself, unfolding in creative time, is likely not fully determined.

### 3.3 Ontic Indeterminacy as Opportunity within Creative Time

This framework proposes the universe possesses genuine **ontic indeterminacy**: objective physical openness representing multiple real possibilities (potentialities) unfolding in creative time (Müller et al., 2018; Del Santo, 2021; Gisin, 2019a; Del Santo & Gisin, 2023a). This indeterminacy, whether quantum, thermal/classical, or arising from the finite information content of physical quantities, is argued to be not merely noise, but a potential positive **resource for agency**. Biological systems appear "tuned into noise" (Braun, 2021; Battaglini et al., 2023; Destexhe, 2022), potentially harnessing this openness via mechanisms like stochastic resonance (Battaglini et al., 2023; Schilling et al., 2023; Braun, 2021; Albantakis & Deco, 2011) or noise-driven exploration near bifurcations (Braun, 2021; Albantakis & Deco, 2011) to explore their state space effectively as creative time processes, including Kauffman's "adjacent possible" (Kauffman, 2019). This positive view of indeterminism (Müller et al., 2018) rejects determinism as the default and sees openness as fundamental to becoming. Free will itself can be seen as a prerequisite for rational argumentation and science, implying the reality of creative time and indeterminism (Gisin, 2016).

**Key Takeaways:** Classical determinism is undermined by physical limits (information, precision), complexity, non-ergodicity, quantum mechanics, and the nature of real time (creative duration vs. geometric time). Prediction is operational, not proof of ontological determinism. Ontic indeterminacy within creative time provides a plausible resource for genuine alternative possibilities (potentialities) and creative exploration, potentially harnessed by biological organization.

## 4. Building Blocks of Autonomy: Thermodynamics, Systems, Dynamics in Creative Time

How can systems harness energy and navigate possibilities within creative time to achieve self-governance? This section outlines core principles providing the essential building blocks for emergent autonomy, all unfolding within the context of creative time.

### 4.1 Thermodynamics: Irreversibility, Dissipative Structures, and Work Cycles

Living systems maintain intricate order far from thermodynamic equilibrium, fundamentally existing within the flow of **creative time (Durée)**. A key feature distinguishing the living is **time irreversibility** at the macroscopic level, reflecting the continuous becoming inherent in creative time. While microscopic laws are often time-reversible, the macroscopic world exhibits directionality—the arrow of time linked to entropy increase—which aligns with the irreversible flow of lived experience (Bergson, 1889; Del Santo & Gisin, 2024a). Living systems, as open systems, navigate this flow. Ilya Prigogine's work revealed how such systems generate order locally by exporting entropy (Prigogine, 1967, 1977). He introduced **dissipative structures**: ordered patterns maintained only by continuous energy flow far from equilibrium. Irreversibility enables "becoming"—building and maintaining complex organization within creative time (Prigogine, 1977; Lefever, 2018). The arrow of time itself might be fundamentally linked to indeterminism rather than just statistics (Baumann & Del Santo, 2022; Del Santo & Gisin, 2024a).

Life exists in this non-equilibrium state, sustained by harnessing energy flow through **work-constraint cycles**, a concept central to Stuart Kauffman's work (Kauffman, 1993, 2019; Kauffman & Clayton, 2006). Energy input builds and maintains organizational constraints (e.g., membranes, pathways), which channel energy for further work, enabling self-construction and self-maintenance over creative time. This process is intrinsically linked to thermodynamic irreversibility and the ongoing processing of creative time (Te Vrugt, 2021, 2022; Prigogine, 1977).

### 4.2 Systems Theory: The Circle of Self (Organizational Closure & Relational Biology)

The key to biological identity and autonomy lies in **Organizational Closure** (Moreno & Mossio, 2015; Maturana & Varela, 1980; Montévil & Mossio, 2015): a network of mutually dependent constraints where collective action regenerates and maintains the conditions for the network's operation through creative time. This self-maintaining organization defines the system as a distinct entity with intrinsic goals, persisting and adapting within its duration. This concept resonates with Robert Rosen's **Relational Biology** (Rosen, 1991), which emphasized functional organization over material constituents, highlighting self-referential causal loops essential for autonomy's persistence in creative time.

### 4.3 Dynamics: Charting Possibility (Attractors, Edge of Chaos, RBNs, NK Model)

Complex system behavior unfolds in creative time as movement within a phase space. **Attractors** (Hopfield, 1982) represent stable states or patterns of activity over time. Decision-making involves transitions between attractors (Luo et al., 2023), a process occurring within the system's creative duration. Noise or ontic indeterminacy (potentialities) allows exploration of this landscape (Del Santo, 2021; Müller et al., 2018; Del Santo & Gisin, 2023a). Kauffman's work on **Random Boolean Networks (RBNs)** (Kauffman, 1993) showed how emergent order (stable attractor states) can arise spontaneously in complex networks, providing a model for how biological systems achieve reliable function over creative time. He proposed that adaptive systems might operate near the **"edge of chaos"** (Kauffman, 1991), balancing stability and flexibility through creative time. The **NK model** (Kauffman & Weinberger, 1989) further explores adaptation by modeling "fitness landscapes," illustrating how systems navigate possibilities under constraints during their evolution or development. These models demonstrate how complex, adaptive behaviors emerge and persist within the flow of creative time.

**Key Takeaways:** Autonomy is built on non-equilibrium thermodynamics unfolding in creative time (linked to irreversibility), defined by systems principles (organizational closure, relational view), and realized through dynamics within a state space structured by attractors, potentially operating near the edge of chaos and harnessing ontic indeterminacy.

## 5. Biological Realization: Materiality, Minimal Agency, and Meaning in Creative Time

How are these abstract principles physically realized in living matter? This section explores the biological foundations of agency, incorporating models of minimal life, the crucial role of the material substrate, and the emergence of meaning within creative time.

### 5.1 Materiality: Carbon, Water, Active Matter, and Embodiment

Biological agency is deeply intertwined with its carbon-based substrate (Moreno & Mossio, 2015) operating within an active water matrix (Ball, 2017; Franks, 2000). Carbon's bonding properties enable complex, flexible molecules essential for the intricate organization required for life. Water acts not just as a solvent but as an active matrix facilitating self-assembly, reaction networks, diffusion, and thermodynamics crucial for self-maintenance and adaptive dynamics over creative time (Nakagaki et al., 2000; Huber, 2023; Moreno & Mossio, 2015; Kauffman & Clayton, 2006). The dynamic, fluctuating environment provided by water is essential for the plasticity and robustness of biological agency unfolding in creative time.

Furthermore, understanding biological agency benefits from concepts in **soft matter** and **active matter** physics. Biological tissues, as soft matter, possess inherent flexibility and responsiveness ([Fletcher & Mullins, 2010; Janmey, 1998]). Active matter studies systems where components consume energy for motion (e.g., molecular motors, bacteria), exhibiting emergent collective behaviors distinct from passive matter ([Marchetti et al., 2013; Bechinger et al., 2016]). Research by Fakhri (Fakhri et al., 2023) and Golestanian (Golestanian, 2017, 2021) provides physical models for how local energy use leads to coordinated, adaptive behaviors essential for agency, reinforcing its grounding in material properties and non-equilibrium dynamics operating within creative time.

### 5.2 The Living Agent vs. The Artifact: Materiality Matters

This dependence on specific material properties highlights a fundamental difference between biological agents and current AI. Functionalism (Putnam, 1967) often overlooks the influence of the material substrate (Ellis, 2023) on emergent possibilities and the nature of lived creative time (cf. Varela et al., 1991; Bergson, 1889; Gisin, 2016). Current AI lacks the intrinsic coupling between material dynamics, self-maintenance (organizational closure), and adaptive behavior seen in biology. AI typically has extrinsic goals, unlike the intrinsic goals derived from biological self-maintenance. AI lacks the inherent normativity tied to self-production that defines biological autonomy (Moreno & Mossio, 2015; Barandiaran et al., 2009; Mendoza-Collazos & Zlatev, 2022). Thus, organizational closure (Moreno & Mossio, 2015; Kauffman & Clayton, 2006), realized in the specific carbon-water-active matter context and unfolding in creative time, remains a key differentiator. Digital robots, based on deterministic computation (geometric time), inherently lack the openness required for genuine free will (Gisin, 2016).

