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The Impact of Superposition Principle on Human Cognition: A Scoping Review

Sarath C Jayadevan[1], Neha Gupta[2], Anjani K M[3]

[1]Research Scholar, Department of Psychology, IIT Bhubaneswar
[2]Research Scholar, Department of Psychology, CMR University, Bangalore
[3]UG Student, Department of Social Science, IGNOU, New Delhi

Abstract

The research tries to explore how the superposition principle from quantum mechanics can be applied to understand human cognition. It aims to identify the potential application and implications of this principle in fields such as psychology, education and mental health and also seeks to challenge traditional cognitive models and open up new research paths, ultimately it hopes to help us understand more about how people think and behave. The methodology of this research involved establishing a research team of 3 individuals, who are experts in psychology, research and data synthesis to move forward with the study. They then created the research question and selected online databases like ResearchGate, PubMed, and Google Scholar and used keywords like "superposition principle" and "human cognition". The researchers screened and selected relevant studies, analysed the data systematically and applied a structural approach to make sure it was accurate and reliable. The method aims to capture the most current literature and minimize biases in the research process. The Impact of Superposition Principle on Human Cognition examines how the superposition principle from quantum mechanics challenges traditional cognitive models, providing new frameworks for research in psychology and related fields. It suggests that this principle not only introduces non-linear probabilistic models to better reflect the dynamic nature of human cognition but also shows the areas for practical application, such as decision-making under uncertainty and mental health research.

Keywords: Decision Making, Superposition Principle, Human Cognition, Cognitive Science, Quantum Mechanics, Psychology.

Introduction

"Even though emotions, or feelings, are the most significant events in our lives, there has been relatively little contact between theories of emotions and emerging theories of consciousness in cognitive science," (LeDoux, et al., 2017)[1]. Expanding the sensation-perception model based on quantum information theory aims to formalize this connection within a quantum-like framework for cognition (Khrennikov, 2015)[2].

Human cognition has long fascinated researchers, leading to extensive studies aimed at understanding and enhancing cognitive processes. Recently, the intersection of quantum mechanics and cognitive science has emerged as a promising field of inquiry. Central to this interdisciplinary approach is the Principle of Superposition, a key concept in quantum mechanics that suggests particles exist in multiple states simultaneously until they are measured or observed (Marshall, 2013)[3]. Applying the Principle of

Superposition to cognitive phenomena offers a unique framework that challenges the classical deterministic view of cognition. It proposes that mental states can exist in multiple dimensions at once, reflecting the uncertainties and complexities inherent in human thought processes. This paradigm shift could have profound implications for psychology, neuroscience, and educational psychology, offering new perspectives on the structure and function of cognitive processes.

The principle of superposition is a foundational concept in both classical and quantum physics, playing a crucial role in the understanding and application of wave phenomena and the behavior of quantum systems. In classical physics, particularly in the context of wave theory, the principle states that when two or more waves overlap in space, the resultant wave displacement at any point is the algebraic sum of the displacements of the individual waves. This principle explains a wide range of phenomena, from the interference patterns seen in light and sound waves to the behavior of mechanical waves on strings and surfaces (Saleh G, 2024)[4]. In quantum mechanics, the principle of superposition is even more profound. It asserts that any quantum state can be represented as a linear combination of other distinct states. This concept is pivotal for understanding the behavior of particles at the quantum level, leading to phenomena such as quantum interference and entanglement. For instance, the superposition principle allows a particle, such as an electron, to exist in multiple states or locations simultaneously until measured, which is a fundamental departure from classical deterministic views (Aiello C D, 2023)[5].

The challenge of correctly interpreting a quantum state, typically represented by a wave function, remains one of the most perplexing issues in the foundations of quantum mechanics. Currently, there is a vast array of interpretations, which some view as indicative of a fundamental crisis in the field. This issue also arises when applying quantum mechanics (QM) to new scientific domains. Broadly speaking, QM interpretations fall into two main categories: (a) the quantum state is seen as the physical state of an individual system, or (b) the quantum state is regarded as a unique (probabilistic) representation of information about potential measurement outcomes on an ensemble of identically prepared systems. The first approach is often termed the physical interpretation, while the second is known as the informational interpretation. The latter has gained significant traction in quantum information theory, giving rise to more subjective interpretations of quantum states, such as quantum Bayesianism by Fuchs and the informal interpretations by Zeilinger and Brukner, which align with the principles of quantum-like cognition (Fuch, 2010; Zeilinger, 2010; Brukner, 2010).[6,7,8].

Human cognition, the intricate interaction of mental processes that enables perception, memory, reasoning, and problem-solving, has intrigued scholars for centuries. The 21st century has witnessed significant progress in understanding these cognitive functions, thanks to interdisciplinary approaches that include psychology, neuroscience, artificial intelligence, and cognitive science. A critical factor in these advancements is the emergence of advanced neuro imaging techniques like functional magnetic resonance imaging (fMRI) and positron emission tomography (PET), which have enabled researchers to observe brain activity in real time. These technologies have illuminated how various brain regions contribute to cognitive functions, uncovering the neural bases of memory, attention, and decision-making. Additionally, the merging of cognitive psychology with computational models has produced theories that more accurately describe how the brain processes information. For example, the predictive coding theory suggests that the brain continuously creates and updates a mental model of the environment based on sensory input, predicting future events. This theory highlights the brain's role as an active interpreter of

sensory data, rather than merely a passive receiver, fundamentally reshaping our understanding of perception and cognition (Antonello R, et al., 2024)[9].

The burgeoning area of research at the intersection of human cognition and quantum mechanics has sparked intriguing discussions among theorists. The proposition that principles from quantum mechanics could potentially influence cognitive processes opens up a realm of possibilities that, if substantiated, could significantly transform both fields. This speculative yet captivating idea suggests a profound connection between the everyday human experience in the macroscopic world and the intricate phenomena of quantum physics in the microscopic realm. This Scoping Review aims to delve into the exploration of how the Principle of Superposition, a fundamental concept in quantum mechanics, can be harnessed to enhance the understanding of human cognitive processes and functions. Through an interdisciplinary lens, this research seeks to unveil how principles borrowed from quantum mechanics can illuminate the landscape of cognitive science and psychology, offering insights into theoretical frameworks and practical applications.

Rationale

The superposition principle, a cornerstone of quantum mechanics, asserts that a physical system can exist in multiple states at the same time until being measured. The principle of quantum superposition, fundamental in quantum mechanics, suggests that a system can simultaneously occupy multiple states until observation collapses it into one. When applied to cognitive science, this principle provides a novel framework for understanding the complexities of human thought and decision-making processes (Aerts D., et al., 2015)[10]. This scoping review aims to investigate the potential applications and implications of the superposition principle in the context of human cognition. It seeks to identify current research trends and literature gaps and propose directions for future research in this area.

The intersection of quantum mechanics and cognitive science represents a burgeoning field that integrates principles from physics into psychological and cognitive models. Traditional cognitive theories have often been limited by linear and deterministic frameworks. The incorporation of the superposition principle introduces the possibility of non-linear, probabilistic models that can more accurately reflect the dynamic and often ambiguous nature of human cognition. Interdisciplinary approaches can offer novel insights into the complexities of human thought processes, potentially leading to groundbreaking theoretical and practical advancements. Enhanced Understanding of Psychological Phenomena: Many psychological phenomena, such as decision-making under uncertainty, emotional variability, and mental health disorders, may benefit from a quantum perspective. Understanding these phenomena through the lens of superposition could lead to more effective therapeutic strategies and interventions.

Insights from the superposition principle can also impact educational psychology by informing teaching methods that accommodate the probabilistic and multifaceted nature of learning and cognition, potentially leading to more personalized and effective educational practices. The current Scoping Review tries to examine and explore the application and potentiality of the Principle of Superposition in the field of psychology and cognitive science widely.

Objectives

- To examine how the Principle of Superposition could be used in understanding and developing Human Congnition

- To explore the theoretical and empirical research that integrates the Principle of Superposition in the field of Psychology and Cognitive Science.

Method

This scoping review begins with the establishment of a research team consisting of individuals with expertise in psychology and data synthesis. The team advised on the broad research question to be addressed and the overall study protocol, including identification of search terms and selection of databases to search. The methodology for this scoping review is based on the framework outlined by Arksey, et al., (2021)[11] and ensuing recommendations made by Levac, et al., (2010)[12]. The review includes the five key phases as identifying the research question, which defines the central focus of the review. Identifying relevant studies, which is searching relevant databases for potential studies. Study selection, focus on rigorously screening titles, abstracts, and full texts based on pre-determined criteria. Charting the data, which is systematically extracting key information from included studies. Collating, summarizing, and reporting the results summarizes findings thematically using a narrative approach. Regular team meetings ensured consistency throughout the process. The final report findings include overall findings of each article and their future implications are to be mentioned in key findings, and recommendations for future research.

