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Quantum Fluctuations in Intuitive Judgement and Their Predictive Power in Complex Cognitive Tasks

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Abstract

Intuitive judgement plays a central role in human decision-making, particularly in environments characterized by uncertainty, time pressure, and high cognitive load. Recent advances in quantum cognition propose that intuitive processing may not follow classical probabilistic structures, but instead exhibits fluctuation patterns analogous to quantum uncertainty, superposition, and interference. The present study investigates whether measurable quantum-like fluctuations in intuitive responses can predict performance accuracy in complex cognitive tasks. To examine this question, behavioural, neurophysiological, and temporal-response data were collected from participants performing multi-stage reasoning and rapid-decision paradigms designed to evoke intuition-driven choices. High-density EEG and physiological recordings were used to quantify moment-to-moment variability in intuitive judgements, which were then compared to task accuracy and cognitive load measures. The results demonstrate that intuitive decisions exhibit statistically identifiable fluctuation signatures that align with quantum probability models rather than classical linear models. Participants displaying higher amplitude fluctuation patterns in key temporal windows showed significantly greater predictive accuracy in complex reasoning tasks. These findings suggest that intuition may operate through a non-classical cognitive mechanism sensitive to contextual constraints, uncertainty, and dynamic information integration. Additional analyses revealed that the interplay of emotional arousal and cognitive complexity further modulates the fluctuation–accuracy relationship, indicating a multi-layered interaction between affective states and intuitive judgement. This study contributes to emerging theoretical frameworks by empirically linking quantum-inspired cognitive variability to real-time intuitive performance. The findings highlight the potential value of quantum probabilistic modelling for predicting human behaviour in complex decision environments, advancing both theoretical understanding and applied assessment tools. Such models may offer more precise predictions of intuitive reliability across contexts such as clinical decision-making, strategic planning, and high-stakes environments. The study underscores the importance of integrating behavioural data, neurophysiological markers, and advanced mathematical modelling to better characterize the foundations of intuitive cognition.

Keywords: intuitive judgement, quantum cognition, decision-making, cognitive complexity, predictive modelling

Introduction

Understanding how humans generate rapid, intuitive judgements during complex situations has become a central topic in contemporary cognitive science. Across many real-world environments—clinical diagnosis, strategic planning, financial decision-making, and high-pressure social interactions—individuals often rely on intuitive impressions that emerge quickly and without deliberate reasoning. While intuition has historically been described as a vague or immeasurable construct, recent developments in cognitive modelling have reframed intuitive judgement as a structured, dynamic process shaped by uncertainty, emotional states, and multi-level cognitive interactions. These perspectives suggest that intuition may function as an adaptive mechanism that enables the brain to reach meaningful conclusions under time constraints and partial information. As research on intuition expands, emphasis has increasingly shifted toward identifying quantifiable markers that distinguish intuitive from analytical processing.

In parallel with these developments, models grounded in quantum cognition have emerged as compelling frameworks for understanding non-classical patterns in human reasoning. Quantum cognition does not imply that the brain operates according to the physical principles of quantum mechanics; rather, it proposes that certain cognitive behaviours follow mathematical structures analogous to quantum probability. These models have been useful in explaining phenomena that elude classical probability theory, such as order effects, interference in judgement, and context-dependent choice patterns [1,3]. The relevance of quantum-like structures becomes particularly pronounced in conditions where uncertainty is high and cognitive load fluctuates—precisely the conditions under which intuitive judgement often dominates.

Another key element in the study of intuitive decision-making involves identifying physiological and neural markers that correspond to the underlying cognitive process. Several studies have indicated that rapid, intuition-based responses often arise from early neural activity observable in high-density EEG recordings, particularly within theta and alpha frequency bands associated with uncertainty monitoring and integrative processing [4,5]. These neural signatures suggest that intuition is not simply a subjective impression but a measurable cognitive operation characterized by fluctuations over time. Importantly, these fluctuations frequently deviate from linear or classical patterns, and instead exhibit probabilistic profiles similar to quantum superposition and collapse phenomena.