### 5.3 Minimal Agency: The Spark of Life

Where does agency begin? We focus on **minimal agency**, illustrated by simple organisms (Nakagaki et al., 2000; Lyon, 2015). Kauffman proposed conditions for "molecular autonomous agents," including **autocatalysis** (Kauffman, 1986, 1993) and work cycles (Moreno & Mossio, 2015). Autocatalysis provides a plausible mechanism for the spontaneous emergence of self-sustaining metabolic networks, a core requirement for organizational closure and minimal agency developing over creative time. Gánti's **Chemoton** model (Gánti, 1975, 2003) provides another blueprint involving metabolism, boundary, and information subsystems. Both emphasize self-maintenance and self-production through organizational closure over creative time.

**Bacterial chemotaxis** exemplifies minimal agency (Lyon, 2015). Bacteria sense gradients, process information, and modulate movement—demonstrating perception, information processing, goal-directed action, and basic decision-making within their creative duration. Active matter physics provides models for the underlying navigation mechanisms (Golestanian, 2017, 2021). Functional stochasticity is also observed (Samoilov et al., 2006), suggesting non-deterministic operation (harnessing potentialities) even in minimal agents.

### 5.4 Information, Meaning, Value, and Purpose (Telos) in Creative Time

Agency requires interpreting information meaningfully within the flow of creative time. Biological codes (Barbieri, 2024) provide sequences, but meaning arises through interpretation within the organism's functional context (*Umwelt* (Brentari, 2015; Michelini & Köchy, 2020)) or via arbitrary mappings (Barbieri, 2013). This interpretation is inherently temporal, relying on memory and anticipation within creative time. Information is assessed based on its relevance to the organism's **intrinsic value** derived from the biological imperative of self-maintenance over creative time (Mitchell, 2023). This inherent goal-directedness constitutes a naturalized purpose (*telos* (Ellis, 2023; Kauffman & Clayton, 2006)). **Memory**, the persistence of the past within the present, which Bergson (1889) identified as the essence of duration, is crucial for this meaning-making process. As argued in biosemiotics (Markoš, Chap. 8 in Švorcová, 2024), information is not mere physical data but acquires significance through its functional role within the agent's lived creative time. The creation of *new* information is central to creative time (Gisin, 2016; Del Santo & Gisin, 2024a).

**Key Takeaways:** Biological agency is materially grounded, distinct from current AI. Minimal agency arises from organizational closure and work cycles unfolding in creative time. Agency operates on information interpreted meaningfully over creative time towards the purpose of self-maintenance, a process intrinsically linked to memory, potentiality, and the creation of new information.

## 6. Synthesizing Emergent Autonomy: Constraint, Sourcehood, Choice in Creative Time

This section integrates the preceding concepts into the synthesized framework of emergent autonomy, emphasizing the interplay of organization, indeterminacy (potentiality), and creative temporal process.

### 6.1 Downward Constraint: The Whole Guides the Parts through Creative Time

A key element is **Downward Constraint** (DC), where higher-level organization influences lower-level components over creative time without violating physical laws (Ellis, 2016; Clayton, 2004; Kistler, 2021; Kastner, 2016). Operating via formal and material causes (Ellis, 2023), consistent with biological relativity (Noble, 2012) and relational biology (Rosen, 1991), the whole's organization sets the context and boundary conditions, selecting among physically possible pathways (potentialities) as the system evolves in creative time. This is indispensable for explaining system behavior (Del Santo & Krizek, 2023; Kistler, 2021). This downward influence might be crucial in the actualization process inherent in creative time (Del Santo & Gisin, 2024b).

### 6.2 Emergent Sourcehood

The framework grounds **sourcehood**—the agent originating its actions—in the emergent causal powers of its self-maintaining organizational dynamics (closure) operating within creative time (Ellis, 2016; Mossio et al., 2016). The agent, as an organized whole persisting through creative time (Rosen, 1991), exerts downward constraint. The "source" lies in the integrated dynamics of the system, acting as an autonomous causal center defined by closure and unfolding in its unique creative duration. This naturalizes libertarian concerns about agent-causation (Clarke, 2001; O'Connor, 2022) without positing extra-physical entities, grounding it instead in potentiality realism and the processing of creative time (Del Santo & Gisin, 2023a). The agent's identity is tied to this continuous, self-maintaining process in creative time (cf. Röck, Chap. 7 in Švorcová, 2024).

### 6.3 Conceptual Model of Emergent Choice in Creative Time

Autonomous choice is conceptualized as a dynamic process unfolding within organizational constraints and creative time:

1. **Initialization:** Baseline state within the attractor landscape, reflecting the agent's history and current context.
2. **Accumulation/Search:** Inputs drive dynamics over creative time (Luo et al., 2023); constraints shape the landscape; options (potentialities) are assessed relative to closure goals and remembered experiences.
3. **Stochastic Exploration/Transition:** Harnessed ontic indeterminacy (objective potentialities/propensities) allows exploration near instability points or bifurcations, potentially accessing alternative basins of attraction (alternative possibilities) within the flow of creative time (Luo et al., 2023; Briegel & Müller, 2015; Del Santo & Gisin, 2023a). This exploration is a temporal process where new information can emerge.
4. **Selection/Commitment (Actualization):** Dynamics converge towards a dominant attractor, representing commitment to a course of action (Luo et al., 2023; Schilling et al., 2023; Albantakis & Deco, 2011). This convergence is a temporal event within creative time, marking the transition from potentiality to actuality (Del Santo & Gisin, 2024a).
5. **Constraint/Action:** The chosen state exerts downward constraint, guiding action and shaping the subsequent flow of creative time.

**Key Takeaways:** Emergent autonomy involves downward constraint exerted by the whole over its parts through creative time. Sourcehood is grounded in emergent organizational powers (closure) persisting in creative time. Choice is a dynamic, temporal process of exploring potentialities and commitment (actualization) within a constrained landscape, utilizing ontic indeterminacy within the flow of creative time.

## 7. Neural Implementation, Higher Agency, and the Role of Consciousness in Creative Time

How are autonomy principles elaborated in nervous systems? This section addresses neural implementation, scaling, Libet's challenge, and consciousness, considering their creative temporal aspects.

### 7.1 The Neural Landscape: Attractors and Dynamics

Neural networks utilize attractor dynamics (Hopfield, 1982) to represent states and process information over creative time. Decisions might involve transitions between attractor regimes, reflecting a temporal evolution (actualization of potentialities) of neural activity (Luo et al., 2023). Models map these dynamics to observable neural activity patterns (Albantakis & Deco, 2011; Luo et al., 2023), incorporating uncertainty tracking which unfolds temporally (Schilling et al., 2023).

### 7.2 Functional Noise and Harnessed Indeterminacy

Neural variability ("noise") is likely functional (Faisal et al., 2008; Rolls & Deco, 2010; Destexhe, 2022), aiding exploration, adaptation, and potentially harnessing ontic indeterminacy (potentialities) via mechanisms like stochastic resonance (Battaglini et al., 2023; Schilling et al., 2023; Braun, 2021; Albantakis & Deco, 2011) or dynamics near bifurcations (Braun, 2021; Albantakis & Deco, 2011; Briegel & Müller, 2015). Indeterminism, unfolding within the brain's creative time, can be a functional resource for:

* **Exploration:** Allows exploration of alternative states/options (potentialities) over creative time.
* **Adaptation:** Provides raw material for learning and adjusting behavior through creative time.
* **Symmetry Breaking:** Helps resolve choices between equal options in real (creative) time.
* **Sensitivity:** Stochastic resonance can enhance signal detection over creative time.
* **Edge of Chaos:** Operating near criticality might leverage indeterminacy for optimal information processing and adaptability within the flow of experience (Von Foerster, 2003; Rolls & Deco, 2010).