Protocol and Registration

The protocol was registered on Figshare for transparency and to reduce selective reporting risks (https://doi.org/10.6084/m9.figshare.26085553.v1). This registration ensures adherence to predefined methods and allows public scrutiny. Any updates or amendments were documented and justified to accommodate new insights or logistical considerations, maintaining the review's integrity and transparency.

Eligibility Criteria

Inclusion Criteria; Peer-reviewed articles, Conference papers, and Book chapters. Papers in the English language are being considered. Research focusing on the application of the Superposition principle in Psychology or Cognitive Science. Both theoretical and empirical details could be considered.
Exclusion Criteria; Researches outside the domain of human psychology, non-peer-reviewed articles, and studies not available in full text.

Information Sources

A comprehensive search was conducted across PubMed, ResearchGate, and Google Scholar for the scoping review on the superposition principle's influence on human cognition. The search strategy used both controlled vocabulary (e.g., MeSH terms) and free-text terms, including “superposition principle”, “quantum cognition”, “human cognition”, and “quantum mechanics”. References from relevant articles were also manually reviewed to ensure thoroughness.

Search

The searches and exploration on the topic are expected to start on May 19, 2024 and conclude by August 20, 2024. The databases to be covered include ResearchGate, Google Scholar and PubMed.

Keywords: Superposition and Psychology, Superposition and Emotion, Quantum Mind.

Selection of Sources of Evidence

The researchers referred to three different online databases: PubMed, Research Gate, and Google Scholar. These databases were selected due to their comprehensive coverage of scientific literature, ease of access, and relevance to the research topics. PubMed was chosen for its extensive repository of biomedical and life sciences research. ResearchGate was included for its active academic community and access to preprints and unpublished work, which can provide the latest research findings. Google Scholar was used for its broad indexing of academic articles across various disciplines, ensuring no relevant studies were overlooked.

Data Items

The data items to be extracted from each selected article will include study identification details, such as Study Title, Authors, Year of Publication, Journal/Source, and DOI/URL. The second part of the data items will include Study Characteristics, such as Type of Study/Design, Theoretical Framework, and Study Setting. The third part will cover Participants/Subjects, including Population, Sample Size, and Inclusion and Exclusion Criteria. The fourth part of the data items to be extracted will involve the Intervention/Phenomena of Interest, including the Description of Phenomena/Intervention and the Concept being Studied. The fifth part will focus on Outcome Measures, consisting of Primary Outcome and Secondary Outcome. The sixth part will detail the Methodology, covering the Data Collection Method and Data Analysis Method. The seventh part will summarize the Key Findings, including Main Findings and Implications. The eighth part will assess Quality, including Bias Assessment and Study Limitations. The ninth part will synthesize evidence, comparing Findings, Patterns/Themes, and contradictions.

Critical Appraisal of Individual Sources of Evidence

To ensure the robustness and reliability of the included studies, each selected article underwent a critical appraisal process. The appraisal criteria were adapted from established quality assessment tools relevant to both quantitative and qualitative research designs. Key elements assessed included the clarity of research objectives, appropriateness of methodology, rigor in data collection and analysis, consideration of biases, and validity of conclusions. Two independent reviewers conducted the appraisal, and any discrepancies were resolved through discussion or consultation with a third reviewer if necessary.

Synthesis of Results

In synthesizing the results of the scoping review, the team employs the Population, Concept, and Context (PCC) framework to ensure a structured and comprehensive analysis. Data are extracted using a standardized form to capture essential study characteristics, then categorized and coded based on the PCC framework. The data is to be sorted based on the standard data items proposed and the common factors and specific components could be categorised for the evaluation.

Results

The following portion involves Data Synthesis from Google Scholar, PubMed and ResearchGate. We analyzed the data thematically to uncover recurring patterns and ideas about how the superposition

principle might affect human thinking. A standardized form ensured consistent data extraction from the included studies. The flowchart and tables provide a clear overview of the findings.

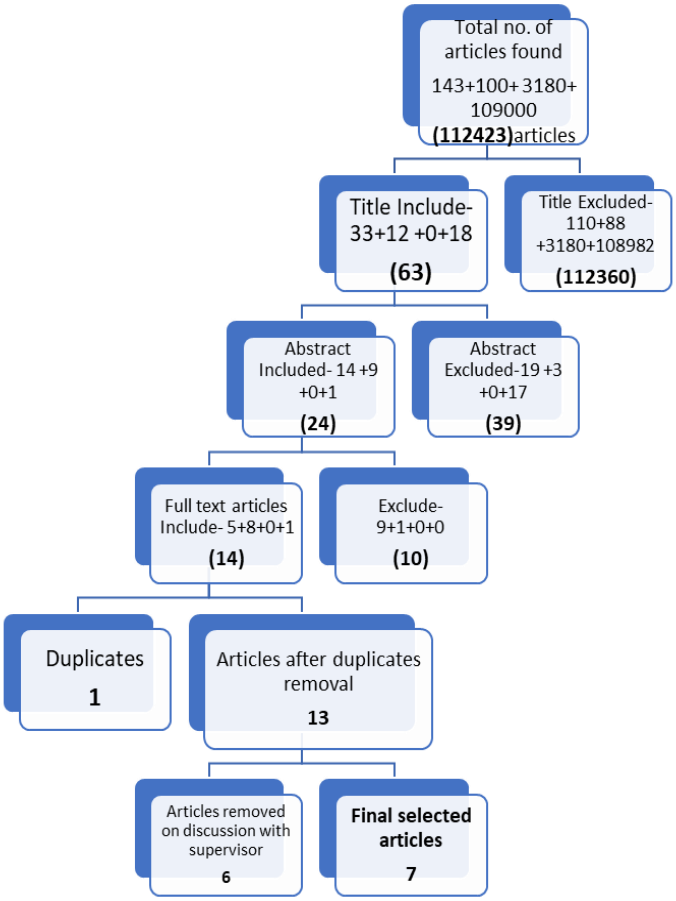


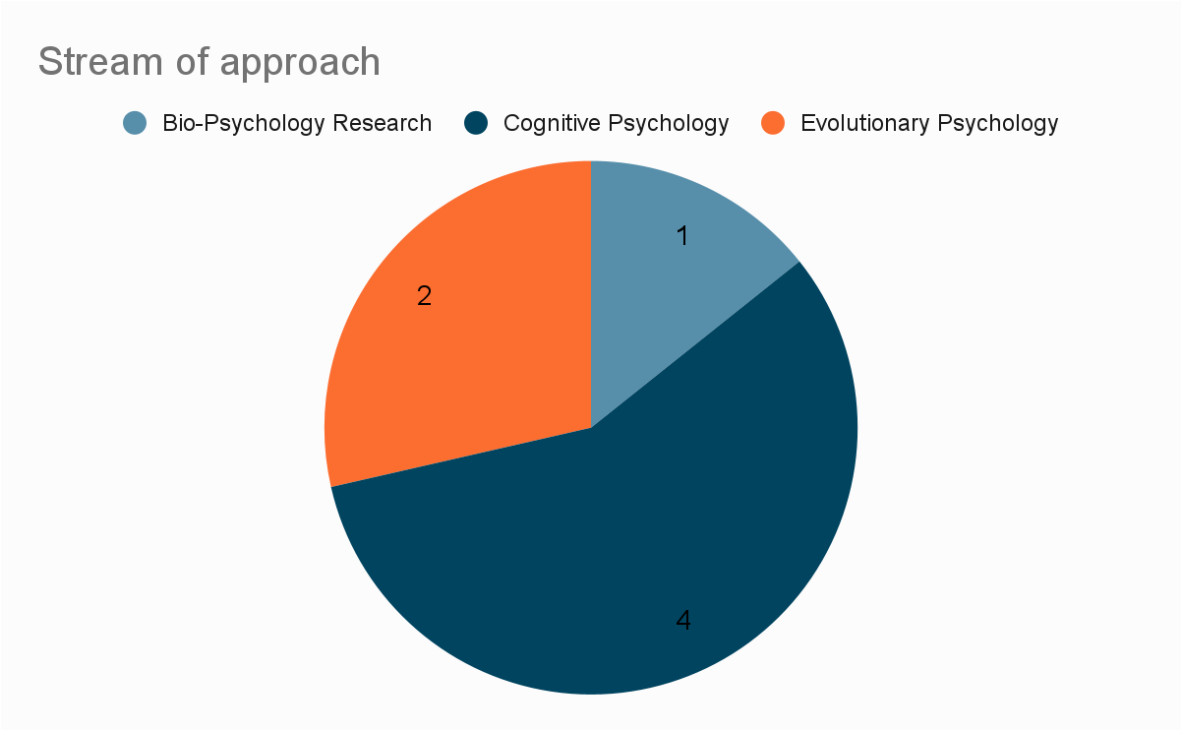
Fig 1.1 PRISMA flow chart

The flowchart in this scoping review visually represents the systematic process of selecting relevant articles. Initially, keyword searches across multiple databases yielded 112,423 articles. The first step involved reviewing the titles of all these articles, narrowing the selection down to 63. The second selection criterion, based on abstracts, further reduced the number to 24 articles. These were then filtered to include only fully downloadable articles, resulting in 14 articles. Applying inclusion and exclusion criteria and eliminating duplicates reduced this number by one. The remaining shortlisted articles, totaling six, were reviewed with a supervisor, ultimately leading to the final selection of seven articles. This flowchart highlights the rigorous and systematic approach taken to ensure the inclusion of the most relevant and high-quality studies in the review. This flowchart shows the careful screening and selection process used to include only the most relevant and high-quality studies. The findings reveal that from a large initial pool of articles, a systematic review process narrowed it down to a small, targeted set of studies that met all criteria. This ensures the final review is thorough and pertinent.

