



ORIGINAL RESEARCH PAPER

A Study of Quantum Cognition in Mark Z. Danielewski's *House of Leaves*

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The current study is an analysis of Mark Z. Danielewski's *House of Leaves* in terms of quantum cognition. A group of physicists and psychologists introduced the bold idea of applying abstract principles from quantum theory outside of physics to the field of human judgment and decision making. Cognitive scientists have long struggled to form a comprehensive understanding of how humans make judgments and decisions under conflict and uncertainty. In the light of quantum cognition, human judgment and decision are not commutative. In this research, the concept of quantum cognition is investigated in *House of Leaves*. The importance of the order in quantum is discussed and narrated the novel in reverse to show the quantum nature of the novel. After that, conjunction fallacy is defined and the researchers chooses three scenarios from the novel to explain conjunction fallacy by the Venn diagram. It is examined how the reader judges the events of the fragmented novel in consideration of quantum essence in *House of Leaves*. With the help of quantum cognition, it is proved there is a close relationship between postmodern literature and physics and in the twentieth century, discoveries in science have affected literature and *House of Leaves*.

Keywords: Conjunction Fallacy, Metafiction, Postmodernism, Quantum Cognition, Uncertainty Principle.

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Introduction

Cognitive scientists have long struggled to form a comprehensive understanding of how humans make judgments and decisions under conflict and uncertainty. Decades of research have seen two approaches crystallize to the surface — heuristic and rational. The heuristic approach is firmly rooted in Herbert Simon's notion of bounded rationality. This approach posits that to make judgments and decisions, people tend to employ simple heuristics (for example, representativeness, anchoring-and-adjustment, take-the-best), which may not always seem rational. This can be viewed as a 'bottom-up' inductive process in the sense that humans learn simple ad hoc rules that can be effective or not depending on the environmental conditions. In stark contrast, the rational approach is founded on theories of subjective probability and expected utility. This approach posits that people can derive inferences from the Bayes rule and decisions from the expected utility rule in a rational manner. This can be viewed as a 'top-down' deductive process, wherein the same basic axioms can be used to derive inferences and utilities across all environmental conditions. Recently, a third approach, quantum cognition, has emerged. In common with the heuristic approach, it assumes that the human decision-maker is subject to bounded rationality. Moreover, like the rational approach, inferences used for decisions are derived from basic axioms that define a probability theory. However, the axioms are different from those employed by the Bayesian approach, and consequently so are the inferences that are derived from it. This question may come as a surprise to some readers because, by and large, cognitive scientists have been exposed to a single probability theory — what we will call classical (more technically, Kolmogorov) probability theory, on which Bayesian models rest. There are, however, several viable probability theories upon which to build probabilistic models of cognition. Quantum cognition is one such alternative that is increasingly gaining attention. What makes quantum cognition controversial is that its associated probability theory was developed within the field of quantum physics (Bruza, Wang and Busemeyer, 2015).

Wolpert and Ghahramani's "Bayes rule in perception, action and cognition" explains the Bayes rule as a framework for making inferences based on uncertain information. The rule posits that probabilities can represent the degree of belief in different propositions, and the rules of probability can be used to update beliefs based on new information. For instance, a doctor may have a prior belief about a patient having a disease, represented by a real number between 0 and 1, representing the probability of the event being true. If a positive blood test is given, the doctor can update their belief about the patient's disease by computing the probability of the test being positive, denoted as $P(A | B)$. The Bayes theorem provides the rule for computing this:

$$P(A|B) = \frac{P(B|A) P(A)}{P(B)}$$

Here $P(B | A)$ is the probability of observing a positive blood test given that a patient has the disease (termed the likelihood for A), and $P(B)$ is the normalization constant which sums up the probability of observing a positive blood test in this

patient under both the possibility that the patient has and doesn't have (indicated by $\bar{A}$) the disease:

$$P(B) = P(B|A) P(A) + P(B|\bar{A}) P(\bar{A})$$

In its most general sense, there is nothing mystical about Bayes rule, it is simply a consistency relationship between probabilities that can be derived straightforwardly. For any two events A and B we can ask what is the probability that both events occur, which is written as $P(A, B)$ where the comma is shorthand for “and”. This can be written in two alternative forms, that is the probability of one of the events happening, e.g. $P(A)$, multiplied by the probability of the second event happening given that the first has happened $P(B|A)$. This gives three expressions which are all identical: $P(A, B) = P(A|B) P(B) = P(B|A) P(A)$. By discarding the left-hand term and dividing both the others by $P(B)$ gives Bayes rule as above. Although the form of Bayes rule may be intuitive, its implications are extensive and often counter-intuitive (2004).