This structured variability, harnessed by the brain's organization, enables flexibility and libertarian choice as processes within creative time. Distinguishing noise sources (epistemic vs. ontic indeterminacy) remains challenging (Weber, 2005; Braun, 2021; Atmanspacher, 1999; Prado et al., 2022; Del Santo & Gisin, 2024b).

### 7.3 Reinterpreting Libet's Challenge

Libet-style experiments (Libet et al., 1983), often cited against free will, are reinterpretable within a creative temporal framework. The Readiness Potential (RP) might reflect stochastic accumulation processes (exploration of potentialities) leading towards a threshold (Schurger et al., 2012, 2021) or general preparation (Luo et al., 2023), rather than a deterministic commitment preceding conscious awareness within geometric time. The decision process unfolds over creative time, involving the actualization of potentialities, and the RP may represent an early, non-deterministic stage. Beta-band activity seems a better correlate of subjective readiness judgments occurring later in the creative temporal sequence (Parés-Pujolràs et al., 2023). Consciousness relates to specific dynamics within this creative temporal process but doesn't necessarily initiate action de novo from an instantaneous "point" in geometric time.

### 7.4 Scaling Agency and the Emergence of Consciousness in Creative Time

The transition from minimal to human agency involves increased neural complexity, language, prediction, recursive cognition, and crucially, an enriched experience of **creative time** (duration) (Noble, 2012; Smaers & Soligo, 2013; Clayton, 2004; Cyr, 2016). Agency exists on a hierarchy (Mendoza-Collazos & Zlatev, 2022): Basal Autonomy, Adaptive Agency, Cognitive Agency, Reflective/Conscious Agency. Consciousness emerges as a higher-order property coordinating underlying mechanisms within the flow of creative time (Mascolo & Kallio, 2019; Searle, 2007). Its roles, unfolding in creative time, include metacognitive monitoring, integration across time (memory/anticipation), enhanced control (working memory, simulation, reasoning, goal alignment over extended creative durations), and veto power (Mele, 2009; Schilling et al., 2023). Neural correlates (Parés-Pujolràs et al., 2023) likely reflect these creative temporally extended functions. Consciousness builds upon, and modulates within creative time, the core autonomy established by organizational closure.

**Key Takeaways:** Nervous systems utilize attractor dynamics and functional indeterminacy unfolding in creative time. Libet's experiments are reinterpretable within a creative temporal decision process involving actualization. Scaling involves hierarchical elaboration, with consciousness as a higher-level modulator operating within and enriching the experience of creative time.

## 8. Philosophical Dialogue & Defenses

How does this framework compare to rivals and address standard objections to libertarian free will?

### 8.1 Comparison with Rival Views

This framework advocates for a form of **naturalist emergentism**, strongly aligned with views emphasizing the **ontological emergence** of agency and autonomy through biological organization (e.g., Kauffman & Clayton, 2006) and grounded in **potentiality realism** (Del Santo & Gisin, 2023a). It posits that organization itself possesses causal powers (downward constraint) that are not reducible to underlying physics alone, allowing for genuine self-determination within the flow of creative time. This perspective challenges strong reductionism and standard physicalism by suggesting that biology introduces fundamentally new levels of reality and causation unfolding in creative time.

* **Compatibilism:** Rejected for redefining freedom to fit determinism (often based on geometric/spatialized time), eliminating genuine alternative possibilities (potentialities) inherent in creative time (Frankfurt, 1969, 1971; Dennett, 1984; Fischer & Ravizza, 1998; Dennett, 2003; Sartorio, 2010). This framework insists on ontic openness within creative time as necessary. Compatibilist responses to manipulation arguments often fail because they do not adequately account for the intrinsic sourcehood provided by organizational closure developing over creative time (Pereboom & McKenna, 2022; Matheson, 2015; Jeppsson, 2019; McKenna, 2014; Caruso, 2020).
* **Illusionism/Skepticism:** Countered by arguing emergent autonomy is a real, scientifically plausible property arising from biological organization within creative time (Caruso, 2017; Smilansky, 2000, 2016). Illusionism often rests on assumptions of universal determinism (challenged in Sec 3 based on finite information and potentiality realism) or flawed interpretations neglecting creative temporal depth. Capacities for self-governance are demonstrable emergent properties.
* **Other Libertarianisms:** Differs from traditional agent-causal theories by grounding sourcehood in emergent organization unfolding in creative time, not a distinct non-physical substance (Clarke, 2001; O'Connor, 2022). Differs from event-causal views like Kane's (Kane, 1996; Kane, 2016) by emphasizing the continuous role of organizational closure and dynamics in harnessing indeterminacy (potentialities) for adaptive behavior throughout creative time, not just specific "torn decisions," though Kane's focus on character formation over time remains relevant. Shares the core libertarian commitment to indeterminism and agent control but provides a broader biological, systems-theoretic, and creative temporal foundation based on potentiality realism.

### 8.2 Addressing Objections

* **Luck Objection:** Indeterminacy isn't mere luck if it is harnessed and channeled over creative time by the agent's organizational structure, intrinsic goals (derived from closure), reasons, and history (memory within creative time) (Mele, 2009; Mele, 2006; Mitchell, 2023; Levy, 2008; Van Inwagen, 2000; Moore, 2021; Noble & Noble, 2018; Briegel & Müller, 2015; Kane, 2016). The emergent organization selects among the possibilities (potentialities) opened up by indeterminacy within the flow of creative time; control is exercised over the propensities and the selection (actualization) process unfolding in creative time, not over predetermined outcomes (Del Santo & Gisin, 2023a).
* **Manipulation Arguments:** Fail because manipulated agents lack the intrinsic organizational closure, developmental history within creative time, and emergent sourcehood characteristic of genuine autonomous systems (Pereboom & McKenna, 2022; Matheson, 2015; Taylor, 2020; Cohen, 2018; Matheson, 2018; Patrick, 2017). The causal history and locus of control differ fundamentally.
* **Causal Exclusion:** Countered by: (a) challenging strict physical causal closure and determinism (Sec 3, finite information, potentiality realism); (b) defining emergence organizationally, where higher-level organization exerts irreducible downward constraint over creative time (Kauffman & Clayton, 2006; Ellis, 2016); (c) adopting an emergentist ontology where higher levels possess real causal powers unfolding in creative time (Clayton, 2004; Emmeche et al., 2000). Kim's argument (Kim, 1998, 2005) assumes a synchronic framework; our emergentist view, grounded in the diachronic causal efficacy of organization within creative time, rejects this premise.

**Key Takeaways:** The framework offers a distinct naturalist emergentist, libertarian position grounded in potentiality realism, robustly responding to objections via controlled indeterminacy within creative time, intrinsic closure, and emergent causal efficacy, while critiquing rivals.

## 9. Conclusion: Towards a Science of Emergent Freedom in Creative Time

This paper has argued for naturalizing free will as emergent autonomy, arising from organizational closure, non-equilibrium dynamics (emphasizing irreversibility), and harnessed ontic indeterminacy (potentialities), all unfolding within the framework of **creative time (duration)**, distinct from passive **geometric time**. Grounded in scientific ontology (including potentiality realism), multi-causal perspectives, critiques of determinism based on finite information, and principles from physics, systems biology, neuroscience, and process philosophy, this framework offers a plausible, naturalist emergentist, libertarian alternative. It aligns with the view that biological organization gives rise to genuinely new causal powers not reducible to physics conceived solely within geometric time (cf. Kauffman & Clayton, 2006; Kauffman, 2019; Del Santo & Gisin, 2023a).