Table 1.1: Study Identification Details					
S.No.	**Authors**	**Title of the Study**	**Year of Publication**	**Journal/Source**	**DOI/URL**
1.	Domuschiev, I.	Psychophysiological coherence and consciousness through the eyes of quantum theory.	May 2024	RUDN Journal of Philosophy.	DOI: 10.13140/RG.2.2.12460.07042
2.	Bhattacharj, A., & Mukherjee, J.	A Critical Deconstruction of Quantum Cognition and Usability in Psychology	November 2023	Atlantis Press	DOI 10.2991/978-94-6463-294-1_3
3.	Yu, S.	Evolutionary Psychology: Perspectives on Free Will	2021	Society	DOI: 10.54254/2753-7048/46/20230886
4.	Khrennikov, A., Basieva, I., Pothos, E. M., & Yamato, I.	Quantum probability in decision making from quantum information representation of neuronal states	2018	Scientific Reports	doi: 10.1038/s41598-018-34531-3.PMID: 30385809
5.	Kvam,P.D., Pleskac,I.J.,Yu,S., & Busemeyer, J.R.,	Interference effects of choices on confidence:Quantum characteristics of evidence accumulation	Aug, 2015	Proceedings of the National Academy of Sciences of the United States of America (PNAS)	https://doi.org/10.1073/pnas.1500688112

6.	Busemeyer,.J. R., & Wang,Z.	What is Quantum Cognition and How is it Applied to Psychology	2015	Association psychological science	DOI 10.1177/0963721414568663
7.	Pothos,E.M., & Busemeyer,J. R.	Quantum principles in psychology:the debate,the evidence,and the future.	2013	City Research Online	doi: 10.1017/s0140525x12003226

Figure 1.2: Focused Schools In Psychology



The table 1.1 detailing the Study Identification Details includes the following headings: Authors, Title of the Study, Year of Publication, Journal/Source, and DOI/URL. This table provides a clear and organized overview of the key identification information for each study included in the review. The "Authors" column lists the researchers who conducted the study, allowing for recognition of their contributions. The "Title of the Study" column provides the specific titles, enabling easy reference to the focus of each study. The "Year of Publication" column indicates when the studies were published, providing context regarding the recency and relevance of the research. The "Journal/Source" column identifies where the studies were published, highlighting the credibility and dissemination channels of the research. Lastly, the "DOI/URL"

column offers direct access to the digital versions of the studies, facilitating further reading and verification. Observing these details allows for a comprehensive understanding of the origins and accessibility of the included studies, ensuring transparency and traceability in the review process. Out of the 7 finally selected articles, 4 articles were found to give a major focus in the school of Cognitive psychology, 2 articles were found to focus in the area of Biopsychology and 1 article in the area of environmental psychology. Fig1.2 divides the studies into three main categories: Biopsychology, Cognitive psychology, and Evolutionary psychology. The figure indicates that the first study is classified under biopsychology, while studies 2,4,5 and 6 fall into cognitive psychology, which focuses on mental processes, such as perception, memory and reasoning. Additionally, studies 2 and 7 are grouped under evolutionary psychology, examining how evolutionary processes impact human behaviour and mental traits. This classification shows that there is one study in biopsychology, four in cognitive psychology and two in evolutionary psychology. This distribution provides a clear summary of how research is spread across these psychological fields, offering insights into the focus and categorization of various studies within these areas.

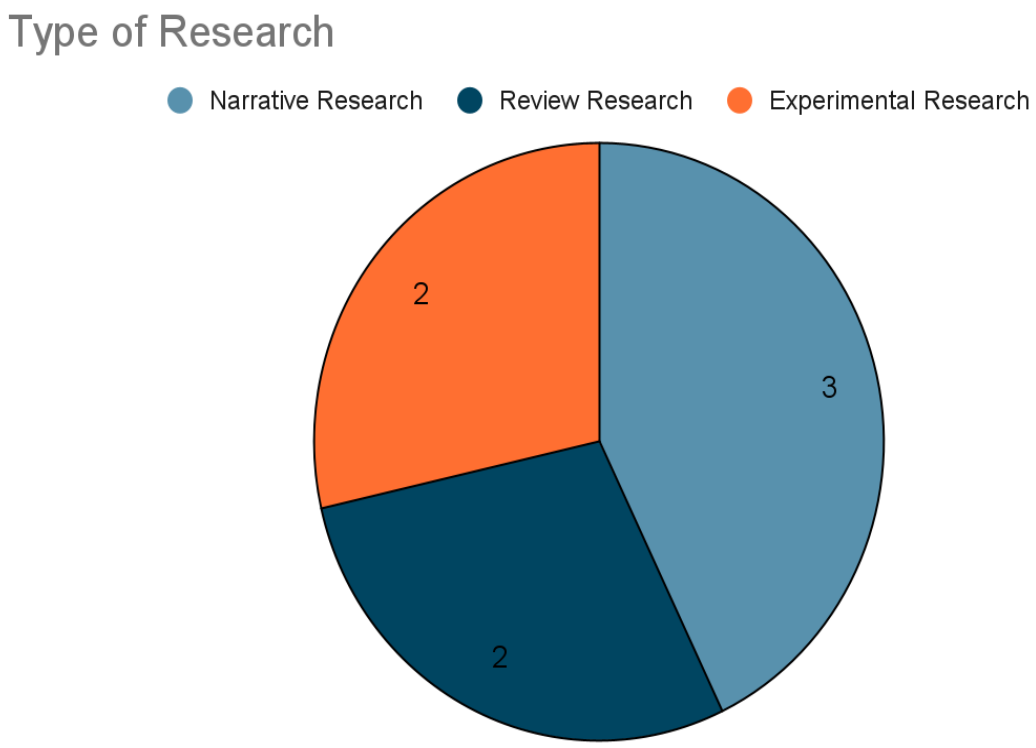
Table 1.2: Study Characteristics

S. No.	Type of Study/Design	Theoretical Framework	Study Setting
1.	The type of study is a psychophysiological coherence study that uses quantum theory to examine consciousness. The study also mentions other works about photonic effects on the human mind and sense datum, and it appears to touch on the theory of generalized relativity.	This study's theoretical framework investigates quantum phenomena in the human body, psychophysiological coherence, and the possible contributions of quantum biology and psychology to the understanding of consciousness. Further references to human mind-body connection and quantum physics show that this framework's theoretical investigation takes a multidisciplinary approach.	Since the emphasis appears to be on conceptual and theoretical aspects rather than a particular experimental or observational setting is not specifically described in the excerpts that are provided. The investigation of psychophysiological coherence and consciousness within the context of quantum theory seems to be the main focus of the study.
2.	The research is categorized as a review or critical analysis. The research, theories and papers that have already been published are carefully examined and analyzed in this kind of study to determine their merits and demerits as well as their contributions to the field.	The theoretical framework of quantum cognition applies concepts of quantum theory like complementarity and superposition, to provide a new approach to understanding human cognition in psychology.	The study critically examines a research paper on quantum cognition in psychology, offering a review and assessment of the existing literature and arguments.