If we relabel A as the “state of the world” and B as “sensory input”, then Bayes rule becomes applicable to the brain:

$$P(\text{state}|\text{sensory input}) = \frac{\overbrace{P(\text{sensory input}|\text{state})}^{\text{Likelihood}} \overbrace{P(\text{state})}^{\text{Prior}}}{\text{Posterior}}$$

The state of the world can be estimated using sensory inputs, such as location of limbs, visual object identity, or poker opponent bluffing. The Bayes rule can be used to estimate the probability of different states given sensory input. The probability of a state is expressed as $P(\text{state})$, reflecting our prior belief in the state before receiving sensory information. These beliefs can be learned through experience. Once sensory input is received, we can update our beliefs using the Bayes rule. The likelihood of the state, or the probability of the sensory input given the hypothesized state, is calculated as $P(\text{sensory input} | \text{state})$. This reflects the probability of receiving the current visual input given a polar bear or a white van. By multiplying the prior by the likelihood and normalizing, we can estimate the posterior of the state, which becomes our new prior belief and can be further updated based on new sensory input.

Bayesian models are used to model our cognitive ability to learn concepts. Wolpert and Gharamani provide an example of a number game where a new number is asked to belong to a set of numbers. By defining a prior over possible ways to generate the set, such as odd numbers, primes, perfect squares, and intervals, and combining this with the likelihood of observing data under each hypotheses, the posterior can be generated. This Bayesian formulation allows for the prediction of complex patterns of human behavior in the number game and can be applied to other forms of human reasoning, such as determining casual relationships. This approach can be applied to various forms of reasoning.

Schrodinger came up with an experiment intended to show probability in quantum physics. In Schrodinger's cat experiment, Schrodinger hypothesized a

radioactive particle that has a 50 percent chance of decaying within an hour. He proposed that you place the radioactive material within a closed box next to a Geiger counter that would detect the radiation. When the Geiger counter detects the radiation from the decay, it will break a glass of poison gas. In addition, inside the box is a cat. If the glass breaks, the cat dies (Andrew Zimmerman Jones and Robbins, 2010). According to Born's interpretation of the wave function, after an hour the atom is in a quantum state where it is both decayed and not decayed — fifty percent chance of each result. This means the Geiger counter is in a state where it's both triggered and not triggered. The glass containing poison gas is both broken and not broken. The cat is both dead and alive. This may sound absurd, but it's the logical extension of the particle being both decayed and not decayed. Schrodinger believed that quantum physics could not describe such an insane world, but that the cat had to be either completely alive or completely dead even before the box is opened and observed (Andrew Zimmerman Jones and Robbins, 2010). After the box is opened, according to this interpretation, the cat's state becomes well defined one way or the other, but in the absence of measurement, it is in both states. Though Schrodinger's cat experiment was created to oppose this interpretation of quantum mechanics, it has become the most dramatic example used to illustrate the strange quantum nature of reality (Andrew Zimmerman Jones and Robbins, 2010).

Twenty years ago, a group of physicists and psychologists introduced the bold idea of applying abstract principles from quantum theory outside of physics to the field of human judgment and decision making. This new framework does not rely on the assumption that the brain is some type of quantum computer, and instead, it uses a probabilistic formulation borrowed from quantum theory that involves non-commutative algebraic principles. This new field, called quantum cognition, has proved to be able to account for puzzling behavioral phenomena that are found in studies of a variety of human judgments and decisions including violations of the "rational" principles of decision making, conjunction and disjunction probability judgment errors, over- and under-extension errors in conceptual combinations, ambiguous concept, order effects on probabilistic inference, interference of categorization on decision making, attitude question order effects and other puzzling results from decision research. In short, quantum models of judgment and decision have made impressive progress in organizing and accounting for a wide range of puzzling findings using a common set of principles (Busemeyer et al.).