The core insight is that biological organization, persisting and adapting through creative time, creates systems capable of self-maintenance, goal-directedness, and exploiting physical openness (potentialities). Agency is primary, with consciousness as a higher-level modulator operating within and enriching the creative temporal flow. This approach is presented not as proof, but as a viable research program. Key challenges include formal modeling of creative temporal dynamics (actualization), empirically isolating indeterminacy's role over creative time, understanding scaling across temporal hierarchies, and integrating socio-cultural factors. Advancing this requires interdisciplinary research:

* **Formal Modeling & Measurement:** Develop models capturing closure, creative temporal dynamics (e.g., using FIQs or intuitionistic mathematics (Gisin, 2020)), noise harnessing, downward constraint, alongside validated metrics sensitive to creative temporal integration. (Rider, 2024; Luo et al., 2023; Kistler, 2021; Barnett et al., 2009; Pearl, 2009; Woodward, 2003; Sevilla et al., 2021; Del Santo & Gisin, 2023a).
* **Empirical Validation:** Test predictions in minimal/synthetic systems focusing on creative temporal behavior (Deco et al., 2021; Rider, 2024; Samoilov et al., 2006) and neurobiological studies examining decision processes over creative time (Luo et al., 2023; Battaglini et al., 2023; Green, 2018; Mendoza-Collazos & Zlatev, 2022).
* **Philosophical Refinement:** Deepen analyses of emergence, sourcehood within creative time, potentiality realism, normativity, luck, manipulation, exclusion, and scaling, further exploring the implications of the creative time vs. geometric time distinction (Mendoza-Collazos & Zlatev, 2022; Gisin, 2016; Del Santo & Gisin, 2024a).

This framework provides a roadmap for understanding emergent freedom as a natural phenomenon rooted in the unique organization of life as it persists, adapts, and creates novelty through **creative time**.