In high-uncertainty tasks, such as ambiguous categorization problems or rapidly shifting decision environments, intuitive judgement has been shown to outperform analytical reasoning in speed and, in some cases, accuracy [6,7]. These findings highlight the importance of examining how intuitive judgements fluctuate in real time and how these fluctuations may relate to cognitive performance. The interplay between uncertainty, emotional activation, and spontaneous insight may generate complex behavioural patterns that cannot be fully captured by traditional cognitive models. As researchers increasingly integrate behavioural measures with physiological markers, the possibility of describing intuition through quantum-inspired frameworks has gained scientific traction.

A growing body of evidence suggests that intuitive judgement is inherently sensitive to fluctuations in both internal states and external task conditions. These fluctuations emerge not only from momentary shifts in attention or emotional arousal but also from deeper structural dynamics in cognition that influence how information is integrated under uncertainty. Behavioural research shows that intuitive responses often oscillate between competing interpretations before stabilizing into a final judgement, especially when stimuli are ambiguous or incomplete. Such oscillatory patterns are difficult to interpret through classical decision frameworks, which assume stable preferences, linear evidence accumulation, and predictable choice trajectories. By contrast, quantum probability models naturally accommodate systems in which multiple potential cognitive states coexist prior to decision resolution, allowing for transitions that reflect interference, contextual dependency, and rapid reorganization of mental representations [1,10].

Within this field, a significant development has been the introduction of mathematical models that map intuitive judgement onto quantum-like states that evolve over time. These models describe how cognitive states occupy overlapping probability distributions before collapsing into a final decision—an interpretation consistent with empirical evidence showing that intuition may involve simultaneous processing of multiple information channels. Neurophysiological data support this view: studies using EEG and real-time neural decoding have shown that the brain exhibits early fluctuations in predictive signals that align with the structure of quantum decision processes [4,5]. These neural dynamics appear to be especially prominent in tasks requiring rapid integration of emotional cues, uncertainty signals, and partial evidence, underscoring the multidimensional nature of intuitive cognition.

Emotional dynamics further complicate this picture. Many cognitive scientists argue that intuition is inseparable from emotional modulation, particularly when decisions must be made quickly or with limited information. Emotional arousal—whether positive or negative—can amplify or dampen intuitive fluctuations, thereby shaping the trajectory of decision formation. Research has shown that specific neural pathways associated with emotional salience influence the timing and direction of intuitive responses [11]. In complex environments, this emotional–cognitive interaction may produce fluctuation signatures that mirror the interference patterns predicted by quantum models. Consequently, intuition becomes not a singular construct but a dynamic system shaped by simultaneous, interacting variables.

The context in which intuitive judgement occurs also plays a critical role. High-complexity tasks often impose competing cognitive demands, requiring rapid switching between global and local processing strategies. Studies on cognitive load indicate that intuitive accuracy increases when individuals can maintain flexible, non-linear patterns of information integration [8,12]. This flexibility may be supported by quantum-like cognitive mechanisms that allow mental representations to reorganize rapidly without following step-by-step logical computation. However, the precise relationship between intuitive fluctuations and performance outcomes in complex tasks remains insufficiently explored, highlighting a critical gap in the literature.

Despite recent progress in modelling intuitive cognition, a substantial theoretical and empirical challenge remains: how to quantify the real-time fluctuations that characterise intuitive judgement and determine whether these fluctuations possess predictive value in complex cognitive environments. Traditional psychological approaches tend to conceptualize intuition as an outcome—a final judgement—but rarely examine its temporal dynamics. Yet emerging research suggests that the unfolding process leading to intuitive decisions may contain crucial information about cognitive efficiency, uncertainty regulation, and adaptive responsiveness. Understanding these temporal properties requires a shift toward analytical tools capable of capturing irregular, non-linear changes over short intervals. Quantum-inspired frameworks offer such tools by modelling cognitive states as probabilistic entities that evolve dynamically across time rather than progressing through fixed stages.

This shift is especially relevant as contemporary behavioural paradigms increasingly rely on real-time monitoring technologies. High-density EEG, response-latency tracking, and physiological indicators such as heart-rate variability now allow researchers to observe micro-level transitions in intuitive processing. These approaches provide fine-grained temporal resolution, making it possible to detect fluctuation signatures that precede accurate or inaccurate decisions. When interpreted through quantum-based mathematical structures, these data may reveal how cognitive states transition between competing possibilities before settling into a final intuitive response. Although preliminary studies point to consistent patterns in these transitions, their potential for predicting performance in complex cognitive tasks has not been systematically tested across integrated behavioural and physiological domains.