The purpose of this research is to investigate quantum cognition in Danielewski's novel, *House of Leaves*. One of the prominent postmodernist writers is Mark Z. Danielewski (5 March 1966). He is the author of the award-winning and bestselling novel *House of Leaves* (2000), the novella *The Fifty-Year Sword* (2005), and National Book Award Finalist *Only Revolutions* (2006). *House of Leaves*, Danielewski's first novel, won numerous awards and this novel is characterized by complicated, multi-layered typographical variations, or page layouts. Sometimes known as visual writing, the typographical variation corresponds directly to the physical space of the events in the fictional world as well as the physical space of the page and the reader.

Quantum physics looks at the world with ambiguity. Cognitive quantum exists naturally in the human mind. Sometimes people think they are unsure about something or have a vague feeling about their choices. Our brains cannot store everything, therefore it decisions based on limited information. When the reader study *House of Leaves*, he or she is confronted with fragmented and ambiguous events, thus these scattered events create many possibilities in the reader's mind. The reader does not have a clear attitude towards the narrative of the story. Quantum cognition refers to situations in which human beings are mentally confused. The purpose of this research is to read *House of Leaves* in the light of quantum cognition in order to study the mind of the reader during the irregular events of this novel. In this study, the probabilities that arose in the minds of readers and talked about in various studies were examined. The reader has doubt about the events of the story and in his or her mind is involved with probabilities, but in any case, he or she has to think about all of them and finally finds a clear answer. Although quantum physics is not very tangible about describing a particle, it is quite understandable for describing mental ambiguities in routine life. In this interdisciplinary research, the researcher wants to bridge the gap between physics and literature, which leads to the quantum behavior of the reader's mind.

New research shows that quantum cognition allows humans to make decisions in the face of uncertainty. Two influential people in the quantum cognition field are Peter D. Bruza (1962-) and Jerome R. Busemeyer (1950-). Busemeyer is a Professor in the Department of Psychological and Brain Sciences at Indiana University, Bloomington, USA. His research includes mathematical models of learning and decision making, and he has formulated a dynamic theory of human decision making called decision field theory. Professor Busemeyer has published over 100 articles in cognitive and decision science journals, including *Psychological Review*, and was Chief Editor of the *Journal of Mathematical Psychology* from 2005 to 2010 (Busemeyer and Bruza, 2012).

Bruza is a Professor in the Faculty of Science and Technology at the Queensland University of Technology, Brisbane, Australia. His research intersects information retrieval, cognitive science, and applied logic. He is a pioneer and co-instigator of the field of quantum interaction (QI) and serves on the steering committee of the quantum interaction symposia. Professor Bruza also serves on the editorial boards of *Information Retrieval*, *Journal of Applied Logic*, *The Logic Journal of the IGPL*, and the "Information Science and Knowledge Management" book series (Busemeyer and Bruza, 2012).

Based on the researcher's studies, it is realized that there had not been a conversation between literature and physics. The researcher has an interdisciplinary look at the postmodern novel, *House of Leaves*. The main novelty of this study is its literary methodology which uses the concept of modern physics to analyze the novel.

Research Questions

The researcher tries to answer the following questions under the light of quantum cognition:

1. To what extent has modern physics affected literature?

2. What are the roles of quantum cognition and human judgment in *House of Leaves*?
3. Are the possibilities discussed by the users on the *House of Leave*'s forum correct?

Order Effects Are Responsible for Creating Uncertainty in the Reader's Judgment

It was the mathematician Neumann who axiomatized quantum theory in the 1930s. Regarding these axioms, he stated: "The set theoretical situation of logics is replaced by the machinery of projective geometry, which in itself is quite simple." He was referring to the fact that the logic underlying classical probability theory is prescribed by Boolean algebra because of its set-theoretic foundation. The associated Boolean logic implies that events can always be combined (for example, via logical conjunction). The consequence, however, is that logical conjunction is commutative, and expressing the combined event 'A and B' is, therefore, the same as stating 'B and A'. In other words, the order of events does not matter. By contrast, inherent in von Neumann's 'machinery of projective geometry' is non-commutativity: the sequence of events 'A and B' is not necessarily the same as the sequence 'B and A' (Bruza, Wang and Busemeyer, 2015).

This example highlights the fact that human judgment is not necessarily commutative. To account for this non-commutativity, a classical model needs to include the sequence of evaluations as part of the description of the event, for example, 'A and B' and 'A before B', (Bruza, Wang and Busemeyer, 2015).

