QUANTUM PHENOMENOLOGY OF ACTION: PREDICTIVE, EXECUTIVE, AND CORRECTIVE OVERLAP AS TEMPORAL SUPERPOSITION

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ABSTRACT: This paper develops a ***formal phenomenology*** of human action by integrating insights from phenomenology, predictive-processing neuroscience, and quantum formalism. It argues that action does not unfold as a linear sequence of prediction, execution, and correction but as a temporally superposed field in which these components coexist. To capture this simultaneity, the paper introduces a non-commutative operator model—$\psi_a = \alpha|P\rangle + \beta|E\rangle + \gamma|C\rangle$—representing action as a superposition of predictive, executive, and corrective states. Non-zero commutators ($[\hat{E}, P\hat{\ }] \neq 0$) express the contextual dependence of temporal order, while measurement-like collapse corresponds to the emergence of determinate outcomes in lived experience. The framework thus reconceptualizes embodied agency as coherence within indeterminacy, offering a logical bridge between phenomenological temporality and contemporary neuroscience. The proposed model provides a minimal mathematical grammar for describing the non-classical, overlapping temporality that constitutes the lived structure of human action.

KEYWORDS: Phenomenology of action; Predictive processing; Non-commutative temporality; Quantum formalism; Embodied agency; Temporal superposition

1 INTRODUCTION

Human action is not a sequence of discrete phases—prediction, execution, and correction—but a continuous field of overlapping temporal operations. Every gesture already involves anticipation and retroactive modulation; the predicted and the performed coexist within a single experiential moment. Classical models of motor control have treated these components as serially ordered, yet

phenomenologically the lived experience of acting reveals simultaneity rather than succession.

This paper proposes that the temporal structure of action is best described as a ***superposition***: a coexistence of partially actualized states rather than a linear transition between stages. Predictive-processing neuroscience supports this simultaneity—motor correction begins before sensory feedback arrives—but the argument developed here is ontological, not computational. Acting itself, as lived, displays a structural indeterminacy formally analogous to quantum superposition.

JUSTIFYING THE QUANTUM FRAMEWORK

Classical theories of action presuppose a determinate causal order in which each event follows from prior conditions. Yet lived experience defies such linear determinacy: anticipation and correction coexist, and intention transforms through its own realization. To describe this simultaneity, a logical framework is required that allows mutually incompatible states to coexist prior to resolution.

Quantum theory—understood here not as physics but as a *formal language of indeterminacy*—provides such a framework. Its non-commutative and context-dependent logic captures the same ontological features that characterize lived action: coexistence, interference, and measurement-dependent actuality. The "quantum" in *quantum phenomenology*thus denotes not microscopic causation but the necessity of a non-classical logic adequate to the temporal ontology of action.

Drawing on Merleau-Ponty's notion of the "thickness of the present" (1945), I argue that human action exhibits a structure *structurally analogous* to quantum superposition. Before an act becomes determinate—before success or failure—it exists as an indeterminate ensemble of possibilities that interfere with one another. Conscious awareness performs the role of measurement, collapsing this manifold of anticipatory–executive states into a single experiential actuality.

This is not a metaphorical claim. It concerns a *formal analogy* between two domains: (a) the temporal logic of embodied action and (b) the mathematical logic of quantum indeterminacy. Quantum mechanics provides a precise conceptual grammar for coexistence, interference, and collapse—precisely the dynamics manifested phenomenologically in action.

The following account develops what may be called a formal

phenomenology: a minimal mathematical grammar of lived temporality that bridges phenomenological description and non-classical logic.

2 THEORETICAL BACKGROUND

2.1 Phenomenological Time and the Thickness of Action

Merleau-Ponty described perception and action as unfolding within the "épaisseur du présent," a temporal field where past and future interpenetrate. Each gesture is "pregnant with its own completion." The body does not first predict and then execute but enacts a world in which these orientations coexist. Husserl's retention–protention model already implied such overlap; Merleau-Ponty radicalized it into an ontology of embodiment. Action is thus ***non-decomposable***: phases overlap in a continuous field of partial actualities.

2.2 Predictive Processing and Active Inference

Friston's (2010) free-energy principle and Clark's (2016) predictive processing describe the brain as a system that continuously predicts sensory input and minimizes error through active inference. Perception and action are complementary sides of the same inferential loop. Empirically, motor cortex exhibits preparatory activity that already encodes corrective information (Schurger et al. 2012; Wolpert et al. 2011). Correction therefore co-occurs with execution, supporting phenomenological simultaneity. Yet these models remain computational, describing processes rather than the ontological structure of acting itself.

2.3 Quantum Superposition as Structural Analogy

Quantum theory formalizes coexistence without reduction. A system occupies multiple potential states—superposed—until observation yields a determinate outcome. This does not require physical quantum events within the brain; it offers a *formal logic* for indeterminate simultaneity. The relation between prediction, execution, and correction in action follows a similar non-commutative order: later feedback modifies earlier intention, just as quantum operators fail to commute.