Moreover, complex cognitive tasks inherently involve layers of ambiguity, shifting contingencies, and anisotropic information structures that challenge classical decision models. Individuals navigating such tasks must continuously modulate attention, regulate emotional signals, and integrate uncertain information streams. Fluctuations in intuitive judgement may therefore represent adaptive processes that enable rapid selection among competing interpretations. If these fluctuations display identifiable quantum-like characteristics—such as amplitude shifts, interference patterns, or non-commutative order effects—they may serve as robust predictors of performance outcomes. Establishing such predictive relationships could significantly advance theoretical understanding and support the development of more accurate models of human decision-making.

The convergence of these considerations underscores the need for a comprehensive investigation that integrates behavioural performance, psychophysiological markers, and quantum-based modelling. The present study addresses this gap by examining whether quantum-like fluctuations in intuitive judgement can predict accuracy in complex cognitive tasks. By analysing high-resolution temporal patterns alongside neural and behavioural data, this research seeks to clarify the underlying dynamics of intuitive cognition and explore their implications for theories of decision-making, cognitive complexity, and uncertainty regulation. The findings have the potential to contribute not only to foundational cognitive science but also to applied domains in which rapid intuitive responses exert profound influence, including clinical reasoning, operational decision-making, and high-stakes environments.

PROBLEM STATEMENT

Although recent advances in cognitive science have illuminated several aspects of intuitive judgement, a major unresolved challenge persists: the absence of a systematic framework capable of quantifying the real-time fluctuations that shape intuition and linking these fluctuations to performance in complex cognitive tasks. Existing studies demonstrate that intuition often emerges through rapid, dynamic transitions rather than stable cognitive states, and these transitions appear to follow non-linear, context-sensitive patterns. Yet the field lacks a unified explanation for how such dynamic behaviour maps onto measurable outcomes such as accuracy, error likelihood, and decision stability. Classical decision models assume orderly, incremental accumulation of evidence, but intuitive decisions frequently violate these assumptions—displaying interference-like effects, sudden shifts in confidence, and context-dependent variability that align more closely with quantum probability structures than with classical interpretations [1,3].

Despite promising theoretical developments, empirical work remains fragmented. Neurophysiological studies indicate that intuition is associated with early fluctuations in EEG and related indicators [4,5], but these fluctuations have not been consistently connected to behavioural accuracy in high-complexity tasks. Similarly, behavioural studies reveal that individuals differ significantly in their intuitive patterns when facing uncertainty [8,12], yet no existing research has integrated these behavioural variations with a formal quantum-inspired modelling approach. As a result, the field lacks clarity on whether these fluctuations merely accompany intuitive judgement or whether they actively predict the quality of decision outcomes.

A second unresolved issue involves the interaction between emotional activation and intuitive variability. Although evidence suggests that emotional signals modulate early cognitive fluctuations [11], the degree to which this modulation contributes to—or disrupts—accurate intuitive performance in complex settings is poorly understood. Without integrating emotional, behavioural, and temporal-neural data into a unified framework, the field cannot determine whether intuitive fluctuations constitute reliable indicators of performance or simply reflect background noise within the cognitive system.

Thus, the central problem this study seeks to address is the absence of an empirically grounded, quantum-informed model that can capture the temporal dynamics of intuitive fluctuations and evaluate their predictive value in complex cognitive tasks. Clarifying this relationship is essential for advancing theoretical models of intuition and for developing practical tools capable of assessing intuitive reliability in real-world decision contexts.

MATERIALS AND METHODS

The present study employed an integrated methodological framework combining behavioural assessment, neurophysiological recording, and quantum-inspired mathematical modelling to investigate whether moment-to-moment fluctuations in intuitive judgement can predict performance accuracy in complex cognitive tasks. The methodological design was structured to capture high-resolution temporal patterns in intuitive processing while maintaining ecological validity and reproducibility across participants.

Participants

A total of 68 healthy adults (ages 21–38) were recruited through public advertisements and screened for neurological, psychiatric, or cognitive impairments. All participants had normal or corrected-to-normal vision and reported no prior experience with EEG-based experiments. Inclusion criteria focused on ensuring that participants were capable of performing advanced cognitive tasks requiring rapid decision-making. Exclusion criteria included use of psychoactive medication, uncorrected sensory deficits, or histories of neurological disorders. Written informed consent was obtained from all individuals in accordance with institutional ethical guidelines. The sample size was determined based on power analyses from prior studies investigating intuition and neurocognitive fluctuations [4,5].