Order effects are pervasive in human cognition, such as in attitude judgments, inferences, and causal reasoning. An interesting example is the results of a 1997 poll in the United States concerning public opinions on the characters of Bill Clinton and Al Gore. Half of 1002 nationally sampled respondents were asked: "Do you generally think Bill Clinton is honest and trustworthy?" Subsequently, they were asked the same question about Al Gore. The other half of respondents answered exactly the same questions but in the opposite order. The results exhibited a striking order effect: the proportion saying 'yes' to both questions significantly increased when Gore was judged first (Bruza, Wang and Busemeyer, 2015).

Order effects are also responsible for introducing uncertainty into a person's judgments. If the first question A produces an answer that creates a definite state with respect to that question, the state created by A may be indefinite with respect to a different question B. Consider the following consumer choice example. Suppose a man is considering the purchase of a new car and two different brands are in contention: a BMW versus a Cadillac. If he directly asks himself what he prefers, he definitely answers with the BMW. But if he first asks himself what his wife prefers (she definitely wants the Cadillac) and subsequently asks himself what he prefers (after taking on his wife's perspective), then he becomes uncertain about his own preference (Busemeyer and Bruza 2012). In this example, the question about his wife's preference disturbs and creates uncertainty about his own preference. Thus, it may be impossible to be in a definite state with respect to two different questions, because a definite state (technically speaking an eigenstate) for one is an indefinite state (superposition) (Busemeyer and Bruza, 2012).

House of Leaves is often described as a postmodern novel because it presents “a denial of order” and a “highly fragmented” world (Postmodern). Postmodernism is related to deconstruction in that it builds on previous understandings of literature while simultaneously challenging those ideas (Throgmorton, 2009).

Both postmodernism and deconstruction reject the idea of clear-cut meaning and understanding and instead see the world as vastly complex and fragmented. Like the postmodern novel that it is, *House of Leaves* attempts to show this complexity of the world. The postmodern view sees life as not always explainable or even understandable, and this novel also presents an inexplicable and incomprehensible story. It makes no attempts to offer any conclusions or resolutions, but instead forces readers to accept and be affected by its fragmented and chaotic world. By presenting a completely unpredictable and constantly changing world, this novel also depicts the postmodern world in which we live (Throgmorton, 2009).

The order effects of measurements are not unique to physics. The order in which questions are asked has long been shown to influence human judgments in social and behavioral research (Wang and Busemeyer, 2013).

The researcher applies quantum probability theory to the reader's judgment. Human judgments display order effects. Because of *House of Leaves*' fragmented plot, the judgment of the reader from the reading of the order of the events in the form of A, B, C, etc. is changed to the reading in the form of Z, Y, X, etc.

There are many gaps in the narrative that create questions about incidents for the reader. The subsequent question must be evaluated based upon the updated knowledge of the reader, which has been changed by the answer to the preceding question. After updating the knowledge of the reader about characters and events, the probabilistic responses to the next question change. This means that during reading the novel, we experience many probabilities that lead to creating uncertainties and parallel universes. At the end of the novel, fragmented events connect and present a new reality to the reader. In fact, we have a completely new story and new information at the end of the novel that if the reader knows before, can influence the reader's judgment on the events. Therefore, we face the non-commutativity novel like a quantum system. Non-commutativity in the novel changes the consequences of our decisions for filling the gaps.

At first glance, incidents in *House of Leaves* appear very strange to the reader. The labyrinth that changes the mental state of people and makes them mad, is unbelievable in real life. So, the reader uses imagination to justify this phenomenon in this fiction. If we look to fragmented parts in reverse order, every strange incident will harmonize with real life. When the reader finishes reading the novel, the new information in the appendix adds to the reader's knowledge; therefore, his or her judgment about the relationship among the characters alters.

This novel in reverse is a remedy for Johnny Truant and is a farewell for the Navidson family. As we read the novel chronologically, we find out Johnny becomes increasingly involved in the plot of The Navidson Record and eventually develops extreme paranoia. As far as we can tell from the abrupt end of his narrative in chapter XXJ, the house manages to consume him as well (Throgmorton, 2009).

It seems that he has symptoms of bipolar disorder. Bipolar disorder, formerly called manic depression, is a mental health condition that causes extreme mood swings that include emotional highs (mania or hypomania) and lows (depression). The uncertainty principle exists in bipolar people. When they become depressed, they may feel sad or hopeless and lose interest or pleasure in most activities. When their mood shifts to mania or hypomania (less extreme than mania), they may feel euphoric, full of energy or unusually irritable. These mood swings can affect sleep, energy, activity, judgment, behavior and the ability to think clearly (Mayo Clinic, 2021).