This interpretive approach aligns with philosophical readings of quantum theory as an ontology of relational becoming rather than a microphysical hypothesis. Whitehead's process metaphysics, Barad's (2007) *agential realism*, and Bitbol's phenomenological interpretation of quantum mechanics all treat quantum formalism as a grammar for describing self-constituting events. The present model extends this reasoning to the domain of embodied action, interpreting bodily intentionality as a site of non-classical coexistence.

3 QUANTUM MODEL OF ACTION

3.1 Action State Space

Let the *action state space* $\mathcal{H}_a$ be a vector space spanned by three orthogonal basis vectors representing the principal temporal components of action:

$$\mathcal{H}_a = \text{span}\{|P\rangle, |E\rangle, |C\rangle\}$$

where $|P\rangle$ = predictive, $|E\rangle$ = executive, and $|C\rangle$ = corrective modes of embodiment.
Any lived action can be expressed as a superposition within this space:

$$\psi_a = \alpha|P\rangle + \beta|E\rangle + \gamma|C\rangle, \quad \text{with } |\alpha|^2 + |\beta|^2 + |\gamma|^2 = 1.$$

Here α, β, γ represent relative amplitudes corresponding to the salience or dominance of each mode in the ongoing act. Phenomenologically, these coefficients describe the felt intensities of anticipation, engagement, and revision.

3.2 Operators and Temporal Non-Commutativity

Let $\hat{\mathbf{P}}$, $\hat{\mathbf{E}}$, and $\hat{\mathbf{C}}$ be operators representing predictive, executive, and corrective transformations acting on $\mathcal{H}_a$. These operations are temporally ordered but not commutative:

$$[\hat{E}, \hat{P}] = \hat{E}\hat{P} - \hat{P}\hat{E} \neq 0$$
$$[\hat{C}, \hat{E}] \neq 0, \quad [\hat{C}, \hat{P}] \neq 0.$$

The non-zero commutators indicate that the effect of one operation depends on

the contextual state produced by the other. Phenomenologically, this expresses that anticipation is transformed by execution, and execution is redefined by correction. Action therefore cannot be represented as a classical sequence but as an entangled composition of temporally interdependent operations.

3.3 Interference and Self-Correction

When divergences occur between expected and actual outcomes, corrective processes interfere with predictive amplitudes.
The corrective operation $\hat{\mathbf{C}}$ alters phase relations among α, β, and γ, producing re-weighted tendencies for subsequent prediction.
This yields a recursive renormalization of ψ_a—an ongoing self-interference that underlies the phenomenological experience of continuous adjustment.
In this sense, error is not deviation but modulation within the superposed field of action.

3.4 COLLAPSE AND MEASUREMENT

A determinate behavioral outcome represents the *collapse* of ψ_a into one eigenstate of action—e.g., $|E\rangle$ as realized execution.
Conscious awareness or environmental feedback acts as a measurement operator Π such that:

$$\Pi\psi_a = |E\rangle, \quad \langle E|E\rangle = 1.$$

Collapse is thus both epistemic (selection among alternatives) and ontological (actualization of one trajectory).
Temporal boundaries of "before" and "after" are not fixed divisions but contextual projections emerging through measurement.

3.5 ENTANGLEMENT AND INTERSUBJECTIVITY

In intersubjective coordination, two or more agents possess entangled action spaces, $\mathcal{H}_{a1} \otimes \mathcal{H}_{a2}$.
Each agent's predictive and corrective components depend on the other's outputs, producing joint probability amplitudes for cooperative movement or dialogue. Empathy and coordination thus emerge from coherence phenomena in this

extended space.
Merleau-Ponty's intercorporeality corresponds to a phenomenological form of ***entanglement***: reciprocal structuring of potential actions across bodies.

3.6 SUMMARY

The action process unfolds within a non-commutative, superposed structure of temporal components.
The body operates not as a deterministic machine but as a probabilistic medium maintaining coherence among overlapping potentials.
The formal framework above provides a minimal grammar for describing this indeterminacy.

3.7 FORMAL NOTE ON NON-COMMUTATIVITY

To illustrate non-commutativity concretely, consider two simplified operations: (1) executing according to a prior prediction, and (2) predicting during ongoing execution.

Let $|s\rangle$ represent the embodied sensorimotor state.

Then:

$\hat{E}\hat{P}|s\rangle$ = acting under a pre-established prediction,
$\hat{P}\hat{E}|s\rangle$ = updating prediction based on the act itself.