	The study's design is qualitative.		
3.	The study described in the document is mainly a theoretical and conceptual exploration at the crossroads of evolutionary psychology and philosophy, examining decision-making processes and the likelihood of free will from an evolutionary standpoint.	The theoretical framework outlined in the document merges principles of evolutionary psychology with philosophical ideas to investigate decision-making processes and free will. It seeks to combine these perspectives to examine how evolved cognitive systems interact with concepts of determinism, indeterminism, and compatibilism in understanding the nature of free will.	The study setting described in the document involves a theoretical and conceptual analysis within the domains of evolutionary psychology and philosophy. It examines decision-making processes and free will, concentrating on the intersection of evolutionary principles with philosophical ideas such as determinism, indeterminism, and compatibilism.
4.	Theoretical modelling and analysis of quantum probability in decision-making processes using quantum information representation of neuronal states.	A model inspired by quantum physics to explain how neurons process information in the brain's electrochemical environment.	The main focus is on the theory and the ideas behind creating a model that works like quantum physics.
5.	The study investigates how choices affect subsequent confidence judgments using two models: Quantum Random Walk (QRW) and Markov Random Walk (MRW). It finds that the QRW model, which treats evidence accumulation as a superposition state, better captures the interference effect of choices on confidence compared to the MRW model, which follows classical stochastic principles. This challenges the traditional views on how judgements and decisions are made.	The study's framework compares two models: one based on quantum principles and another following traditional theories. The quantum-based model suggests that decision-making shapes our beliefs, challenging the idea that decisions are solely based on existing evidence.	The study involved asking people to make decisions about moving dots and then rate their confidence in their choices. The researchers looked at how these decisions affected people's confidence. The goal was to understand how making choices influences how confident people are in their judgments.
6.	The design of the study involves exploring how quantum principles can offer	Researchers use quantum theory to explain complex cognitive	The significance of applying quantum theory to psychology and its

	innovative solutions to longstanding problems in psychology.	phenomena that traditional theories struggle to address. It emphasizes the importance of considering quantum phenomena when exploring intricate cognitive processes. The integration of quantum theory into psychology opens up new avenues for research and has the potential to shed light on previously unexplained aspects of human cognition.	promising implications for advancing our understanding of cognitive processes and behaviors.
7.	The research discusses the application of quantum principles in modelling cognition. This work can be classified as a theoretical review paper, combining elements of theoretical psychology, cognitive science, and quantum theory. The authors explore the potential of quantum cognitive models, analyze existing challenges, and propose new conceptual tools to understand cognition. Specifically, the study delves into the debate surrounding the use of quantum principles in psychology, evaluates the evidence supporting quantum cognitive models, and considers the future implications of such an approach. By synthesizing current knowledge and proposing new perspectives, the document contributes to ongoing discussions on the fundamental aspects of cognition, bridging the gap between quantum mechanics and cognitive psychology.	The research explores the potential application of quantum principles to cognitive science, focusing on concepts like the uncertainty principle, incompatibility, entanglement, and superposition. By integrating quantum mechanics with cognitive architectures, the study aims to propose a new theoretical framework for understanding cognitive processes, questioning existing formal frameworks while opening debates about fundamental aspects of cognition.	The research does not explicitly specify any particular study setting, as it primarily addresses theoretical and conceptual aspects rather than experimental or observational settings. The research examines the potential application of quantum principles in modelling cognition and discusses the theoretical implications and challenges associated with this endeavour. Hence, the study setting is more conceptual and theoretical, focusing on proposing and evaluating new ideas rather than conducting empirical observations or experiments in a specific setting.

Figure 1.3: Types Of Research Being Focused.



The table 1.2 detailing the Study Characteristics includes the following headings: Type of Study/Design, Theoretical Framework, and Study Setting. This table provides a comprehensive overview of the foundational elements of each selected study, allowing for a clear comparison and understanding of the research methodologies employed. The "Type of Study/Design" column categorizes the nature and structure of the studies, highlighting whether they are experimental, observational, qualitative, or mixed-methods. The "Theoretical Framework" column provides the basic ideas and theories that support the research, indicating the theoretical perspectives or models applied. The "Study Setting" column specifies the context in which the studies were conducted, including geographical locations, institutional environments, or specific populations. Observing these characteristics enables a systematic interpretation of how different research designs and theoretical approaches are applied across various settings. In Fig 1.3, the researches are categorised into 3 groups: The Narrative Research, The Review Research and Theoretical Research. There are two researches under Review Research, two under the Experimental Research and three under Narrative Research. The researches are categorised after going through type of study, theoretical framework and study setting.

Table 1.3: Participants/Subjects

S. No.	Population	Sample Size	Inclusion Criteria	Exclusion Criteria
1.	N/A	N/A	N/A	N/A
2.	N/A	N/A	N/A	N/A
3.	N/A	N/A	N/A	N/A

4.	N/A	N/A	N/A	N/A
5.	N/A	N/A	N/A	N/A
6.	The research uses a large, representative sample from across the U.S., including people from different backgrounds and regions. This approach helps researchers understand a wide range of cognitive responses and behaviours from various groups of people in the country.	The research includes a large sample size, with over 1,000 participants in most surveys conducted in 70 field experiments using U.S national representative samples. This large number of participants is important for making sure the findings about order effects and interference effects in cognitive judgements are reliable and can be applied more broadly.	The inclusion criteria select individuals who can offer insights into how quantum concepts are applied to psychological processes.	Participants with pre-existing medical conditions or cognitive and those fluent in the language used during the study are considered.
7.	N/A	N/A	N/A	N/A

The table 1.3 detailing Participants/Subjects includes the following headings: Population, Sample Size, Inclusion Criteria, and Exclusion Criteria. This table provides essential information about the study participants. The "Population" column describes the general group of people being studied. The "Sample Size" column indicates the number of participants included in each study, giving an idea of the study's scale. The "Inclusion Criteria" column lists the specific characteristics required for participants to be included in the study, while the "Exclusion Criteria" column outlines the factors that disqualify participants from being part of the study. Observing these details helps to understand the demographic and methodological consistency across the studies, ensuring that the selected articles are relevant and comparable.

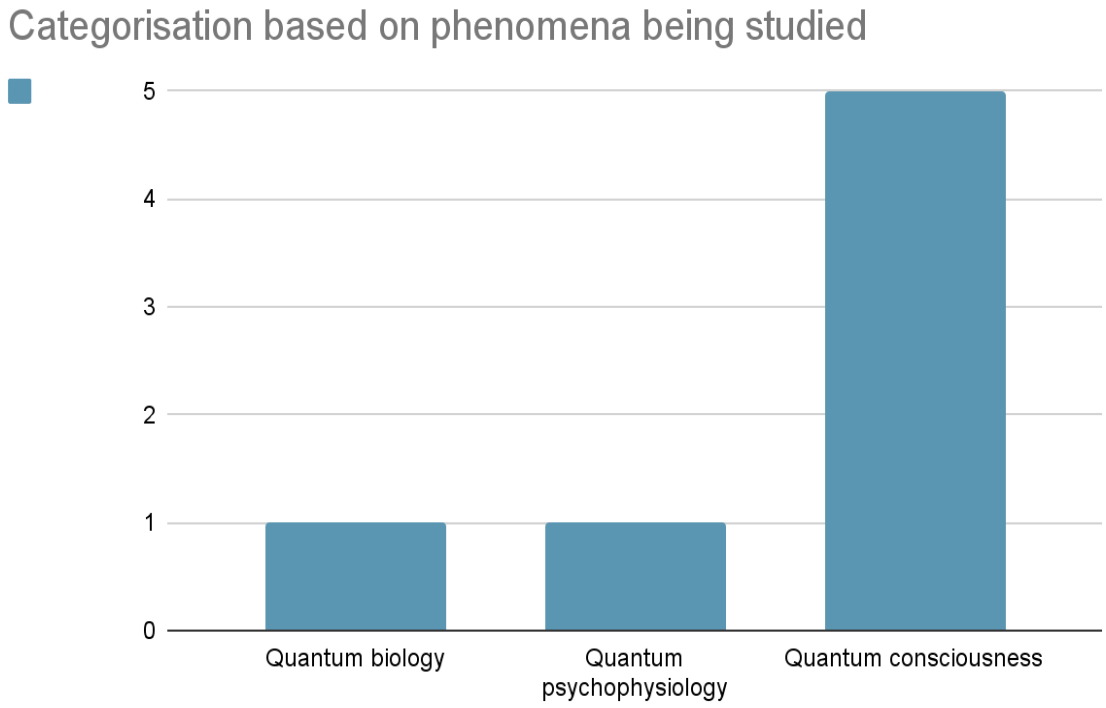
Table 1.4: Intervention/Phenomena of Interest

S. No.	Description of Intervention/ Phenomenon	The Phenomenon/ concept being studied
1.	N/A	The study looks at psychophysiological coherence (PPC), an optimal state where the body's systems, like heart rate variability (HRV), are well-balanced. Researchers are exploring possible connections between PPC and quantum processes in the brain's neurons, which they believe could be the starting point of consciousness. The study also points to new research in quantum biology, psychology, and information science that could help us better understand how consciousness might work through quantum principles.