When Johnny Truant is in the phase of depression, he stops bathing, rarely eats, stops going to work, and distances himself from essentially everyone. And when he is in the mania phase, he goes out with his friends, drinks a lot, meets many girls and has sex with them. In the chronological order of the novel, the uncertainty principle is obvious in this character. He has dual behavior like particles in physics. On the contrary, reading the novel in reverse shows Johnny's past through Pelafina Lievre's letters. This information helps the reader understand Johnny's subconscious mind and the beast inside of his head.

The link between Zampano and Johnny's mother can find in Zampano's poem and Pelafina's letter. In Zampano's poem, "That Place", is found a reference to "summer love I and rootbeer" (Danielewski, 2000). Here Zampano describes a summer in which "some children went down to that place I and they never came back" (Danielewski, 2000). Just a few pages later, in the Whalestoe letters, Pelafina gives Johnny this exhortation: "May your summer be full of rootbeer, joy, and play" (Throgmorton, 2009).

Another instance of this strange repetition appears early in *House of Leaves*. Zampano writes: "Echo, however, rejects his amorous offers and Pan, being the god of civility and restraint, tears her to pisces, burying all of her except her voice" (Danielewski, 2000). In another one of Pelafina's letters, she tells Johnny, "To endure over two months without a word and then with the first words learn such terrible news tore me to pisces" (Danielewski, 2000). This misspelling of "pieces" in a variant of the phrase "to tear to pieces" seems unlikely to have happened by chance. Instead, they appear to be hinting at some mysterious connection between Pelafina and Zampano. Just as Eros and Aphrodite escaped death together by transforming themselves into two fish, so perhaps Pelafina and Zampano shared some past experiences unknown to readers (Throgmorton, 2009).

Hayles makes further observations about Johnny's encounter with the beast in her piece, *Remediation in House of Leaves*. Hayles said in one scene Johnny proceeds to spill black ink on himself, then anxiously explains, — I am doused in black ink [...] and the floor is black, and — have you anticipated this or should I be more explicit? — jet on jet; for a blinding instant I have watched my hands vanish, in fact, all of me has vanished, one hell of a disappearing act too, the already foreseen dissolution of the self, contrast, slipping into oblivion (Scarano and Krause, 2011).

When Johnny looks at his reflection in the ink tray, he sees, —I am not gone, not quite. My face has been splattered with purple, as have my arms, granting contrast, and thus defining me, marking me, and at least for the moment, preserving me.

Hayles insightfully points out that this purple matches the nail polish that his mother wore while strangling him, — marking him in a complex act of inscription that here merges with the purple and black ink to form overdetermined double writing that operates simultaneously to negate and assert, obliterate and create, erase and mark. In other words, the ink that Johnny spills on his person both negates and affirms his existence: it simultaneously defines and destroys him. Johnny exists only through reflection, and he is destroyed by the very reflective consciousness that so defines him (Scarano and Krause, 2011).

Hayles points out that, once escaping the storeroom, — a client in the shop later calls attention to the long bloody scratch on the back of his [Johnny's] neck. However, she notes that other details that Johnny offered during the encounter, including soiling his pants, prove untrue, and, — the scratch that remains the only verifiable evidence of the encounter recalls the half-moon cuts his mother left on his neck when she tried to strangle him at age seven. The dance between presence and absence that permeates *House of Leaves* is extremely powerful at this juncture — as Hayles explains, it is unclear to the reader whether the scratch is an actual scar left by Pelafina's attack, a fresh wound incurred in the fray of Johnny's disorientation, or, despite seeming impossibility, a mark left by the beast. One thing that Hayles does not explicitly state, however, is more certain: there is a direct connection between Johnny's history and experiences with his mother and the only physical mark left on him by the beast (Scarano and Krause, 2011).

Hayles's explanation shows why Johnny and Lude see a long animal scratch around Zampano's body while the old man has no scratches on his body. Zampano's corpse awakes Johnny's subconscious mind when he was about to die and experience death as his mother tries to strangle him. Therefore, the labyrinth and the beast that engage the reader's mind about its ontological presence, are related to his past.