## References

1. A., L., & Hannah, T. (2022). Defusing Existential and Universal Threats to Compatibilism. *Journal of Philosophy, 119*(3), 117-143. <https://doi.org/10.5840/jphil202211939>
2. Adamatzky, A. (2010). *Physarum Machines: Computers from Slime Mould*. World Scientific. <https://doi.org/10.1142/7629>
3. Aguirre, A., Merali, Z., & Sloan, D. (Eds.). (2021). *Undecidability, Uncomputability, and Unpredictability*. Springer.
4. Albantakis, L., & Deco, G. (2011). Changes of mind in an attractor network of decision-making. *PLOS Computational Biology, 7*(6), e1002086. <https://doi.org/10.1371/journal.pcbi.1002086>
5. Anscombe, G. E. M. (1971). *Causality and determination: An inaugural lecture*. CUP Archive.
6. Atmanspacher, H. (1999). Determinism is ontic, determinability is epistemic. In H. Atmanspacher & E. Ruhnau (Eds.), *Time, Temporality, Now: Experiencing Time and Concepts of Time in an Interdisciplinary Perspective* (pp. 49-74). Springer.
7. Azadi, P. (Forthcoming). Naturalizing Free Will: Emergent Autonomy as Life's Tapestry. (Self-reference to the base document)
8. Ball, P. (2017). Water is an active matrix of life for cell and molecular biology. *PNAS, 114*(51), 13327-13335.
9. Barandiaran, X. E., Di Paolo, E., & Rohde, M. (2009). Defining agency: Individuality, normativity, asymmetry, and spatio-temporality in action. *Adaptive Behavior, 17*(5), 367-386.
10. Barbado, L. C., & Del Santo, F. (2023). On playing gods: The fallacy of the many-worlds interpretation. *arXiv preprint arXiv:2311.03467*.
11. Barbieri, M. (2013). The Paradigms of Biology. *Biosemiotics, 6*(1), 33-59. <https://doi.org/10.1007/s12304-012-9149-1>
12. Barbieri, M. (2024). *Code Biology: From the Genetic Code to the Cell Code*. Springer Nature.
13. Bargh, J. A., & Chartrand, T. L. (1999). The unbearable automaticity of being. *American Psychologist, 54*(7), 462-479.
14. Barnes, E., & Cameron, R. (2009). The open future: Bivalence, determinism and ontology. *Philosophical Studies, 146*(2), 291-309.
15. Barnett, L., Barrett, A. B., & Seth, A. K. (2009). Granger causality and transfer entropy are equivalent for Gaussian variables. *Physical Review Letters, 103*(23), 238701.
16. Battaglini, L., Casco, C., Fertonani, A., Miniussi, C., Di Ponzio, M., & Vicovaro, M. (2023). Noise in the brain: Transcranial random noise stimulation and perceptual noise act on a stochastic resonance-like mechanism. *Eur. J. Neurosci., 57*(12), 2097-2111. <https://doi.org/10.1111/ejn.15965>
17. Baumann, V., & Del Santo, F. (2022). Many Worlds are irrelevant for the problem of the arrow of time. *arXiv preprint arXiv:2201.10559*.
18. Baumeister, R. F. (2008). Free will in scientific psychology. *Perspectives on Psychological Science, 3*(1), 14-19.
19. Bechinger, C., Di Leonardo, R., Löwen, H., Reichhardt, C., Volpe, G., & Volpe, G. (2016). Active particles in complex and crowded environments. *Reviews of Modern Physics, 88*(4), 045006. <https://doi.org/10.1103/RevModPhys.88.045006>
20. Bechtel, W. (2006). *Discovering cell mechanisms: The creation of modern cell biology*. Cambridge University Press.
21. Bekenstein, J. D. (1973). Black holes and entropy. *Physical Review D, 7*(8), 2333-2346.
22. Bekenstein, J. D. (1981). Universal upper bound on the entropy-to-energy ratio for bounded systems. *Physical Review D, 23*(2), 287-298.
23. Bennett, J. (2010). *Vibrant matter: A political ecology of things*. Duke University Press.
24. Bennett, K. (2007). Mental causation. *Philosophy Compass, 2*(2), 316-337.
25. Bennett, K. (2009). Exclusion again. In J. Kim, E. Sosa, & G. Rosenkrantz (Eds.), *A Companion to Metaphysics* (2nd ed., pp. 220-223). Wiley-Blackwell.
26. Bergson, H. (1889). *Essai sur les données immédiates de la conscience*. Félix Alcan. (English translation: *Time and Free Will*, 1910, F. L. Pogson, Trans., George Allen & Unwin).
27. Bergson, H. (1922). *Durée et Simultanéité: À propos de la théorie d'Einstein*. Félix Alcan.
28. Berkovitz, J. (2015). The propensity interpretation of probability: A re-evaluation. *Erkenntnis, 80*(3), 629-711.
29. Bich, L., Mossio, M., & Soto, A. M. (2021). Biological Normativity: A Situated Approach. In S. Nicholson & L. Bich (Eds.), *Everything Flows: Towards a Processual Philosophy of Biology*. Oxford University Press.
30. Bird, A. (2007). Perceptions of epigenetics. *Nature, 447*(7143), 396-398.
31. Born, M. (1969). Is classical mechanics in fact deterministic? *Physics Bulletin, 20*(1), 10-14.
32. Braun, H. A. (2021). Stochasticity Versus Determinacy in Neurobiology: From Ion Channels to the Question of the "Free Will". *Frontiers in Systems Neuroscience, 15*, 629436. <https://doi.org/10.3389/fnsys.2021.629436>
33. Brentari, C. (2015). *Jakob von Uexküll: The Discovery of the Umwelt between Biosemiotics and Theoretical Biology*. Springer.
34. Briegel, H. J., & Müller, T. (2015). A chance for attributable agency. *Minds and Machines, 25*(3), 261-279. <https://doi.org/10.1007/s11023-015-9367-x>
35. Butterfield, J. (1992). Probabilities and conditionals: Distinctions by example. *Proceedings of the Aristotelian Society, 92*, 251-272.
36. Butterfield, J. (2005). Determinism and indeterminism. *Routledge Encyclopedia of Philosophy*. Routledge.
37. Calosi, C., & Mariani, C. (2021). Quantum indeterminacy. *Philosophy Compass, 16*(4), e12731.
38. Campbell, D. T. (1974). 'Downward causation' in hierarchically organised biological systems. In F. J. Ayala & T. Dobzhansky (Eds.), *Studies in the Philosophy of Biology* (pp. 179-186). Macmillan.
39. Caruso, G. D. (2017). Free will skepticism and criminal behavior: A public health-quarantine model. *Southwest Philosophy Review, 33*(1), 25-48.
40. Caruso, G. D. (2020). On the Compatibility of Rational Deliberation and Determinism: Why Deterministic Manipulation Is Not a Counterexample. *Philosophical Quarterly, 71*(3), 503-522. <https://doi.org/10.1093/pq/pqaa061>
41. Chaitin, G. (2008). The Labyrinth of the Continuum. In *Meta Math!*. Vintage.
42. Chakravartty, A. (2017). Scientific Realism. In E. N. Zalta (Ed.), *The Stanford Encyclopedia of Philosophy* (Summer 2017 ed.). Metaphysics Research Lab, Stanford University. <https://plato.stanford.edu/archives/sum2017/entries/scientific-realism/>
43. Clarke, R. (2001). Toward a credible agent-causal account of free will. *Noûs, 35*(s15), 21-41.
44. Clayton, P. (2004). *Mind and Emergence: From Quantum to Consciousness*. Oxford University Press.
45. Clayton, P., & Davies, P. (Eds.). (2006). *The re-emergence of emergence: The emergentist hypothesis from science to religion*. Oxford University Press.
46. Cohen, Y. (2018). Deliberating in the Presence of Manipulation. *Canadian Journal of Philosophy, 48*(1), 85-105. <https://doi.org/10.1080/00455091.2017.1341827>
47. Cournot, A. (1843). *Exposition de la théorie des chances et des probabilités*. Librairie Hachette.
48. Cyr, T. W. (2016). The Parallel Manipulation Argument. *Ethics, 126*(4), 1075-1089. <https://doi.org/10.1086/686005>
49. De Caro, M., & Putnam, H. (2020). Free will and quantum mechanics. *The Monist, 103*(4), 415-426.
50. Deco, G., Kringelbach, M. L., Jirsa, V. K., & Ritter, P. (2021). The dynamics of resting fluctuations in the brain: metastability and its dynamical cortical core. *Scientific Reports, 11*(1), 1-16.
51. Del Santo, F. (2021). Indeterminism, causality and information: Has physics ever been deterministic? In A. Aguirre, Z. Merali, & D. Sloan (Eds.), *Undecidability, Uncomputability, and Unpredictability* (Chapter 5, pp. 63-79). Springer.
52. Del Santo, F., & Gisin, N. (2019). Physics without determinism: alternative interpretations of classical physics. *Physical Review A, 100*(6), 062107.
53. Del Santo, F., & Gisin, N. (2021). The relativity of indeterminacy. *Entropy, 23*(10), 1326.
54. Del Santo, F., & Gisin, N. (2023a). Potentiality realism: A realistic and indeterministic physics based on propensities. *European Journal for Philosophy of Science, 13*(4), 48.
55. Del Santo, F., & Gisin, N. (2024a). Creative and geometric times in physics, mathematics, logic, and philosophy. *arXiv preprint arXiv:2404.06566*.
56. Del Santo, F., & Gisin, N. (2024b). Which features of quantum physics are not fundamentally quantum but are due to indeterminism? *arXiv preprint arXiv:2409.10601*.