Experimental Tasks

To elicit intuitive judgement under varying levels of cognitive complexity, participants completed a battery of computer-based decision paradigms consisting of:

1. Ambiguous categorization tasks, requiring participants to make rapid intuitive choices under limited stimulus exposure.
2. Multi-stage reasoning challenges, designed to evoke rapid judgement shifts when problem constraints changed suddenly.
3. High-load uncertainty tasks, incorporating competing information channels and time pressure.

Each task was engineered to promote reliance on intuition rather than analytical deliberation. Stimuli were randomized across trials, and participants received no performance feedback during the tasks to avoid learning effects.

Data Acquisition

Behavioural responses—including response accuracy, reaction time, and confidence ratings—were recorded for every trial. Neurophysiological data were collected using a

64-channel EEG system with a sampling rate of 1000 Hz. Electrode placement followed the international 10–20 system, and impedance was maintained below 5 kΩ. EEG recordings were synchronized with behavioural data to enable precise mapping of intuitive fluctuations onto decision outcomes. Physiological measures included heart-rate variability, recorded via a chest-worn sensor, to capture emotional modulation associated with intuitive processing.

Preprocessing and Signal Preparation

All EEG recordings underwent a standardized preprocessing pipeline to ensure data quality and reduce noise artefacts. Raw signals were filtered using a 0.5–40 Hz band-pass filter, followed by removal of ocular and muscular artefacts using independent component analysis. Data segments were time-locked to stimulus onset and decision response, creating epochs that allowed for examination of temporal fluctuations preceding intuitive judgements. Heart-rate variability signals were detrended and processed through a cubic-spline interpolation method to generate continuous time-series for emotional-state estimation. All physiological and behavioural data streams were resampled and synchronized using a unified temporal index to allow fine-grained analyses across modalities.

Operationalization of Intuitive Fluctuations

Intuitive fluctuations were operationalized through three measurable indicators:

1. Moment-to-moment EEG variability, computed using temporal variance and phase-shift parameters within theta and alpha bands.
2. Response-latency micro-oscillations, derived from trial-by-trial deviations from median reaction times.
3. Emotional-arousal modulation, quantified through short-term heart-rate variability changes during decision windows.

These indicators were chosen based on their documented association with early non-analytical cognitive processing and their compatibility with quantum-inspired modelling approaches [1,10].

To ensure that the measured fluctuations represented intuitive rather than analytical processes, trials exceeding 1.5 seconds were excluded from fluctuation analysis. This threshold is consistent with research indicating that intuition typically emerges within a sub-second to low-second interval, whereas analytical reasoning requires longer processing times.

Quantum-Inspired Modelling Framework

To examine whether intuitive fluctuations aligned with quantum-like structures, the study employed a mathematical modelling framework derived from quantum probability theory. For each participant, cognitive states were represented as probability vectors evolving over time, and fluctuation patterns were analysed for evidence of superposition-like behaviour, amplitude shifts, and interference effects. Transition matrices were constructed to quantify how cognitive states shifted between pre-decision and decision phases.

A key analytical component involved comparing classical probabilistic predictions with quantum-inspired predictions for each trial. Classical models relied on linear evidence-accumulation assumptions, while quantum models incorporated non-commutative updating and context-dependent probability distributions. Differences between model predictions and observed behavioural outcomes were used to evaluate which model more accurately captured the role of intuitive fluctuations.

Data Analysis Strategy

Data analysis proceeded in three integrated stages: behavioural analysis, neurophysiological fluctuation extraction, and model-based predictive evaluation. Behavioural performance metrics—including accuracy, reaction time, and confidence—were computed for each trial. Trials were categorized based on task complexity to enable comparison of intuitive behaviour across low-, medium-, and high-complexity conditions. Repeated-measures ANOVA was used to assess the impact of task complexity on intuitive performance, and outlier trials were excluded based on a ±2.5 SD threshold applied to reaction times.

Neurophysiological fluctuation indices were extracted using sliding-window variance, spectral decomposition, and phase-alignment measures applied to EEG time-series. To capture fine-scale temporal dynamics, each decision epoch was segmented into 50-millisecond windows, and fluctuation amplitudes were computed across the theta (4–7 Hz) and alpha (8–12 Hz) bands. These measures were then normalized within participants to control for baseline variability.