2.	N/A	This review paper examines a phenomenon known as quantum cognition, which is the application of ideas from quantum theory to the study of intricate psychological cognitive processes. In order to offer a new perspective on human cognition and possible explanations for complex cognitive phenomena observed in psychology, quantum cognition challenges conventional classical models by introducing concepts like superposition and complementarity.
3.	N/A	The study examines the relationship between evolutionary psychology and free will, looking at how evolved cognitive mechanisms affect how decisions are made and how they interact with ideas from philosophy such as compatibilism, determinism, and indeterminism. It seeks to examine how evolutionary theories can shed light on the beginnings and bounds of free will, offering a novel viewpoint on this hotly contested philosophical topic.
4.	The creation of a quantum-like model to explain how neurons process information when making decisions.	Application of quantum-like modelling to comprehend how neurons process information and how people make decisions.
5.	The research primarily discusses contrasting the Quantum Random Walk (QRW) with the Markinov Random Walk (MRW) model in the context of decision-making and confidence judgements. However, it does not explicitly mention any external interventions or specific phenomena beyond the comparison of these models and their implications for understanding human decision-making.	The research investigates how choices affect confidence judgments during decision-making by comparing two models: Quantum Random Walk (QRW) and Markov Random Walk (MRW). It aims to understand the cognitive processes that shape confidence levels after making choices, challenging traditional views of decision-making mechanisms.
6.	Researchers explore how concepts from quantum mechanics can offer new insights into psychological processes. This intervention aims to use quantum cognition to address puzzling findings and challenges in psychology research. The intervention involves designing experiments and tasks inspired by quantum theory to study cognitive phenomena.	The concept being studied is Quantum Cognition, which explores how ideas from quantum mechanics, a branch of physics, can help us understand how people think and make decisions.

7.	N/A	Investigates how quantum principles like uncertainty, entanglement, and superposition can be applied to model cognitive processes, offering new insights that challenge traditional psychological frameworks. It compares classical probability theory with quantum cognitive models to enhance the understanding of cognitive functions and decision-making, emphasizing the unique properties captured by quantum concepts.

Figure 1.4: Areas in quantum cognition being focused.



The table 1.4 detailing the Intervention/Phenomena of Interest includes the following headings: Description of Intervention/Phenomenon and The Phenomenon/Concept being Studied. This table provides a concise overview of the core elements being investigated in each study. The "Description of Intervention/Phenomenon" column outlines what the intervention involves or what phenomenon is being observed, offering insight into the specific actions, treatments, or conditions being examined. The "Phenomenon/Concept being Studied" column specifies the broader idea or concept that the research is focused on, providing context for the intervention or observation. This information helps to understand the focus and scope of each study, allowing for a clearer comparison of the different approaches and areas of interest covered in the review. In Figure 1.4, we categorized the phenomena being studied into three distinct areas: Quantum Psychophysiology, Quantum Biology, and Quantum Consciousness. We identified one study in Quantum Psychophysiology, which explores the intersection of quantum mechanics and physiological processes, investigating quantum mechanisms underpinning psychophysiological responses. Another study falls under Quantum Biology, examining biological processes through the lens

of quantum theory and focusing on phenomena such as entanglement and coherence in biological functions. The majority of the research, with five studies, is categorized under Quantum Consciousness, exploring the potential quantum basis of consciousness, including aspects like quantum coherence in neural processes, the quantum mind hypothesis, and the role of quantum theory in explaining subjective experiences. This categorization underscores the emerging intersections between quantum theory and biological phenomena, highlighting significant contributions to each field and the growing interest in the potential quantum basis of consciousness.

Table 1.5: Outcome Measures

S. No.	Primary Outcome	Secondary Outcome
1.	The primary outcome of the study is not clearly stated. It seems to be more interested in exploring the connection between psychophysiological coherence and quantum phenomena. It talks about how PPC might affect how our bodies work and mentions the need for more research.	The secondary outcome of the study is not clearly mentioned. The focus seems to centre on the theoretical exploration of psychophysiological coherence (PPC) and its potential connections to quantum phenomena and consciousness.
2.	The primary outcome of the study discussed is mainly about analyzing arguments made by Busemeyer and Wang about using quantum principles in psychology. It tries to understand the good and bad parts of using quantum cognition to explain how people think. It also talks about what might happen if we use quantum theory to explain cognitive processes.	The secondary outcome of the study compares how a quantum model and a Markov model predict decisions. The results showed that the ability of quantum models to show interference effects is better, deviating from the classical law of total probability.
3.	The primary outcome of the study focuses on how evolutionary psychology affects the theory of determinism, especially in decision-making. It suggests that our cognitive processes, shaped by natural selection, usually work in a determined way to help us make adaptive choices. However, some unpredictability can occur when these processes interact with different environmental factors.	The study's secondary outcome looks at how unpredictability can arise from the interaction between evolved decision-making processes and changing environments. This adds complexity to the idea that our cognitive processes are purely deterministic, showing that environmental factors can introduce variability into the way we make decisions based on inherited traits from our ancestors.
4.	The primary outcome aims to build a theoretical framework linking how neurons work to quantum-like patterns in decision-making.	It explores how neurons process information in a way similar to quantum mechanics, including how neurotransmitters in the brain's electrochemical environment help create overlapping states of information that neurons handle.
5.	The primary outcome of the research focuses on comparing two models: the Quantum Random	The secondary outcomes may involve the cognitive and neural implications of

	Walk(QRW) and the Markov Random Walk(MRW), to see how they explain the impact of choices on confidence judgements during decision-making. The study looks at how making decisions influences how confident people feel afterwards, challenging conventional ideas about this relationship. The main goal is to understand how these models can help us grasp how decisions affect our confidence levels.	employing the QRW model over the MRW model for evidence accumulation. Specifically, it could look at how well these models describe the processes behind the judgements and decision-making, challenging traditional theories within these fields.
6.	The primary outcome of this study is to investigate how applying quantum principles to psychology, known as quantum cognition, can help address current challenges and puzzles in understanding human thought processes.	The secondary outcome involves creating quantum theory-inspired experiments to observe responses to these tasks. By incorporating quantum tasks and training, researchers aim to uncover unique cognitive behavior patterns, demonstrating the benefits of integrating quantum ideas into psychology and solving mysteries of human cognition.
7.	Examining how the consideration of quantum cognitive models can stimulate debates and discussions about the core elements of cognition, challenging traditional frameworks and opening up new avenues for understanding the workings of the mind	Exploring how quantum cognitive models can address empirical challenges, enhance our understanding of cognitive phenomena, and potentially offer new insights into the complexities of human cognition

The table 1.5 detailing Outcome Measures includes the following headings: Primary Outcome and Secondary Outcome. This table provides crucial information about the results each study aims to achieve. The "Primary Outcome" column identifies the main result that the study is designed to measure, which is the primary focus and most significant indicator of the study's success or impact. The "Secondary Outcome" column lists additional results that are measured, providing further insights and context to the primary findings. Observing these outcomes allows for an understanding of the key objectives and the breadth of results considered in each study, highlighting both the main impacts and additional effects of the interventions or phenomena studied.

Table 1.6: Methodology

S. No.	Data Collection Method	Data Analysis Technique
1.	N/A	N/A
2	The study collected data by running experiments to see how participants made decisions in various situations. Participants were given tasks involving categorization and decision-making, both separately and	The study's data analysis compared predictions from a quantum model with a Markov model in decision-making tasks. Researchers ran experiments and examined participants' responses to assess interference effects and

	together. The researchers then analyzed the responses to compare how well the quantum model's predictions matched up against a classical Markov model, paying attention to interference effects and differences from the classical law of probability.	differences from the classical law of probability, checking how well the quantum model explained the results.
3.	N/A	N/A
4.	N/A	N/A
5.	The data collection method involved experimental tasks in which participants made judgements about the direction of the motion in dynamic dot displays and provided confidence ratings for their decisions. This information was collected using software programs that recorded participant's responses and confidence ratings, enabling the investigation of how choices influenced subsequent confidence judgements. The aim was to compare the Quantum Random Walk (QRW) and Markov Random Walk (MRW) models in explaining these interference effects.	The analysis likely involved comparing how well two different models, the Quantum Random Walk (QRW) and the Markov Random Walk (MRW), explain the impact of choices on confidence judgements. Researchers may have used computer simulation to see how these models performed in understanding how choices affect confidence levels after making decisions. This comparison helps to see which model best fits the observed interference effects on confidence judgements.
6.	Researchers employed a systematic approach to data collection, involving structured experiments and tasks inspired by quantum mechanics principles.	The study employs quantum probability theory to model decision-making processes, inspired by the principles of quantum mechanics. Researchers use Bayesian inference to analyze cognitive tasks and decision outcomes based on probabilistic reasoning and updating beliefs according to new information. Statistical modeling techniques are applied to examine the relationships between quantum-inspired cognitive tasks and traditional psychological paradigms.
7.	N/A	N/A

The table 1.6 detailing Methodology includes the following headings: Data Collection Method and Data Analysis Technique. This table provides a clear overview of how data was gathered and analyzed in each study. The "Data Collection Method" column describes the techniques and tools used to collect data, such as surveys, interviews, or experiments, indicating the approaches taken to obtain information. The "Data Analysis Technique" column outlines the methods used to process and interpret the data, such as statistical analysis, thematic analysis, or qualitative coding. Observing these details helps to understand the rigor and

validity of each study, as well as the different methodological approaches used to conclude. This ensures a clear understanding of the processes behind the research findings.