This question rises why Lude sees scratch marks near Zampano's body while he did not experience such a childhood. One probability is that he is an illusion from Johnny's mind because he uses drugs in this case, Lude deludes the reader and there is the uncertainty principle in Lude's story. He either can be real or unreal. Another probability of the presence of Lude is that he represents Johnny's desire.

Lude could be a homonym for "lewd," meaning crude or offensive in a sexual manner. "Lude" is also a word that refers to a drug: Quaaludes, most often appearing as Methaqualone, are a depressant sedative type drug. Also, one more important definition appears in the *Oxford English Dictionary* — "Lude" is from the Latin root "lūd-us" which means "play," and the second definition of Lude is listed as "a game." So, Lude's name is signifying to readers the nature of Johnny Truant and Lude's relationship — a relationship based on playing and games, most often playing with drugs and "lewd" behavior (Noah, 2012).

Danielewski by using an illusory character in the story wants to show us Johnny's pain. He suffers from being abandoned by his mother and being raised by the foster system. His hallucination and using drugs send out the signals for the reader to discover why Johnny suffers from mental illness.

As it is stated, reading the novel in reverse is a remedy for Johnny and his dual behavior is justified by the reader. As the reader continues his or her reading in reverse, he or she finds out although Johnny his hallucination goes on to some chapters after the beginning, Lude is dead in his mind and the end, his mental health becomes better and compromises with his past. He can find a job in the tattoo shop and rent an apartment. Gradually, he becomes less obsessed with The Navidson Record and eventually becomes a normal person.

Leaves in the title of this novel are derived from the verb “to leave”. Johnny’s father dies and leaves him and also his mother leaves him. All the explorers leave each other. The house causes people to leave their senses, reality leaves and the impossible happens in the end, the Navidson family leaves the house.

Karen, Will Navidson’s partner, seems to be extremely insecure regarding her relationship with Will, but at the end of the story, she is reunited with Navidson after she conquers her claustrophobia and saves him from the labyrinth. In fact, the uncertainty principle is in the title of the novel. Although the book is about “leaving”, Will and Karen recover their relationship and try to put the past behind. But as it is mentioned, the novel in reverse is a farewell for the Navidson family.

The beginning of the story starts with the marriage of Karen and Will. They move to the new house from New York. This house awakes their subconscious mind because it is dark and has a narrow hallway both of them live there in fear. Karen is claustrophobic and afraid of the dark.

Karen’s uprising is not pleasant. Her stepfather rapes her and her sister and Will are raised by an alcoholic father who eventually and their mother leaves them at an early age. He cannot sleep and eat food. Karen reveals her true love for Will. Although she suffers from her fear and her memories from the past, she helps him several times and saves him from death. Karen insists on moving from the house, but Will rejects her request. The situation is getting worse. Both of them for escaping from their fear, involve themselves in their work and be separated from each other. Examining the novel in reverse shows that quantum system event ‘A and B’ is not the same as stating ‘B and A’. In other words, the order of the events is very important and it influences on human judgment.

Conjunction Fallacy in *House of Leaves*

Conjunction fallacy shows that the probability of an event A can never be less than the probability of the conjunction of A with another event: $p(A) \geq p(A \cap B)$. It relies on models exploiting the mathematics of quantum mechanics.

The famous Linda problem shows conjunction fallacy in a short story describing a hypothetical person, Linda. Linda is 31 years old, single, outspoken, and very bright. She majored in philosophy. As a student, she was deeply concerned with issues of discrimination and social justice and also participated in anti-nuclear demonstrations. Which of the following is more probable? (a) Linda is a bank teller, (b) Linda is a bank teller and is active in the feminist movement (Wang and Busemeyer, 2013).

According to classical probability theory, the probability of the conjunction of events (b) can never exceed the probability of one of its constituent events (a). However, many studies have robustly shown that human participants consistently

rate option (b) as being more probable than (a), participants read a description of a liberal female college student named Linda and are asked to judge the probability of a series of statements about her after she graduated. This extensively studied experimental paradigm has shown that human participants consistently rate the probability of the conjunction (being a feminist and bank teller) to be greater than that of its constituent event (See Fig.3.1). This probability judgment error is so robust that it has been named the conjunction fallacy, and was originally explained by the representativeness heuristic (Bruza et al., 2014).