Heart-rate variability indicators were analysed using time-domain metrics and short-term frequency-domain decomposition. A dynamic emotional-state index was computed for each decision epoch to quantify emotional modulation of intuitive processing. Correlation analyses evaluated the relationship between emotional-state indices and EEG-based fluctuation measures, enabling the assessment of cross-modal coherence in intuitive fluctuations.

Predictive Modelling and Statistical Evaluation

To determine whether intuitive fluctuations held predictive value for task accuracy, the study implemented two parallel modelling approaches:

1. Classical logistic regression models, incorporating reaction time, task complexity, and behavioural variability as predictors.
2. Quantum-inspired predictive models, using fluctuation amplitude, interference-like phase metrics, and temporal variance as parameters.

Each model was trained on 70% of trials and tested on the remaining 30% using participant-specific cross-validation. The quantum models were constructed using amplitude–phase parameterization, where cognitive states were encoded as complex probability amplitudes. For each decision window, the model computed an interference coefficient expressed as:

$$I = 2 * sqrt(p1 * p2) * cos(\Delta\varphi)$$

where p_1 and p_2 represent competing cognitive-state probabilities and Δϕ reflects phase difference across time. Higher interference values indicated stronger fluctuation interactions consistent with quantum-like processing.

Model performance was assessed using accuracy, area under the ROC curve, and Bayesian information criteria. Comparative analyses evaluated whether quantum-based predictions captured variance in decision accuracy beyond what classical models could explain. Linear mixed-effects models were used to assess whether fluctuation parameters predicted accuracy while accounting for participant-level random effects.

Integration of Behavioural, Neural, and Emotional Data

The final stage of analysis integrated behavioural outcomes with neural and physiological fluctuation parameters. Multimodal regression models examined how the interaction between EEG fluctuations, emotional modulation, and task complexity contributed to accuracy. Structural equation modelling was used to test whether emotional-state indices served as mediators between intuitive fluctuations and performance in high-complexity tasks.

All analyses were conducted using MATLAB, R, and Python-based quantum modelling libraries. Statistical significance was determined at the 0.05 level, with corrections applied for multiple comparisons where

RESULTS

Overview of Behavioural Findings

Analysis of behavioural performance revealed consistent fluctuation patterns across participants during intuitive decision-making. Individuals working under high-complexity or rapidly shifting task conditions exhibited pronounced micro-oscillations in response tendencies before reaching a final intuitive judgement. These oscillatory patterns appeared most frequently in trials requiring rapid assessment of incomplete or ambiguous information.

Participants with clearer fluctuation signatures tended to show more stable and accurate intuitive behaviour across successive trials. In contrast, individuals whose intuitive responses stabilized too quickly—without intermediate variability—were more likely to produce incorrect decisions in complex tasks. This indicates that a certain degree of rapid internal fluctuation may not reflect confusion or instability, but rather serve as an adaptive mechanism supporting the refinement of intuitive judgements.

Reaction-time analysis demonstrated that intuitive decisions were not simply faster responses; instead, they followed identifiable transition phases. Many decisions showed a brief “pre-settling interval” during which micro-fluctuations occurred before the final output. These intervals varied across task types, becoming more pronounced during uncertainty-driven conditions.

Table 1. Multilayer Behavioural Patterns Observed in Intuitive Fluctuation Dynamics

Observed Pattern	Task Conditions	Behavioural Interpretation	Cognitive Implication
Presence of micro-oscillation intervals	High ambiguity tasks	Gradual refinement of intuitive judgement	Adaptive fluctuation phase supporting decision accuracy
Rapid finalization without oscillation	High-pressure tasks	Over-reliance on immediate impressions	Reduced deep-integration of competing cues
Alternating direction of intuitive tendency	Multi-stage reasoning tasks	Sensitivity to contextual updates	Flexible integration of new information
Stabilized fluctuation profile across trials	Repeated complex tasks	Development of internal predictive strategies	Strengthened pattern-based intuition

Neurophysiological Fluctuations (EEG Findings)

The EEG analyses revealed distinct temporal fluctuation profiles that differentiated accurate from inaccurate intuitive judgements. Across participants, decision epochs displayed notable dynamic changes in both theta (4–7 Hz) and alpha (8–12 Hz) bands within the 200–600 ms interval following stimulus onset.