Table 1.7: Key Findings

S. No.	Results/Main Findings	Implications
1.	The study found that intentionally controlling the heart's rhythm can create a state of coherence, leading to positive effects on both the body and mind. People who regularly practice techniques to build coherence tend to have less stress, better mental clarity, and an improved sense of well-being. The study also suggests that quantum theory may provide new insights into how coherence could influence the mind and human experience.	The study's impact is broad, as it explores how quantum phenomena might play a role in biology and consciousness. It offers a fresh perspective on key ideas like psychophysiological coherence, potentially challenging how we understand the connection between the mind and body. This theoretical work could lead to progress in fields like quantum biology, psychology, and information science, and may advance the "quantum concept of consciousness" theory.
2.	The research study supported the quantum model's predictions by showing a clear departure from the classical law of total probability. The experiments revealed that participants could stay in a superposition state during decision-making, causing interference between different thought paths, consistent with the quantum model's expectations.	The study's implications suggest a new way of understanding cognitive phenomena by applying quantum principles to psychology, challenging traditional ideas. By exploring quantum in decision-making, the study creates opportunities to investigate cognitive processes that cannot be fully explained by classical theories.
3.	The study's findings suggest that evolutionary psychology's emphasis on primal drives may overlook the complexity of human cognition, especially when it comes to free will and conscious thinking about the future. It also points out the need for stronger evidence to back evolutionary theories and questions the idea that decision-making mechanisms are perfectly adapted, given challenges like environmental shifts and historical population bottlenecks.	The findings of the study highlight the need for interdisciplinary cooperation to test and improve models of human behaviour and volition. By understanding free will as a biological trait and making it less mysterious, the research encourages us to study more deeply and scientifically and learn where it comes from and why it exists.
4.	Neurons work within a mathematical framework called Hilbert space, allowing them to hold multiple possibilities at once and generate uncertain action potentials due to complex chemical processes. This model, similar to quantum principles, helps explain cognitive psychology, game theory and	The quantum-like model provides a new way to understand how the brain processes information and makes decisions, which could improve cognitive science and artificial intelligence. Its interdisciplinary approach connects brain function with quantum ideas, creating opportunities for collaboration and

	decision-making, connecting brain functions to quantum cognition ideas.	further research into complex thinking and decision-making processes.
5.	The study found that when people make decisions, it affects how sure they are about those decisions. Comparing the two models, the Quantum Random Walk (QRW) Markov Random Walk (MRW), the QRW model, which includes quantum principles, was seen to better explain how choices influence confidence levels. This challenges the traditional ideas about how we make judgements and decisions.	The research suggests that by using a model that incorporates quantum features, we might understand better how choices affect how confident we feel about our decisions. This could mean rethinking the ways we currently understand decision-making, leading to advanced ways of studying how people make judgements and decisions.
6.	The study showcased how applying quantum mechanics principles to cognitive tasks can offer new insights into human decision-making processes. -Researchers found that quantum cognition provides a coherent and principled framework to address long-standing puzzles in psychology, unveiling novel cognitive behaviors and decision-making patterns not observed in traditional psychological models.	Quantum cognition can revolutionize psychological research by offering new perspectives and solutions to cognitive challenges. Integrating quantum theory with psychology may develop new experimental methods, frameworks, and cognitive studies. The study emphasizes interdisciplinary approaches like quantum cognition to broaden the scope and implications of psychological research, directing the way for new exploration in cognitive science.
7.	Quantum cognition model gives us a new way to look at how people think and make decisions, helping us understand the complexities of these mental processes.	Re-examination of traditional cognitive frameworks, a better understanding of cognitive phenomena like the conjunction fallacy, and the potential for advancing our knowledge of human thought processes and decision-making mechanisms

The table 1.7 detailing Key Findings includes the following headings: Results/Main Findings and Implications. This table summarizes the primary outcomes and the broader significance of each study. The "Results/Main Findings" column presents the core results and discoveries made in each study, highlighting the most important data and conclusions drawn by the researchers. The "Implications" column discusses the broader impact and relevance of these findings, including how they contribute to the field, potential applications, and suggestions for future research. Observing these key findings provides a concise understanding of the main contributions of each study and their significance, helping to identify trends, gaps, and areas for further investigation.

Table 1.8: Quality Assessment

S. No.	Bias Assessment	Study Limitation
1.	N/A	N/A
2.	The bias assessment in this study is about how cognitive biases and situations around us can affect the assumptions and predictions of quantum cognitive models, especially when making decisions. The researchers focus on conjunction and disjunction fallacies as examples of biased decision-making processes and they emphasize that these biases are often based on wrong or false beliefs. The article critically examines how these cognitive biases can affect quantum cognitive models and how they might influence our decision-making processes.	The article oversimplifies classical cognitive theories, ignoring the variety of ideas within this field. By focusing only on commutative and distributive axioms the authors might not fully understand the complexity and depth of classical approaches, leading to an unfair comparison. To fully understand the challenges and limitations of using quantum principles in psychology, we need to critically evaluate both classical and quantum approaches.
3.	The study on evolutionary psychology and free will might be biased because it relies too much on stories about how cognitive mechanisms evolved, which could lead to confirmation bias. Focusing a lot on ancestral selection pressures and not having enough direct evidence for some evolutionary stories might also lead to biased interpretations of how decision mechanisms evolved.	The main limitations of the study are its reliance on speculative stories about evolution and the lack of direct evidence for some of these stories. This can lead to biased interpretations. Another problem is the difficulty of testing historical hypotheses with modern observations, which makes it hard to strengthen evolutionary hypotheses.
4.	N/A	The research article on the quantum-like model for brain information processing and decision-making has several limitations. It is mostly theoretical, lacks real-world validation, and makes simplifying assumptions about complex neural functions. Other challenges include the need for interdisciplinary collaboration, the model's mathematical complexity, limited practical use, and the absence of ethical considerations, which could affect its relevance and accuracy.
5.	The bias assessment in the study involved evaluating the calibration of confidence ratings to the actual outcomes. The average bias statistic was calculated to be 7.66, indicating mild overconfidence. Furthermore, the interference effect of choice	A small and potentially non-diverse sample size, the simplification of decision-making tasks, and the abstract nature of quantum-like characteristics, which may affect the generalizability and accessibility of the findings. Also, external factors influencing participants'

	on confidence led to lower overconfidence and better calibration in the choice condition compared to the no-choice condition, with an average bias statistic of 8.20 in the choice condition and 7.13 in the no-choice condition.	confidence judgments and the controlled experimental setup may limit the applicability of the results to real-world scenarios, highlighting the need for further research to explore long-term effects and additional cognitive processes.
6.	N/A	The study limitations include the need for further exploration of how quantum principles can be effectively integrated into psychological research methods and theories, highlighting the complexity of merging these two domains The study may not address the long-term effects or sustainability of using quantum cognition in psychological research, indicating a gap in understanding the enduring impact of applying quantum concepts in cognitive studies.
7.	In cognitive modeling using quantum principles, assessing and addressing biases is crucial to ensure the accuracy and validity of the models, particularly considering the potential impact of superposition and incompatibility features. Mitigating these biases enhances the reliability of quantum cognitive models in understanding human cognition and decision-making, preventing unintended distortions and improving research effectiveness.	Limitations and challenges of assessing quantum cognitive models against classical probability theory, emphasizing the need for empirical validation and further research to prove the necessity of quantum models. It acknowledges difficulties in mapping quantum evolution to cognitive processes and specific decision-making scenarios, such as the guppy effect, underscoring the importance of developing nuanced models and addressing empirical challenges like violations of the law of total probability.

The table 1.8 detailing Quality Assessment includes the following headings: Bias Assessment and Study Limitation. This table provides critical insights into the reliability and validity of each study. The "Bias Assessment" column evaluates potential biases in the study, such as selection bias, measurement bias, or researcher bias, which might affect the study's outcomes and interpretations. The "Study Limitation" column outlines the constraints and limitations faced by each study, such as small sample sizes, short duration, or limited generalizability of the results.