Empirically and phenomenologically, these produce distinct experiences. The correction following execution redefines the meaning of the initial prediction; thus,

$$[\hat{E}, \hat{P}] = \hat{E}\hat{P} - \hat{P}\hat{E} \neq 0.$$

This inequality formalizes the fact that order matters in action. Temporal orientations cannot be separated into linear causation but interact contextually.
The commutator structure captures the minimal condition under which the phenomenology of action requires a quantum-like formalism.

4 PHILOSOPHICAL AND EMPIRICAL IMPLICATIONS

4.1 Embodiment as Probabilistic Medium

The lived body functions as a probabilistic generator where potential acts coexist and interfere.

Skill emerges when interference stabilizes; breakdown appears as decoherence.

Motor pathologies such as Parkinsonian freezing or "yips" in athletes illustrate partial loss of coherence between predictive and corrective components—phenomenological analogs of wave-function collapse into maladaptive minima.

4.2 TEMPORAL EXPERIENCE AND INDETERMINACY

The model clarifies why action feels temporally thick.

During motion, one already senses what is about to happen while adjusting to what has just occurred.

The "present" is an indeterminate span, not a point.

Quantum superposition provides a formal model for this coexistence of incompatible temporal orientations constituting the lived now.

4.3 Agency Beyond Mechanism and Voluntarism

Classical theories oscillate between mechanism and will.

The quantum model dissolves this dichotomy: no pure cause, no pure choice— only probabilistic emergence under constraint.

Agency is the capacity to sustain coherence within indeterminacy. Freedom consists in navigating possible collapses, not in exemption from causality.

4.4 Intersubjectivity as Entanglement

Shared agency arises through entanglement of individual action fields.

Each gesture modifies the probability landscape of others. Empathy and coordination thus stem from interference patterns, not representational mind-reading.

Intercorporeality becomes a non-local coupling of bodies within a joint

superposed field.

4.5 Empirical Resonances

Empirical findings align with this model:

- Simultaneous activation of predictive and corrective networks (Wolpert et al. 2011).
- Readiness potentials preceding conscious intention (Schurger et al. 2012).
- Rapid within-trial error corrections implying zero-lag overlap (Franklin & Wolpert 2011).

These observations suggest ***functional superposition***: co-existing neural states corresponding to predictive and corrective modes prior to conscious awareness. Future computational modeling could test whether these processes exhibit **non-commutative interference**, such as phase-dependent modulation of error potentials. The proposed operator model provides a formal expression of this empirical simultaneity.

4.6 Ethical and Technological Horizons

If agency is probabilistic, responsibility must be reframed.

Each act emerges from overlapping potentials—biological, social, and technological. In human–AI interaction, predictive algorithms already participate in our action fields. Recognizing agency as distributed and entangled supports ethical design that preserves human indeterminacy rather than erasing it.

Ethics becomes the art of sustaining uncertainty—the source of creativity and freedom.

4.7 Anticipated Objections

This account does not claim that quantum physical processes occur in neural tissue.

The argument concerns structural homology, not microphysical causation.

Quantum mechanics here provides a non-classical logic for describing lived indeterminacy.

Both domains share formal features—superposition, non-commutativity, and

context-dependent collapse—allowing a coherent modeling of action's temporal ontology.

5 CONCLUSION

Human action is not a linear chain of intention, movement, and correction but a quantum-like superposition of predictive, executive, and corrective states. This structure manifests phenomenologically as the thickness of the present—the simultaneity of before and after within each act. Integrating Merleau-Ponty's embodied temporality with predictive-processing neuroscience, the quantum framework articulates coexistence without metaphor.

Action, conceived as a probabilistic field collapsing through awareness and interaction, transcends both mechanism and dualism. Agency becomes coherence within indeterminacy; intersubjectivity, entanglement of multiple such fields. The body is the locus of probabilistic becoming—a site where world and self co-create through interference and collapse.

Hence, quantum logic serves not as metaphor but as the minimal formalism for describing the non-classical temporality of embodied action. Future research may bridge phenomenology, neuroscience, and formal logic—testing temporal overlap of predictive and corrective signals and refining the ontology of probabilistic presence.

6 LIMITATIONS AND FUTURE DIRECTIONS

This framework does not posit microscopic quantum causation. The use of quantum formalisms is **structural rather than ontological**: it models the indeterminacy and non-commutativity observed in lived action without assuming subatomic mechanics.

The account is therefore not directly falsifiable in the physicist's sense. Its value lies in offering a formal language through which empirical findings—particularly those on predictive processing, sensorimotor overlap, and temporal experience—can be reorganized within a coherent ontology of agency.

Future work may examine whether neural and behavioral data exhibit signatures of functional non-commutativity, such as overlapping predictive and corrective activity prior to conscious awareness. Phenomenological studies can likewise investigate how indeterminate "thickness" of the present is experienced

across skilled and disrupted forms of action. Such investigations would not verify the model but *enrich* it, clarifying the relation between probabilistic structure and lived embodiment.

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