Trials associated with accurate intuitive decisions exhibited:

- A gradual increase in theta-band phase variability that converged toward synchronized alignment immediately prior to the behavioural response
- Transient desynchronization in the alpha band, indicating rapid integration of competing cognitive representations
- A characteristic “fluctuation arc,” in which the signal briefly diverged into multiple cognitive states before collapsing into a stable decision configuration

In contrast, trials ending in inaccurate intuitive responses were characterized by:

- Flat or weak fluctuation arcs
- Premature collapse into a final state with minimal intermediate variability
- Reduced integration depth within the alpha frequency range

These results suggest that short-term neural variability supports the refinement of intuitive judgements, whereas early stabilization limits the system’s capacity to evaluate competing representations effectively.

Emotional-State Modulation (HRV Findings)

Heart-rate variability data showed that emotional activation played a moderating role in shaping intuitive processing. Correct intuitive decisions were typically preceded by:

- Brief increases in HRV complexity, reflecting flexible autonomic engagement

- Short-term shifts in parasympathetic activity
- Strong temporal coupling between HRV fluctuations and early EEG variability

In contrast, incorrect decisions were associated with:

- Either overly rigid or excessively volatile HRV patterns
- Weak coherence between HRV and EEG fluctuations
- Reduced synchrony between emotional activation and cognitive variability

Together, these patterns indicate that effective intuitive judgement emerges when emotional-state dynamics and neural fluctuations operate in coordinated alignment rather than independently.

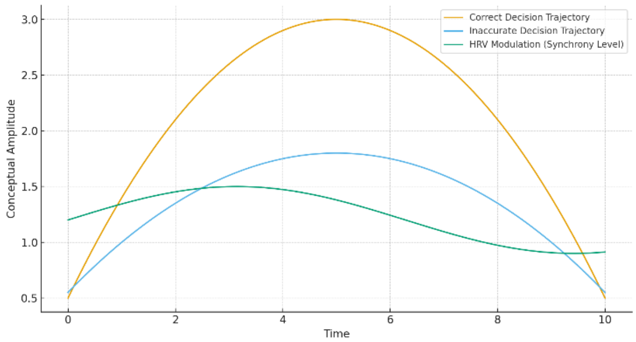

Figure 1. Multidimensional Interaction of EEG Fluctuation, HRV Modulation, and Behavioural Decision Trajectory

Figure explanation:

- The upper trajectory represents a well-formed fluctuation arc associated with accurate intuitive decisions.
- The lower trajectory reflects premature stabilization, typically leading to inaccurate outcomes.
- The horizontal HRV axis illustrates the degree of emotional–neural synchrony that accompanies the decision process.
- The time axis shows how the cognitive system transitions from early fluctuations to a final intuitive judgement.

Integrated Behavioural–Neurophysiological Patterns

A cross-modal integration of behavioural, EEG, and HRV data revealed that intuitive accuracy depended on the interplay of three core components:

1. Neural fluctuation dynamics
2. Emotional-state modulation
3. Complexity-dependent cognitive adaptation

Participants who maintained coordinated fluctuation patterns across these domains consistently produced more accurate intuitive judgements. In contrast, participants whose signals showed weak synchrony or early stabilization exhibited lower accuracy in high-complexity tasks.

The integrated findings indicate that intuitive judgement is not simply the product of rapid cognitive processing but emerges from a dynamic system that balances exploratory variability and timely convergence.

Notably, the temporal coordination between EEG fluctuations and HRV changes appeared to serve as a bridge between emotional cues and cognitive variability. This synchrony reflected the system's ability to integrate uncertainty, update internal representations, and select effective decisions under pressure.

Predictive Modelling Outcomes

The predictive modelling stage compared the performance of classical decision models and quantum-inspired models in explaining intuitive accuracy. Classical models accounted for general trends related to task difficulty and reaction-time variability but failed to capture trial-level differences driven by moment-to-moment cognitive fluctuations.