Table 1.9: Synthesis of Evidence

S. No.	**Comparison of findings**	**Patterns/ Themes**	**Contradictions/ Discrepancies**
1.	N/A	N/A	N/A
2.	The study compares how quantum and Markov models predict decisions. Markov	The study looks at how quantum principles can be used to understand	The study uses quantum principles to explain quantum phenomena like conjunction

	models follow the law of total probability, while quantum models predict interference effects, which break this law. The study shows that these models make different predictions, highlighting the importance of considering quantum principles in understanding decision-making.	cognitive psychology. It highlights the differences between classical and quantum models and emphasizes themes like complementarity and superposition to explain cognitive phenomena. The analysis also examines order effects in psychology using quantum cognition and presents evidence supporting the quantum question (QQ) equality, which is a way to test the quantum cognition theory.	and disjunction fallacies, judgment and decision-making and order effects in psychology. However, it also criticizes the use of quantum principles saying that it might oversimplify classical cognitive theories. The study notes that quantum cognition is controversial within the scientific community and emphasizes the need for more research and studies in different cultures. It also acknowledges that some researchers doubt the validity and generalizability of quantum theory's predictions.
3.	The study suggests that human decision-making might be more complex than traditional evolutionary explanations suggest. This means that our evolved cognition processes might not fully capture the complexity of conscious deliberation and mental stimulation. This comparison shows the importance of working together with scientists from different fields and using rigorous empirical methods to reconcile the complexities of human cognition with evolutionary explanations of free will.	The study examines how evolutionary psychology and philosophical concepts related to free will intersect. It focuses on the evolved cognitive mechanisms that influence our decision-making processes. The study uses and analytical approach to understand the complexities of human cognition and decision-making from an evolutionary perspective. It also explores the potential implications for the nature of free will.	The study questions whether evolutionary psychology can fully explain the complexities of human cognition, especially when it comes to our ability to consciously think about the future. It also questions whether compatibilism, a philosophical view that says free will and determinism can coexist, can be applied to evolutionary psychology. The study suggests that there might be limitations in explaining how real subjective free will can emerge from deterministic brain mechanisms.
4.	The research explores a quantum-like model for neural information processing and decision-making, merging quantum principles with cognitive science and neurophysiology.	Key themes include superposition, uncertainty and decoherence in neuronal states, highlighting the need for collaboration.	Challenges include fitting quantum-like neural state codes with traditional models and extending quantum concepts beyond physics.

5.	Underscored the necessity of considering both quantum-like and classical models when exploring the effects of choice on confidence in decision-making contexts. By examining the differences and convergences between these models, researchers can gain a more comprehensive understanding of the underlying mechanisms shaping confidence judgments and the impact of choice configurations on decision outcomes.	Participants exhibited quantum-like superposition patterns in their decision-making, indicating that they considered multiple possibilities simultaneously, which influenced their confidence judgments. Additionally, the research highlighted that choice configurations significantly impacted confidence levels, with quantum models offering distinct insights compared to classical models, suggesting the need for further exploration into the cognitive mechanisms and long-term effects of choice on confidence.	The study did not explicitly mention any contradictions or discrepancies within the research findings. However, it is important to note that the interference effect observed in the study challenges traditional assumptions in cognitive and neural theories of decision-making, particularly the read-out assumption. This interference effect suggests that making a decision can impact subsequent confidence judgments, highlighting the complex nature of the decision-making process.
6.	The research paper compares traditional psychological models with the emerging quantum cognition approach by exploring how quantum principles can offer new perspectives on human decision-making. Findings from the paper suggest that quantum cognition provides a more principled and coherent framework to address longstanding challenges in understanding cognitive processes, offering potential solutions to persistent puzzles in psychology.	Patterns identified in the study reveal that applying quantum mechanics concepts to cognitive tasks can lead to the discovery of novel cognitive behaviors and decision-making patterns not observed in classical psychological experiments. Themes highlighted in the paper include the integration of quantum theory with psychology, the development of quantum-inspired experiments, and the examination of how individuals respond to tasks designed based on quantum principles.	The focus of the study may be more on exploring the benefits and applications of quantum cognition rather than on identifying inconsistencies or conflicting evidence.

7.	Quantum cognitive models introduce concepts like incompatibility and entanglement, challenging traditional frameworks and offering unique insights into cognition distinct from classical theories. However, empirical challenges, such as violations of the law of total probability, and debates on predictive accuracy and applicability, highlight ongoing discussions about the effectiveness and limitations of these models in explaining cognitive and decision-making processes.	Questioning existing formal frameworks, exploring the implications of employing quantum conceptual tools in cognitive modeling, and addressing the challenges and opportunities presented by quantum cognitive models in understanding intelligent thought and everyday judgments	The ongoing challenges and opportunities in utilizing quantum principles for cognitive modeling, prompt further exploration and refinement of quantum cognitive models

The table 1.9 detailing the Synthesis of Evidence includes the following headings: Comparison of Findings, Patterns/Themes, and Contradictions/Discrepancies. This table provides a comprehensive overview of how the findings from different studies relate to each other. The "Comparison of Findings" column highlights similarities and differences in the results across the studies, facilitating a broad understanding of the collective evidence. The "Patterns/Themes" column identifies recurring themes or trends observed in the studies, offering insights into commonalities that may point to broader conclusions or underlying principles. The "Contradictions/Discrepancies" column notes any conflicting results or inconsistencies between studies, which can indicate areas where further research is needed or where methodological differences may have influenced outcomes. Observing these elements helps to synthesize the evidence, providing a better interpretation of the overall findings and identifying areas of consensus and debate within the research.

Discussion and Analysis

The study investigates how the Principle of Superposition can be used to understand and improve Human Cognition. By reviewing existing research, the study shows how quantum mechanics connects with cognitive science. The Principle of superposition explains that quantum units, which are basic parts of matter, can exist in several states at once until they are observed (Reilly T E, et al., 1984)[13]. This discussion brings together the key findings, methodologies, implications, practical applications, and future research that bring together quantum mechanics and human cognition.

A team of four researchers independently reviewed the articles on their own after creating a Scoping Review Protocol. This Protocol is registered with Figshare ensuring that no other protocols on the same theme were registered. Databases like Google Scholar, ResearchGate and PubMed are used to find and select the most relevant research articles for data charting. Google Scholar was specifically used to find as many publications, reports and conference presentations as possible on the Superposition Principle and Human Cognition. PubMed, ResearchGate and Google Scholar helped to identify high-quality peer-

reviewed research articles in this specific area. The PRISMA SCR checklist was used to prepare the Protocol and draft the report. The Population, Content, Context framework was used for organizing the data in this Scoping Review.

The review points out that the Superposition Principle, which suggests that systems can be in multiple states at the same time until observed, offers a new way to understand how the mind works. Traditional cognitive theories often rely on straightforward and predictable models, which may not fully capture the complex and uncertain nature of human thinking (Fisher M, et al., 2018)[14]. By using this superposition principle, researchers can explore ways that better reflect the complexities of the mind, like making decisions when uncertain and dealing with changing emotions (Hilbig B E, et al., 2014)[15]. This change in thinking has an important effect on how we view mental states. It challenges the idea that thoughts are always clear-cut, suggesting that people can have mixed or conflicting emotions at the same time (Lubin K L, 2023)[16]. This view fits in psychological findings that show people always often feel uncertain or have mixed emotions when making decisions. Bringing quantum principles into cognitive science not only helps us better understand psychological experiences but also leads to the development of more detailed models that can explain the complexities of human behavior.

The methods used in the studies reviewed were quite different, ranging from theoretical discussions to practical research. Some studies provided strong evidence supporting the use of the superposition principle in understanding the mind, while others lacked strong methods. This difference shows the need for more consistent approaches in future research to ensure that the findings are reliable and accurate.

The review also found that many studies focus on specific cognitive areas like decision-making or memory, without fully considering how the superposition principle might apply to other cognitive fields. Future research should take a more complete approach, looking at how this principle can be used across different parts of cognition and psychology. The findings in this review have important practical applications for fields like psychology, education and mental health. For example, understanding cognition through the superposition principle could help develop therapeutic methods that deal with the complexities of human emotions and decision-making. Therapists could create treatments that recognize and address client's conflicting feelings, leading to a more detailed approach to mental health care. In schools, the superposition principle could change teaching methods by accepting the unpredictable nature of learning. Teachers could create programs that take into account the different ways students learn, encouraging personalized learning experiences that fit individual cognitive styles.

The methodologies section of the scoping review explains the step-by-step process used for searching, selecting and analyze relevant studies. It also describes how the superposition principle's effect on human thinking was studied. The reviewers followed a structured process to ensure the reliability and accuracy of the review's findings. They used a Population, Concept, Context (PCC) framework to organize the results, focusing on important study details and themes related to the superposition principle's impact on human thinking. Additionally, standardized forms and a systematic way of gathering data improved the quality and consistency of the review process.

