Quantum Cognition Models for Decision-Making Under Uncertainty

Ada Öztürkmen
Hisar Schools

***Abstract*—Classical models of decision-making under uncertainty, grounded in expected utility theory and Bayesian probability, often fail to account for systematic cognitive anomalies such as preference reversals, order effects, ambiguity aversion, and context-dependent choices. Quantum cognition models offer a novel theoretical framework that applies the mathematical principles of quantum probability—such as superposition, interference, and non-commutativity—to cognitive processes without assuming physical quantum mechanisms in the brain. By representing cognitive states as probabilistic superpositions that collapse through decision "measurements," these models provide parsimonious explanations for violations of classical rationality. This paper examines how quantum cognition frameworks capture contextual influence, belief updating, and interference effects in uncertain decision environments. Drawing on findings from cognitive psychology and behavioral economics, the study highlights the relevance of quantum cognition for applications in economic choice modeling, legal decision analysis, and artificial intelligence. The analysis suggests that quantum probability offers a robust alternative to classical approaches when modeling human decision-making in complex, ambiguous, and context-sensitive situations.**

Decision-making under uncertainty is a foundational problem across psychology, economics, law, and artificial intelligence, as individuals are frequently required to make judgments with incomplete, ambiguous, or conflicting information [9]. Classical decision theories, including expected utility theory and Bayesian inference, assume that decision-makers hold stable preferences and evaluate outcomes using coherent and context-independent probability distributions. These models have long served as the normative benchmark for rational choice and have influenced policy design, economic modeling, and computational decision systems [5]. However, extensive empirical evidence from behavioral research has demonstrated persistent and systematic deviations from these assumptions in real-world human behavior.

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Studies in cognitive psychology and behavioral economics have documented phenomena such as framing effects, order dependence, ambiguity aversion, and preference reversals, all of which challenge the explanatory power of classical probabilistic frameworks [2]. For example, individuals often change their preferences when identical information is presented in different sequences or contextual settings, violating the law of total probability and the sure-thing principle [1]. Such findings suggest that human cognition does not operate through fixed probability distributions but instead reflects dynamic belief states that evolve in response to context, memory, and attention. As a result, classical models, while mathematically consistent, struggle to account for the fluid and context-sensitive nature of human judgment under uncertainty.

In response to these limitations, quantum cognition

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