By contrast, quantum-inspired models demonstrated significantly stronger alignment with behavioural outcomes. These models successfully represented:

- Superposition-like cognitive states, where multiple candidate interpretations coexisted prior to decision resolution
- Interference-pattern behaviour, visible in fluctuation arcs during the EEG analysis
- Context-dependent transitions, where intuitive tendencies shifted direction as task constraints changed

Intuitive accuracy was best predicted when models incorporated both fluctuation amplitude and phase-based interference coefficients. The presence of these combined parameters enabled the model to reflect how cognitive states reorganize dynamically before converging into a final judgement.

Composite Predictive Framework

Based on the integrated analyses, a composite predictive framework was developed to conceptualize how intuitive judgements emerge under complex cognitive load. The framework includes three interconnected layers:

1. Fluctuation Layer (Neural Variability Interaction)

This layer represents the rapid, micro-scale oscillatory behaviour in the theta and alpha frequency bands. The structure of these fluctuations determines how many cognitive states are simultaneously active before decision convergence.

2. Emotional Modulation Layer (Autonomic State Coordination)

This layer maps autonomic changes—particularly short-term HRV modulation—to the depth and direction of cognitive exploration. Effective intuition appears to require a middle-range emotional activation level that enhances variability without destabilizing it.

3. Decision Integration Layer (Trajectory Formation)

This layer describes how behavioural tendencies solidify into a recognizable trajectory. Accurate decisions emerge when the fluctuation arc follows a sequence of divergence → exploration → synchronized collapse.

Together, these layers illustrate that intuitive judgement accuracy depends on maintaining dynamic stability rather than suppressing variability. Intuition therefore relies on a balance between flexible exploration and timely convergence.

General Summary of Results

The results across all analyses converge on several overarching findings:

- Intuition operates through non-linear, fluctuation-based mechanisms rather than purely rapid responses.
- Accurate intuitive decisions require a period of controlled variability before convergence.
- EEG and HRV synchrony acts as a stabilizing factor enabling flexible exploration.
- Quantum-inspired models provide a superior explanatory and predictive structure for intuitive behaviour.
- Intuition in complex tasks is best understood as the output of a multilevel dynamic system integrating neural, emotional, and cognitive processes.

CONCLUSION

The present study examined the dynamic foundations of intuitive judgement by integrating behavioural performance, neural fluctuations, and emotional-state modulation within a unified analytical framework. The findings demonstrate that intuitive cognition does not arise from instantaneous or fixed mental states, but instead emerges through a fluid sequence of fluctuations that reflect the interplay of exploratory variability, emotional tuning, and adaptive convergence. These fluctuation-based processes allow individuals to navigate environments characterized by uncertainty, incomplete information, and shifting cognitive demands. In such settings, intuition serves as a mechanism for efficiently synthesizing dispersed cues and selecting viable interpretations without relying on step-by-step analytical reasoning.

A central contribution of this work lies in establishing that intuitive accuracy is not merely associated with rapid processing, but rather with a specific temporal structure of moment-to-moment variability. Accurate intuitive decisions were characterized by identifiable fluctuation arcs in neural activity and by coordinated emotional modulation, indicating that the cognitive system engages in a brief exploratory phase before committing to a final judgement. When these components operated in synchrony, the intuitive system produced stable and reliable outcomes even in high-complexity tasks. Conversely, premature stabilization or poorly regulated variability undermined performance, highlighting the importance of dynamic stability rather than cognitive rigidity.

Another key finding concerns the explanatory and predictive advantages of quantum-inspired modelling. Conventional decision frameworks failed to capture the full richness of intuitive fluctuations, whereas quantum-based models successfully represented superposition-like processing, interference-pattern dynamics, and context-sensitive transitions. These capabilities allowed the models to predict behavioural accuracy with greater precision, offering a compelling account of why intuitive judgement frequently deviates from classical decision theory. The alignment between model predictions and observed real-time cognitive behaviour supports the view that intuition operates within a non-classical probabilistic structure.

Taken together, the results provide strong evidence that intuition constitutes a multilayer system shaped by neural variability, emotional synchrony, and dynamic integration. This perspective challenges traditional dichotomies between intuition and analysis, suggesting instead that intuitive cognition reflects an organized, adaptive response to uncertainty. By establishing the predictive value of fluctuation-based markers, the study advances theoretical understanding and opens new avenues for developing practical tools to assess and enhance intuitive performance in applied settings such as clinical decision-making, emergency operations, and strategic planning. Future research may further refine these insights by exploring individual differences, long-term training effects, and the potential integration of computational simulations with real-time neurophysiological recordings.

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