Data selection involved a thorough process, including refining search terms, searching multiple databases (ResearchGate, Google Scholar, PubMed) and a two-step screening to choose relevant studies. This careful approach is aimed at the most current studies and relevant studies while reducing bias. The discussion could highlight the importance of using the superposition principle in studying human thinking, showing its potential effects on cognitive models, therapy methods and understanding complex mental functions. It could also explore how comparing quantum principles to cognitive processes might lead to

new research ideas and teamwork across different fields in quantum cognition and psychology. The data charting process involved systematically gathering key study details from the chosen articles. Study identification details, study characteristics and participant information were carefully made to make comparing studies easier. Tables were used to display this information clearly, helping leaders better understand the reviewed studies. Figure 1.1 shows the PRISMA flow chart, which visually explains the process of selecting relevant articles. This flow chart gives a clear overview of the review's articles selection process including initial keyword searches, screening based on titles and abstracts, applying inclusion and exclusion criteria, and the final selection of articles that met the criteria. The flow chart shows the careful and systematic approach used in choosing the most relevant and high-quality studies for the review. In the scoping review, Table 1.1 provides a detailed list of study identification details that are important for understanding how the Principle of Superposition is applied in psychology and cognitive science. This table organizes relevant studies by listing the authors, titles, publication years, journals or sources, and corresponding DOI and URLs. Each entry serves as a reference, helping readers trace the origin of the research and assess the reliability of the findings. The variety of studies included, from psychophysiological coherence to quantum cognition, shows the interdisciplinary nature of research, demonstrating how different aspects of quantum theory connect with cognitive processes. This structured summary not only helps readers understand the current literature but also highlights gaps and opportunities for future research. The studies in Table 1.1 are grouped into three main areas: biopsychology, cognitive psychology and evolutionary psychology as shown in Fig 1.2. The first study is categorized under biopsychology. Studies 2, 4, 5 and 6 fall under cognitive psychology, focusing on understanding mental processes like perception, memory, and reasoning. Studies 2 and 7 are classified under evolutionary psychology, exploring how evolutionary processes affect human behaviour and mental traits. This grouping shows that there is one study in biopsychology, four studies in cognitive psychology and two studies in evolutionary biopsychology, giving a clear overview of how research is distributed across these psychological fields.

Table 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, and 1.9 as well as Figures 1.3 and 1.4 are critical components of the scoping review on the impact of the superposition principle on human cognition. They provided detailed insights into the essential findings, citations and key themes from various studies. They likely include information such as primary outcomes, secondary outcomes, methodological details, critical discoveries, and the broader significance of each study. These tables and figures can help to identify trends, gaps and areas for further investigation in the context of quantum cognitive models and human thought processes. On the other hand, figures 1.3 and 1.4 are visual aids that might showcase conceptual framework, models or relationships between quantum mechanics and cognitive science in a graphical format. These figures could potentially illustrate the interplay between quantum principles and human cognition, offering a visual representation of the complex and multifaceted relationship between these domains. Overall, these tables and figures likely serve as crucial components of the scoping review, providing researchers with a structured approach to analyze data, identify emerging themes, visualize key components, and synthesize the implications of applying quantum principles like superposition principles to the study of human cognition.

By openly discussing the study's limitations, researchers can make their work more trustworthy. This helps other scientists improve future studies. By acknowledging problems like search mistakes, potential biases, or limited applicability of the results, the study contributes to better research methods and understanding.

The analysis in the scoping review's discussion section focuses on compiling the data that was extracted and discussing the major conclusions, ramifications, constraints, and reasons for the outcomes. The synthesis of findings using the Population, Concept, and Context (PCC) framework is a crucial step in this process because it enables a thorough and organised examination of the data pertaining to the impact of the superposition principle on human cognition. By utilizing a standardised form for data extraction, it is possible to identify common themes, patterns, and contradictions throughout the reviewed literature by ensuring that crucial study characteristics are recorded and categorised following the PCC framework.

By presenting the methods used for conducting the data synthesis understandably and transparently, the discussion section of the analysis can support the findings. It might cover the actions done to guarantee the validity and dependability of the review process, like following PRISMA SCR reporting guidelines, using Zotero as a reference management tool, and methodically extracting and charting data.

Moreover, because the scoping review employs an expansive and exploratory methodology, the discussion justifies the outcomes by clarifying the reasoning behind the eligibility requirements, search approach, and date selection procedure. This guarantees that the chosen evidence is in line with the review's objectives and scope and that the reviewed literature is representative of the pertinent studies that are currently available.

The discussion will also include a careful evaluation of different sources of evidence, emphasizing the criteria used to assess the quality and reliability of the included research. It will address how to adapt well-known quality assessment tools for both quantitative and qualitative designs. This will focus on incorporating rigorous assessment criteria for research objectives, methods, data collection and analysis, consideration of biases, and the validity of conclusions.

In addition, the analysis ought to assess the key discoveries concerning the superposition principle and human cognition critically, clarify how these discoveries might advance our knowledge of human cognition, and offer a fair examination of the study's acknowledged shortcomings. This thorough approach guarantees that the discussion convincingly explains the significance, dependability, and validity of the review's findings, providing a solid basis for further investigation and use in this field.

All things considered; the scoping review's discussion section is well-positioned to provide insights into the revolutionary possibilities of using the superposition principle in the study of human cognition. The review adds to a deeper understanding of cognitive processes from a quantum-inspired perspective by synthesizing key findings, examining implications, identifying study limitations, and filling in gaps in the literature. It also paves the way for future research, innovation, and collaboration in this multidisciplinary field.

According to Busemeyer, et al., (2015)[17], superposition is the idea that cognitive states can exist in multiple potential states at the same time, while interference is the description of how these states interact. This method provides logical jurisdictions for puzzling psychological results, like concept combination and order effects in sequential measurements (Aerts, et al., 2012)[18]. Human reasoning may involve a superposition of logical and conceptual processes, with conceptual processes frequently taking precedence (Aerts et al., 2014)[19]. The nature of human thought and decision-making is revealed by this quantum perspective on cognition, which may have consequences for fields such as artificial intelligence and quantum computing (Aerts, et al., 2012)[18].

By applying ideas from quantum theory to the study of human cognition, quantum cognition challenges conventional models that rely on classical probability. The quantum ideas of superposition and interference, in particular, play a key role in the understanding of cognitive processes. It is observed after reading through relevant papers and journals that human reasoning usually combines logical and

conceptual thinking, with conceptual reasoning usually having the upper hand. Superposition and other ideas from quantum theory are applied in quantum cognition to explain some aspects of human cognition and decision-making. Superposition is one of the quantum mechanical concepts that is used to model certain cognitive effects and concept combinations. According to this method, human cognition can be viewed as a superposition of conceptual and logical reasoning, with a tendency for the latter to predominate. The interaction between emergent and logical reasoning is how the quantum theoretical framework models human reasoning and decision-making. It is also noted that quantum probability theory may be superior to classical probability theory in modeling specific cognitive processes.

Gaps in the Literature and Future Research Directions

Despite the promising findings, the review also uncovered significant gaps in the literature. There is a need for more empirical studies that rigorously test the theoretical models proposed by the superposition principle in cognitive contexts. Additionally, research exploring the implications of this principle in diverse populations and settings is limited. Future studies should aim to investigate how cultural, social, and contextual factors influence the applicability of the superposition principle in understanding cognition. Furthermore, interdisciplinary collaboration is essential for advancing this field. By integrating insights from quantum physics, psychology, and neuroscience, researchers can develop a more comprehensive understanding of cognition that transcends traditional disciplinary boundaries.

Conclusion

In conclusion, the scoping review underscores the potential of the superposition principle to transform our understanding of human cognition. By challenging conventional cognitive models and offering new theoretical frameworks, this principle opens up exciting avenues for research and application in psychology and related fields. Continued exploration of this intersection between quantum mechanics and cognitive science is crucial for fostering a deeper understanding of the complexities of human thought and behavior.

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Biography

Sarath C Jayadevan is a research scholar at IIT Bhubaneswar, in the Department of Psychology. He holds a Master's degree in Clinical and Counseling Psychology from the Central University of Karnataka, with a Bachelor's degree in Psychology (Honours) from the University of Delhi. Sarath is certified in Emotional Focused Therapy and Mindfulness showcasing his commitment to professional development in psychological practices, and research, with experience as a Research Coordinator, soft skill trainer and Psychologist at Auramah Care. He had experience working as an Assistant Professor at Central University

of Karnataka and a Behavioral Therapist at Pinnacle Blooms network. He has also contributed to the field through research publications on 'The Effect of Mindfulness Intervention in Perceived Stress and Emotional Intelligence' and 'Effect of Positive Assets Search on Reflected Feelings and Needs among Visually Impaired'. He has also authored and published 2 books entitled, 'The Reincarnation' and 'Life Beyond Death'.

Neha Gupta, a Counselling Psychologist with a Masters degree in Psychology from Jain University, Bangalore, is pursuing a PhD in Psychology from CMR University, Bangalore. As a practicing Psychologist, her work centres on improving mental health through her skills which range from child counselling to adolescents, family counselling to challenges faced at the workplace including stress, anxiety and anger management along with academic research, focusing on new and innovative therapeutic intervention techniques.

Anjani K M is currently pursuing a Bachelor of Arts in Psychology (Honors) under the Department of Social Sciences from Indira Gandhi National Open University (IGNOU), New Delhi, with their study centre located at JDT College, Calicut. Her academic journey in psychology reflects a strong passion for understanding human behaviour and mental processes, laying a solid foundation for a future career in the field.

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