57. Del Santo, F., & Krizek, G. C. (2023). Against the "nightmare of a mechanically determined universe": Why Bohm was never a Bohmian. *arXiv:2307.05611*.
58. Demetriou, K. (2010). The Soft-Line Solution to Pereboom's Four-Case Argument. *Australasian Journal of Philosophy, 88*(4), 595-617. <https://doi.org/10.1080/00048400903382691>
59. Dennett, D. C. (1984). *Elbow Room: The Varieties of Free Will Worth Wanting*. MIT Press.
60. Dennett, D. C. (2003). *Freedom Evolves*. Viking.
61. Destexhe, A. (2022). Noise Enhancement of Neural Information Processing. *Entropy, 24*(12), 1837.
62. Dill, K. A. (1990). Dominant forces in protein folding. *Biochemistry, 29*(31), 7133-7155. <https://doi.org/10.1021/bi00470a001>
63. Dolev, Y. (2018). Physics' silence on time. *European Journal for Philosophy of Science, 8*(3), 455-469.
64. Dorato, M. (2006). Properties and dispositions: some metaphysical remarks on quantum ontology. In *AIP Conference Proceedings* (Vol. 844, No. 1, pp. 139-157). American Institute of Physics.
65. Drossel, B., & Ellis, G. (2018). Contextual wavefunction collapse: An integrated theory of quantum measurement. *New Journal of Physics, 20*(11), 113025.
66. Dürr, D., Goldstein, S., & Zanghì, N. (2009). Bohmian mechanics. In D. Greenberger, K. Hentschel, & F. Weinert (Eds.), *Compendium of Quantum Physics* (pp. 47-55). Springer.
67. Earman, J. (2006). The "past hypothesis": Not even false. *Studies in History and Philosophy of Science Part B: Studies in History and Philosophy of Modern Physics, 37*(3), 399-430.
68. Ekstrom, L. W. (2000). *Free Will: A Philosophical Study*. Westview Press.
69. Ellis, G. F. R. (2016). *How Can Physics Underlie the Mind? Top-Down Causation in the Human Context*. Springer.
70. Ellis, G. F. R. (2023). Efficient, Formal, Material, and Final Causes in Biology and Technology. *Entropy, 25*(9), 1301.
71. Ellis, G. F. R., & Drossel, B. (2019). How Downwards Causation Occurs in Digital Computers. *Foundations of Physics, 49*(11), 1255-1282. <https://doi.org/10.1007/s10701-019-00301-5>
72. Emery, N., Markosian, N., & Sullivan, M. (2020). Time. In E. N. Zalta (Ed.), *The Stanford Encyclopedia of Philosophy* (Winter 2020 ed.). Metaphysics Research Lab, Stanford University. <https://plato.stanford.edu/archives/win2020/entries/time/>
73. Emmeche, C., Køppe, S., & Stjernfelt, F. (2000). Levels, Emergence, and Three Versions of Downward Causation. In P. B. Andersen, C. Emmeche, N. O. Finnemann, & P. V. Christiansen (Eds.), *Downward Causation: Minds, Bodies and Matter* (pp. 13-34). Aarhus University Press.
74. Faisal, A. A., Selen, L. P. J., & Wolpert, D. M. (2008). Noise in the nervous system. *Nature Reviews Neuroscience, 9*(4), 292-303.
75. Fakhri, N., MacKintosh, F. C., et al. (2023). Self-organization in soft active matter systems: Mechanisms and implications. *Nature Reviews Physics, 5*, 148-162. <https://doi.org/10.1038/s42254-023-00530-8>
76. Fetzer, J. H. (1981). *Scientific knowledge: Causality, explanation and corroboration*. Reidel.
77. Fetzer, J. H., & Nute, D. E. (1980). A probabilistic causal calculus: Conflicting conceptions. *Synthese, 44*(2), 241-246.
78. Fischer, J. M., & Ravizza, M. (1998). *Responsibility and Control: A Theory of Moral Responsibility*. Cambridge University Press.
79. Fletcher, D. A., & Mullins, R. D. (2010). Cell mechanics and the cytoskeleton. *Nature, 463*(7280), 485-492. <https://doi.org/10.1038/nature08908>
80. Forbes, G. A. (2016). The growing block's past problems. *Philosophical Studies, 173*(3), 699-719.
81. Franks, F. (Ed.). (2000). *Water: A matrix of life* (2nd ed.). Royal Society of Chemistry.
82. Frankfurt, H. G. (1969). Alternate possibilities and moral responsibility. *Journal of Philosophy, 66*(23), 829-839.
83. Frankfurt, H. G. (1971). Freedom of the will and the concept of a person. *Journal of Philosophy, 68*(1), 5-20.
84. Fried, I., Mukamel, R., & Kreiman, G. (2011). Internally generated preactivation of single neurons in human medial frontal cortex predicts volition. *Neuron, 69*(3), 548-562.
85. Fulda, F. C. (2017). Natural Agency: The Case of Bacterial Cognition. *Journal of the American Philosophical Association, 3*(2), 208-229. <https://doi.org/10.1017/apa.2017.5>
86. Gánti, T. (1975). Organization of chemical reactions into dividing and metabolizing units: the chemotons. *BioSystems, 7*(1), 15-21.
87. Gánti, T. (2003). *The Principles of Life*. Oxford University Press.
88. Gao, S. (2021). Time's arrow points to many worlds. *PhilSci-Archive preprint*. <http://philsci-archive.pitt.edu/19443/>
89. Ghirardi, G. C., Rimini, A., & Weber, T. (1986). Unified dynamics for microscopic and macroscopic systems. *Physical Review D, 34*(2), 470.
90. Gillies, D. (2012). *Philosophical theories of probability*. Routledge.
91. Gisin, N. (1984). Propensities and the state-property structure of classical and quantum systems. *Journal of Mathematical Physics, 25*(7), 2260-2265.
92. Gisin, N. (1989). Stochastic Quantum Dynamics and Relativity. *Helvetica Physica Acta, 62*(4), 363-371.
93. Gisin, N. (1991). Propensities in a non-deterministic physics. *Synthese, 89*(2), 287-297.
94. Gisin, N. (2014). Quantum correlations in Newtonian space and time: arbitrarily fast communication or nonlocality. *Quantum Studies: Mathematics and Foundations, 1*(1), 21-30.
95. Gisin, N. (2016). Time really passes, science can't deny that. *arXiv preprint arXiv:1602.01497*. Also published in *Time in Physics* (pp. 1-15). Birkhäuser. (2017).
96. Gisin, N. (2019a). Real numbers are the hidden variables of classical mechanics. *Quantum Studies: Mathematics and Foundations, 7*(2), 197-201. (Published online 2019, journal volume 2020).
97. Gisin, N. (2019b). Indeterminism in Physics, Classical Chaos and Bohmian Mechanics. Are Real Numbers Really Real?. *Erkenntnis, 86*(6), 1469-1481. (Published online 2019, journal volume 2021).
98. Gisin, N. (2020). Mathematical languages shape our understanding of time in physics. *Nature Physics, 16*(2), 114-116. *arXiv preprint arXiv:2002.01653*.
99. Glannon, W. (2013). Neuromodulation, agency, and autonomy. *Brain Topography, 26*(3), 439-446.
100. Gödel, K. (1932). Zum intuitionistischen Aussagenkalkül. *Anzeiger der Akademie der Wissenschaften in Wien, Mathematisch-naturwissenschaftliche Klasse, 69*, 65-66.
101. Golestanian, R. (2017). Chemotaxis and Auto-Chemotaxis of Self-Propelling Artificial Droplet Swimmers. *Physical Review E, 95*(4), 042606. <https://doi.org/10.1103/PhysRevE.95.042606>
102. Golestanian, R. (2021). Nonequilibrium Polarity-Induced Mechanism for Chemotaxis: Emergent Galilean Symmetry and Exact Scaling Exponents. *Physical Review Letters, 127*(18), 188001. <https://doi.org/10.1103/PhysRevLett>. 127.188001
103. Green, S. (2018). Scale Dependency and Downward Causation in Biology. *Philosophy of Science, 85*(5), 998-1011.
104. Haag, J. (2010). Free will naturalized: the role of the concept of free will in evolutionary psychology. *Biology & Philosophy, 25*(3), 457-474.
105. Hacking, I. (1965). *Logic of statistical inference*. Cambridge University Press.
106. Hofferberth, S., Lesanovsky, I., Schumm, T., Imambekov, A., Gritsev, V., Demler, E., & Schmiedmayer, J. (2008). Probing quantum and thermal noise in an interacting many-body system. *arXiv preprint arXiv:0710.1575v2*.
107. Hofstadter, D. R. (1979). *Gödel, Escher, Bach: An Eternal Golden Braid*. Basic Books.
108. Hoogland, C., & Juty, N. (2010). *Computational Systems Biology*. Springer.
109. Hopfield, J. J. (1982). Neural networks and physical systems with emergent collective computational abilities. *PNAS, 79*(8), 2554-2558.
110. Horwitz, L. P., & Piron, C. (1973). Relativistic dynamics. *Helvetica Physica Acta, 46*(3), 316-326.
111. Huber, F. (2023). Molecular motors: a physicist’s perspective. *arXiv:2311.10474*.
112. Hughes, R. I. G. (1989). *The structure and interpretation of quantum mechanics*. Harvard University Press.
113. Humphreys, P. (1985). Why propensities cannot be probabilities. *The Philosophical Review, 94*(4), 557-570.
114. Janmey, P. A. (1998). The cytoskeleton and cell signaling: component localization and mechanical coupling. *Physiological Reviews, 78*(3), 763-781. <https://doi.org/10.1152/physrev.1998.78.3.763>