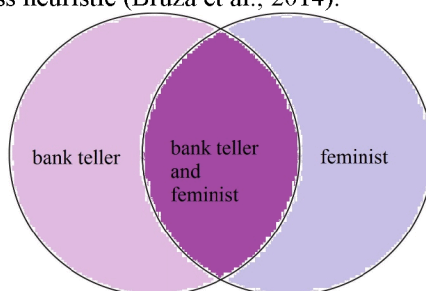


Fig.3.1. Conjunction fallacy. The probability of two events occurring together (in “conjunction”) is always less than the probability of either one occurring alone.

The researcher is chosen three probable scenarios from *House of Leaves*’ forum which the users of the website predict are possible for this novel. For applying the Linda problem to the scenarios, it is considered one condition for each problem to predict the probability of occurrence.

First scenario: Pelafina is the author of *House of Leaves* because of the Dante font. Pelafina’s font in her letters is Dante and it can be matched with the title page (MZD Forums, n.d.). Danielewski by choosing Dante font wants to send signals to the reader that Pelafina is the author of *House of Leaves* (See Fig.3.2).

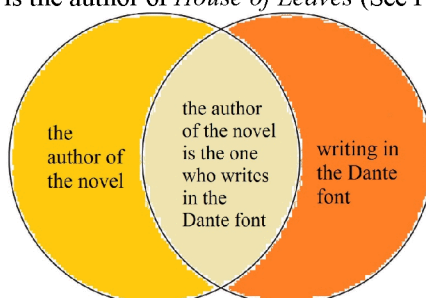


Fig.3.2. Venn diagram for the first scenario

As the diagram shows, when two events can occur separately or together, the conjunction, where they overlap, cannot be more likely than the likelihood of either one of the two individual events. However, people forget this and ascribe a higher likelihood of combined events, erroneously associating representativeness of events with higher probability (Díaz and Batanero, 2009). So, it is unlikely to occur that Pelafina is considered as the author.

Second scenario: Pelafina is the author of *House of Leaves* because the whole plot comes from the schizophrenic brain (See Fig.۳.3). The entire book has so many exact phrases that are repeated by different characters so according to me, there is no question the whole story should be a schizophrenic brain creation. All the names, for example, Lude, Leeder, Hook, Thumper, etc. are literally describing what those people do. Lude is a lewd character. Thumper is a prostitute. If you read the thread about names you will find a lot of names are literally describing the person who bears that name or something they have done in the book. This is a sign that these people are imaginary and were created by a schizo. Chad seems to be a younger version of Gdansk man because they both are always angry and chad wants to be an architect and Gdansk man is apparently working on a construction site. This is a perfect example of the limitations of a schizophrenic person's ability to create distinct personalities. That is why a lot of the characters resemble each other and their inner fears and issues are similar. They have all been created by the same person (MZD Forums, n.d.).

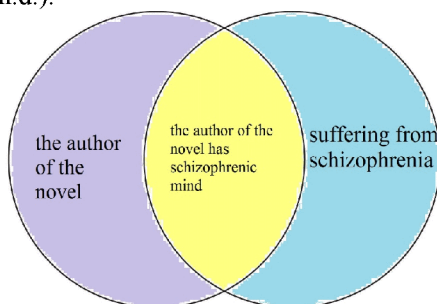


Fig.3.3. Venn diagram for the second scenario

Conditional probability is defined as the likelihood of an event or outcome occurring, based on the occurrence of a previous event or outcome. As it is shown in the diagram, the likelihood of each event is more than the intersection of two events. Therefore, the probability of occurrence in the second scenario is low.

Third scenario: Karen is the author of *House of Leaves* because of her writing in her journal in The Navidson Record. Karen spends the rest of her day writing in a journal. ... There is ample footage of her hard at work at this task, filling page after page ... Though she eventually uses up the entire volume, not one word is ever visible in The Navidson Record. To this day the contents of her journal remain a mystery. (MZD Forums, n.d.).