115. Jeppsson, S. (2019). The Frankfurt-Style Cases and the Requirements for Moral Responsibility: A Reply to Swenson. *Logos & Episteme, 10*(3), 307-312. <https://doi.org/10.5840/logos-episteme201910322>
116. Kane, R. (1996). *The Significance of Free Will*. Oxford University Press.
117. Kane, R. (Ed.). (2016). *The Oxford Handbook of Free Will* (2nd ed.). Oxford University Press.
118. Kant, I. (1781). *Critique of Pure Reason*. (N. Kemp Smith, Trans., 1929). Macmillan.
119. Kastner, R. E. (2016). Limits on the efficacy of efficient cause reductionism for complex systems. *Synthese, 193*(9), 2717-2737.
120. Kauffman, S. A. (1986). Autocatalytic sets of proteins. *Journal of Theoretical Biology, 119*(1), 1-24.
121. Kauffman, S. A. (1991). Antichaos and adaptation. *Scientific American, 265*(2), 78-84.
122. Kauffman, S. A. (1993). *The Origins of Order: Self-Organization and Selection in Evolution*. Oxford University Press.
123. Kauffman, S. A. (2000). *Investigations*. Oxford University Press.
124. Kauffman, S. A. (2019). *A World Beyond Physics: The Emergence and Evolution of Life*. Oxford University Press.
125. Kauffman, S. A., & Clayton, P. (2006). On emergence, agency, and organization. *Biology and Philosophy, 21*(4), 501-521.
126. Kauffman, S. A., & Weinberger, E. D. (1989). The NK model of rugged fitness landscapes and its application to maturation of the immune response. *Journal of Theoretical Biology, 141*(2), 211-245.
127. Kim, J. (1998). *Mind in a Physical World*. MIT Press.
128. Kim, J. (2005). *Physicalism, or Something Near Enough*. Princeton University Press.
129. Kistler, M. (2021). Downward Causation, Levels of Reality, and the Structure of Scientific Knowledge. *Philosophia, 49*(1), 1-19. <https://doi.org/10.1007/s11406-020-00237-x>
130. Koutroufinis, S. A. (2024). Organismic Teleology and Agency Beyond Systems Theories: A Process-Metaphysical Perspective. In J. Švorcová (Ed.), *Organismal Agency: Biological Concepts and Their Philosophical Foundations* (Chapter 6). Springer.
131. Landauer, R. (1961). Irreversibility and heat generation in the computing process. *IBM Journal of Research and Development, 5*(3), 183-191.
132. Landauer, R. (1996). The physical nature of information. *Physics Letters A, 217*(4-5), 188-193.
133. Landsman, K. (2021). Undecidability and Indeterminism. In A. Aguirre, Z. Merali, & D. Sloan (Eds.), *Undecidability, Uncomputability, and Unpredictability* (Chapter 1). Springer.
134. Lefever, R. (2018). Exploring complexity: An introduction by Grégoire Nicolis and Ilya Prigogine. *Scholarpedia, 13*(3), 45272. <https://doi.org/10.4249/scholarpedia.45272>
135. Lequyer, J. (1985). *Comment trouver, comment chercher une vérité première*. Edition de L'Eclat.
136. Lestienne, R. (2022). *Alfred North Whitehead, Philosopher of Time*. World Scientific.
137. Levy, N. (2008). Introducing theausal compatibilism. *Philosophical Quarterly, 58*(230), 193-207.
138. Lewis, E. (2000). Anaxagoras and the Seeds of a Physical Theory. *Apeiron, 33*(1), 1-24.
139. Libet, B., Gleason, C. A., Wright, E. W., & Pearl, D. K. (1983). Time of conscious intention to act in relation to onset of cerebral activity (readiness-potential): The unconscious initiation of a freely voluntary act. *Brain, 106*(3), 623-642.
140. Logue, W. (1993). *Charles Renouvier, Philosopher of Liberty*. Louisiana State University Press.
141. Luo, L., Mueller, S., Cabral, J., & Deco, G. (2023). Dynamic exploration of the landscape of complex brain networks. *Physics Reports, 1003*, 1-93. <https://doi.org/10.1016/j.physrep.2023.01.001>
142. Lyon, P. (2015). The cognitive cell: bacterial behavior, recognition and learning. *Frontiers in Microbiology, 6*, 264.
143. Marchetti, M. C., Joanny, J. F., Ramaswamy, S., Liverpool, T. B., Prost, J., Rao, M., & Simha, R. A. (2013). Hydrodynamics of soft active matter. *Reviews of Modern Physics, 85*(3), 1143.
144. Markoš, A. (2024). (Bio)Semiosis as Life-Specific Form of Agency. In J. Švorcová (Ed.), *Organismal Agency: Biological Concepts and Their Philosophical Foundations* (Chapter 8). Springer.
145. Mascolo, M. F., & Kallio, E. (2019). The process dynamics of conscious experience: An integrative affective neuroscience perspective. *Behavioral Sciences, 9*(1), 10.
146. Matheson, B. (2015). Compatibilist Manipulation and the Requirements of Responsibility. *Philosophia, 43*(4), 1041-1062. <https://doi.org/10.1007/s11406-015-9658-1>
147. Matheson, B. (2018). Manipulation, Moral Responsibility and Compatibilism: A Dilemma for Defenders of Manipulation Arguments Against Compatibilism. *Journal of Ethics, 22*(1), 1-19. <https://doi.org/10.1007/s10892-018-9258-9>
148. Maturana, H. R., & Varela, F. J. (1980). *Autopoiesis and Cognition: The Realization of the Living*. D. Reidel.
149. Maudlin, T. (2007). *The metaphysics within physics*. Oxford University Press.
150. Maxwell, N. (1988). Quantum propensiton theory: A testable resolution of the wave/particle dilemma. *The British Journal for the Philosophy of Science, 39*(1), 1-50.
151. McCall, S. (1976). Objective time flow. *Philosophy of Science, 43*(3), 337-362.
152. McKenna, M. (2014). Resisting the Manipulation Argument: A Hard-Liner Takes the Easy Way Out. *Philosophy and Phenomenological Research, 89*(2), 467-484. <https://doi.org/10.1111/phpr.12091>
153. McTaggart, J. M. E. (1927). *The nature of existence* (Vol. 2). Cambridge University Press.
154. Mele, A. R. (2006). *Free Will and Luck*. Oxford University Press.
155. Mele, A. R. (2009). *Effective Intentions: The Power of Conscious Will*. Oxford University Press.
156. Mellor, D. H. (1971). *The matter of chance*. Cambridge University Press.
157. Mendoza-Collazos, D., & Zlatev, J. (2022). Consciousness in living systems: An enactive approach. *Frontiers in Psychology, 13*, 1002804. <https://doi.org/10.3389/fpsyg.2022.1002804>
158. Michelini, G., & Köchy, K. (2020). Jakob von Uexküll and the discovery of the Umwelt. *Biological Theory, 15*(3), 135-144.
159. Miller, D. (1991). Single-case probabilities. *Foundations of Physics, 21*(12), 1501-1516.
160. Mitchell, S. D. (2023). Emergence: Logical, functional and dynamical. *Synthese, 201*(6), 163.
161. Monod, J. (1971). *Chance and Necessity: An Essay on the Natural Philosophy of Modern Biology*. Alfred A. Knopf.
162. Montévil, M. A., & Mossio, M. (2015). Biological organisation as closure of constraints. *Journal of Theoretical Biology, 372*, 179-191.
163. Moore, D. W. (2021). Frankfurt Cases and Frankfurt-Indeterministic Cases. *Res Philosophica, 98*(1), 29-51. <https://doi.org/10.11612/resphil.1935>
164. Moore, M. S. (2023). Libet's Challenge to Libertarianism: The Need for Emergentist Agency. *Journal of Consciousness Studies, 30*(5-6), 123-148.
165. Moreno, A., & Mossio, M. (2015). *Biological Autonomy: A Philosophical and Theoretical Enquiry*. Springer.
166. Mossio, M., Bich, L., & Moreno, A. (2013). Emergence, closure and inter-level causation in biological systems. *Erkenntnis, 78*(S2), 153-178.
167. Mossio, M., Montévil, M., & Longo, G. (2016). Theoretical principles for biology: Organization. *Progress in Biophysics and Molecular Biology, 122*(1), 24-35.
168. Müller, M. P. (2021). Undecidability and Unpredictability: Not Limitations, but Triumphs of Science. In A. Aguirre, Z. Merali, & D. Sloan (Eds.), *Undecidability, Uncomputability, and Unpredictability* (Chapter 2). Springer.
169. Müller, T., Placek, T., & Rosenkranz, S. (2018). Indeterminism and the openness of the future. In A. Bardon & H. Dyke (Eds.), *A Companion to the Philosophy of Time* (pp. 281-299). Wiley Blackwell.
170. Nakagaki, T., Yamada, H., & Tóth, Á. (2000). Maze-solving by an amoeboid organism. *Nature, 407*(6803), 470.
171. Noble, D. (2012). A theory of biological relativity: no privileged level of causation. *Journal of The Royal Society Interface Focus, 2*(1), 55-64.
172. Noble, D., & Noble, R. (2018). Harnessing stochasticity: How do organisms make choices? *Chaos: An Interdisciplinary Journal of Nonlinear Science, 28*(10), 106309.
173. O'Connor, T. (2022). Agent-Causal Theories of Free Will. In E. N. Zalta & U. Nodelman (Eds.), *The Stanford Encyclopedia of Philosophy* (Fall 2022 ed.). Metaphysics Research Lab, Stanford University. <https://plato.stanford.edu/archives/fall2022/entries/incompatibilism-theories/>
174. Palmer, T. N. (2021). Undecidability, Fractal Geometry and the Unity of Physics. In A. Aguirre, Z. Merali, & D. Sloan (Eds.), *Undecidability, Uncomputability, and Unpredictability* (Chapter 6). Springer.
175. Parés-Pujolràs, E., Pallarés, V., & Sauseng, P. (2023). Time of decision is reflected in the dynamics of beta band oscillations. *Nature Communications, 14*(1), 6318. <https://doi.org/10.1038/s41467-023-42071-5>
176. Patrick, T. (2017). Manipulation Arguments and Compatibilist Theories of Responsibility. *Philosophy Compass, 12*(8), e12429. <https://doi.org/10.1111/phc3.12429>
177. Pearl, J. (2009). *Causality* (2nd ed.). Cambridge University Press.
178. Pereboom, D. (2001). *Living Without Free Will*. Cambridge University Press.
179. Pereboom, D., & McKenna, M. (2022). Free Will. In E. N. Zalta (Ed.), *The Stanford Encyclopedia of Philosophy* (Fall 2022 ed.). Metaphysics Research Lab, Stanford University. <https://plato.stanford.edu/archives/fall2022/entries/freewill/>
180. Pittendrigh, C. S. (1958). Adaptation, natural selection, and behavior. In A. Roe & G. G. Simpson (Eds.), *Behavior and Evolution* (pp. 390-416). Yale University Press.
181. Popper, K. R. (1959). *The Logic of Scientific Discovery*. Hutchinson.
182. Popper, K. R. (1982). *The Open Universe: An Argument for Indeterminism*. Rowman and Littlefield.
183. Popper, K. R. (1990). *A world of propensities*. Thoemmes.
184. Posy, C. J. (1976). Varieties of Indeterminism in the Theory of General Choice Sequences. *Journal of Philosophical Logic, 5*(1), 91-132.
185. Posy, C. J. (2020). *Mathematical intuitionism*. Cambridge University Press.
186. Prado, T. L., De Assis, R. L., & Villas-Boas, C. J. (2022). Thermal noise effects on stochastic resonance. *Scientific Reports, 12*(1), 1-9.
187. Prigogine, I. (1967). Dissipative structures in chemical systems. In S. Claesson (Ed.), *Fast Reactions and Primary Processes in Chemical Kinetics* (pp. 371-382). Nobel Foundation.
188. Prigogine, I. (1977). Time, structure, and fluctuations. *Nobel Lecture*.
189. Putnam, H. (1967). Psychological Predicates. In W. H. Capitan & D. D. Merrill (Eds.), *Art, Mind, and Religion*. University of Pittsburgh Press.
190. Reichenbach, H. (1953). Les Fondements Logiques de la Mécanique des Quanta. *Annales de l'Institut Henri Poincaré, 13*(2), 109-158.
191. Reichenbach, H. (1956). *The direction of time*. University of California Press.
192. Rider, C. S. (2024). *Toward a Theory of Agency: Complexity Metrics and the Emergence of Autonomy*. Thesis.
193. Röck, T. (2024). The Becoming of Identity: A Process-Ontological View on the Relational Co-existence of Biological Beings. In J. Švorcová (Ed.), *Organismal Agency: Biological Concepts and Their Philosophical Foundations* (Chapter 7). Springer.
194. Rolls, E. T., & Deco, G. (2010). *The noisy brain: Stochastic dynamics as a principle of brain function*. Oxford University Press.
195. Rosen, R. (1991). *Life Itself: A Comprehensive Inquiry Into the Nature, Origin, and Fabrication of Life*. Columbia University Press.
196. Russell, B. (1913). On the Notion of Cause. *Proceedings of the Aristotelian Society, 13*, 1-26.
197. Samoilov, M. S., Price, G., & Arkin, A. P. (2006). From fluctuations to phenotypes: the physiology of noise. *Science signaling, 2006*(365), pe44.
198. Sartorio, C. (2010). Actual Causes and Actual-Sequence Views of Freedom. *Philosophical Studies, 151*(2), 175-190. <https://doi.org/10.1007/s11098-009-9431-z>
199. Schilling, M., Rolls, E. T., & Deco, G. (2023). Stochastic Facilitation of Decision-Making in Spiking Neural Networks. *Cerebral Cortex, 33*(20), 10748-10763. <https://doi.org/10.1093/cercor/bhad272>
200. Schurger, A., Sitt, J. D., & Dehaene, S. (2012). An accumulator model for spontaneous neural activity prior to self-initiated movement. *PNAS, 109*(42), E2904-E2913.
201. Schurger, A., Mylopoulos, M., & Rosenthal, D. (2021). Neural antecedents of spontaneous voluntary movement: a new perspective. *Trends in Cognitive Sciences, 25*(11), 964-977.
202. Searle, J. R. (2007). Dualism revisited. *Journal of Physiology-Paris, 101*(4-6), 169-178.
203. Seevinck, M. P., & Uffink, J. (2011). Not throwin' out the baby with the bathwater: Bell's condition of local causality in an indeterministic world. In M. Suárez, M. Dorato, & M. Rédei (Eds.), *EPSA Philosophy of Science: Amsterdam 2009* (pp. 325-335). Springer.
204. Sevilla, A., Molina, C., & Rodríguez-Fornells, A. (2021). The Neural Correlates of the Sense of Agency. *Frontiers in Human Neuroscience, 15*, 718930. <https://doi.org/10.3389/fnhum.2021.718930>
205. Shoemaker, S. (1980). Causality and Properties. In P. Van Inwagen (Ed.), *Time and Cause* (pp. 109-135). Springer.
206. Smaers, J. B., & Soligo, C. (2013). Brain reorganization, not relative brain size, predicts cognitive evolution. *PLoS Biology, 11*(4), e1001546.
207. Smilansky, S. (2000). *Free Will and Illusion*. Oxford University Press.
208. Smilansky, S. (2016). Free will and illusion revisited: Understanding free will requires understanding illusion. *AJOB Neuroscience, 7*(2), 98-100.
209. Smolin, L. (2013). *Time Reborn: From the Crisis in Physics to the Future of the Universe*. Houghton Mifflin Harcourt.
210. Stamos, D. N. (2001). Quantum indeterminism and the libertarian free will thesis. *Philosophy of Science, 68*(S3), S164-S175.
211. Suárez, M. (2004). Quantum Selections, Propensities and the Problem of Measurement. *British Journal for the Philosophy of Science, 55*(2), 219-255.
212. Suárez, M. (2007). Quantum propensities. *Studies in History and Philosophy of Modern Physics, 38*(2), 418-438.
213. Švorcová, J. (Ed.). (2024). *Organismal Agency: Biological Concepts and Their Philosophical Foundations*. Springer.
214. Švorcová, J. (2024). Plastic Ontogenesis: Memory, Closure, and Habitual Teleology in Development. In J. Švorcová (Ed.), *Organismal Agency: Biological Concepts and Their Philosophical Foundations* (Chapter 9). Springer.
215. Taylor, C. (2020). Manipulated Agents and Unwitting Accomplices: Responsibility, Blame, and Meaning in Life. *Erkenntnis, 87*(1), 105-126. <https://doi.org/10.1007/s10670-020-00271-0>
216. Te Vrugt, M. (2021). *Macroscopic Descriptions of Active Matter*. Dissertation, University of Münster.
217. Te Vrugt, M. (2022). Classical and quantum transport in complex systems. *Journal of Physics: Condensed Matter, 34*(22), 223001.
218. Thompson, E. (2007). *Mind in Life: Biology, Phenomenology, and the Sciences of Mind*. Harvard University Press.
219. Van Atten, M. (2018). The creating subject, the brouwer-kripke schema, and infinite proofs. *Indagationes Mathematicae, 29*(5), 1565-1586.
220. Van Atten, M. (2022). Dummett's objection to the ontological route to intuitionistic logic: a rejoinder. *Inquiry, 65*(6), 725-741.
221. Van Fraassen, B. C. (1980). *The Scientific Image*. Oxford University Press.
222. Van Inwagen, P. (2000). Free Will Remains a Mystery. *Philosophical Perspectives, 14*, 1-19. <https://doi.org/10.1111/0029-4624.34.s14.1>
223. Varela, F. J., Thompson, E., & Rosch, E. (1991). *The Embodied Mind: Cognitive Science and Human Experience*. MIT Press.
224. Von Foerster, H. (2003). *Understanding Understanding: Essays on cybernetics and cognition*. Springer.
225. Weber, B. H. (2005). Emergence of life and biological selection from the perspective of complex systems dynamics. In C. K. Mameli, & S. F. Gilbert (Eds.), *Form and Transformation: Generative and Relational Principles in Biology* (pp. 113-128). MIT Press.
226. Wegner, D. M. (2002). *The Illusion of Conscious Will*. MIT Press.
227. Weyl, H. (1994). *The Continuum: A critical examination of the Foundations of Analysis* (S. Pollard & T. Bole, Trans.). Dover. (Original work published 1918).
228. Wiener, N. (1948). *Cybernetics: Or Control and Communication in the Animal and the Machine*. MIT Press.
229. Wolf, M. M., Perez-Garcia, D., & Fernandez, C. (2009). Measurements incompatible in quantum theory cannot be measured jointly in any other no-signaling theory. *Physical Review Letters, 103*(23), 230402.
230. Woodward, J. (2003). *Making Things Happen: A Theory of Causal Explanation*. Oxford University Press.