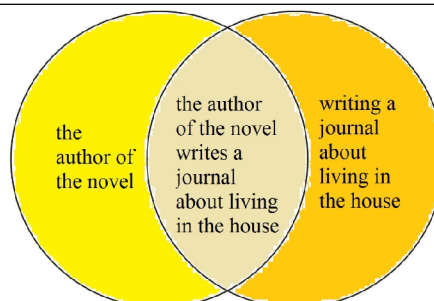


Fig.3.4. Venn diagram for the third scenario

According to quantum cognition, a key to explaining the conjunction fallacy is the incompatibility between events (Bruza et al., 2014). In these scenarios, the reader must be uncertain about the event and he or she must suspend between the two states. The users of the forum judge two events that can occur together. In the first scenario, they are uncertain about two events and eventually they predict Pelafina is the writer of *House of Leaves*. In the second scenario, the users predict Pelafina is the author because she was in a mental institution and the events of the novel are similar to the schizophrenic mind. At first glance, it is a logical prediction, but quantum probability shows us something else. In the third scenario, the users expect Karen is the author of the novel because it is mentioned she writes her time in the house. The reader becomes suspect that he or she reads Karen's mind, but the quantum probability shows the probability of occurrence of this event is lower than considering Karen as a character who just writes about herself in the house. The conjunction fallacy occurs when people judge the probability of a conjunction $P(A \wedge B)$ to be greater than one or other constituent probabilities $P(A)$ or $P(B)$, contrary to the requirements of probability theory. In cases where A causes B, the quantum probability model predicts that the conjunction fallacy should only occur for constituent B and not for constituent A. Experimental results show that the fallacy occurs equally for both, contrary to the quantum probability prediction. These results suggest that people's probability estimates do not follow quantum probability theory (Costello, Watts and Fisher, 2018).

Conclusions

This study was an interdisciplinary research which analyzed *House of Leaves* in the light of modern physics. It showed the new scientific discoveries in the twentieth century have indirectly affected literature. In parallel to modern physics, postmodern literature was developed and these two different fields of study met each other and their characteristics overlapped.

Quantum cognition dealt with how people made judgments and decisions under the uncertainty principle. The sequence of events had a key role in quantum cognition; this means that event 'A and B' was not the same as the event 'B and A'. The researcher studied the novel in reverse to show that *House of Leaves* had a quantum nature. The researcher used other articles and theses to show other researchers unknowingly had quantum look to the novel. The views that other researchers had in the novel were understood only in reverse look. Events in the

reading process had different meanings when the reader put the fragmented events together at the end of the story.

Conjunction fallacy was used in quantum mechanics to predict the probability of an event with one or more conditions. The researcher used probabilities which the users in *House of Leaves*' forum predict. Three scenarios were taken and studied under the light of conjunction fallacy. The result was that people's probability estimates did not follow quantum theory, so their predictions for the novel were wrong.

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بررسی شناخت کوانتومی در رمان «خانه برگ‌ها» اثر مارک ز. دانیلفسکی

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مطالعه حاضر تحلیل کوانتم شناختی از رمان «خانه برگ‌ها» از مارک ز. دانیلفسکی است. گروهی از فیزیکدانان و روانشناسان ایده جسورانه‌ای برای اصول انتزاعی نظریه کوانتوم خارج از فیزیک را در حوزه قضاوت و تصمیم‌گیری انسان معرفی کردند. دانشمندان علوم شناختی مدت‌ها تلاش کرده‌اند تا درک جامعی از نحوه قضاوت و تصمیم‌گیری انسان در شرایط تضاد و عدم قطعیت داشته باشند. در پرتو شناخت کوانتومی، قضاوت و تصمیم انسان قابل تعویض نیستند. در این تحقیق دو مفهوم شناخت کوانتومی در «خانه برگ‌ها» بررسی شده است: اهمیت نظم در کوانتوم برای نشان دادن ماهیت کوانتومی رمان به صورت معکوس مورد بحث و روایت قرار گرفته است. پس از آن، مغالطه ربط تعریف می‌شود و محققان سه سناریو از رمان را برای توضیح مغالطه ربط با نمودار ون انتخاب می‌کنند. در این مقاله بررسی می‌شود که خواننده چگونه وقایع رمان از هم گسیخته را با در نظر گرفتن جوهر کوانتومی در «خانه برگ‌ها» قضاوت می‌کند. با کمک شناخت کوانتومی، در این مقاله ثابت می‌شود که بین ادبیات پست‌مدرن و فیزیک رابطه نزدیکی وجود دارد و در قرن بیستم، اکتشافات علم بر ادبیات و «خانه برگ‌ها» تأثیر گذاشته است.

واژه‌های کلیدی: مغالطه عطف، فراداستان، پست‌مدرنیسم، شناخت کوانتومی، اصل عدم قطعیت.

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