CHAOS AND BORGES: A MAP OF INFINITE BIFURCATIONS

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ABSTRACT

The article proposes a methodology for the analysis of the logical structure of the time and plot in Jorge Luis Borges' short story "The Garden of Forking Paths" (1941). It builds on the ways Borges transmutes mathematical aesthetics into language through the lens of chaos theory and its links with literature. It becomes apparent that "The Garden" is a metaphor for a mathematical concept of time and its infinite bifurcations. This analysis of the 'orderly disordered' narrative focuses on the three main properties of chaotic systems in "The Garden". Secondly, temporal iteration and folding become the main structural devices employed by establishing analogies among fictional levels. In "The Garden", Borges describes a novel by Ts'ui Pên whose plot bifurcates at every point in time, with all the possible worlds coexisting in some sort of 'super-space' and 'super-time' coalescing in a moment. Then, the analysis shows that the story is a deterministic system by means of the moment-bound nature of the events. Thirdly, "The Garden" is sensitive to initial conditions because small changes generate infinite bifurcations. A close reading through the recursive symmetries across narrative levels confirms the structural pattern and elicits the experience of time as being complex and dynamic.

KEYWORDS: labyrinth; chaotic system; time; iteration; non-linearity; initial conditions.

1. BORGES AND MATHEMATICS

Jorge Luis Borges used elements of mathematics in his works and transmuted them into a literary style. There have been a number of publications on Borges' use of mathematical concepts in his fiction, such as Martinez "Borges and Mathematics" and Bloch's *The Unimaginable Mathematics of Borges' Library of Babel*. One important piece of evidence for the extent of Borges' mathematical training is found by reading the contents of his review of Kasner and Newman's *Mathematics and the Imagination* in *Selected Non-fictions*. In this essay, he covered a good sampling of logical paradoxes, diverse orders and infinity, topology and probability. Borges states that he will record "the immediate and accessible charms of mathematics, those which even a mere man of letters can understand, or imagine he understands." (Borges 1940[1]: 249) For Borges, innovative science that resembled fiction had the ability to stir his imagination, produce incredible narratives that bind the laws of nature with the fiction genre. He had the skill to cross the disciplinary boundaries to constitute fictional worlds.

His review of Kasner and Newman's book shows he had tried to understand the ideas behind complex mathematical concepts, although it is quite vague to what extent he engaged with the mathematical concepts he goes on to list:

the endless map of Brouwer, the fourth dimension glimpsed by More and which Charles Howard Hinton claims to have intuited, the mildly obscene Moebius strip, the rudiments of the theory of transfinite numbers, the eight paradoxes of Zeno, the parallel lines of Desargues that intersect in infinity, the binary notation Leibniz discovered in the diagrams of the I Ching, the beautiful Euclidean demonstration of the stellar infinity of the prime numbers, the problem of the tower of Hanoi, the equivocal or two-pronged syllogism. (Borges 1940[1]: 249)

According to mathematician and novelist Guillermo Martínez (2007), the fact that Borges mentions the latter mathematical concepts in his review, suggests that Borges had knowledge of at least first year university algebra and analysis studies. He was also aware of what in those days were controversial debated topics in the foundations of modern mathematics. In his essay "Avatars of the Tortoise" he says, "five or seven years of metaphysical, theological, and mathematical training would prepare me (perhaps) for properly planning a history of the infinite." (Borges 1962: 202) However, Bloch identifies two other sources for Borges' mathematical thinking. Firstly, Poincaré's 1908 *Science et Méthode*. In his book, Poincaré sets the foundations of elementary set theory, by explaining Georg Cantor's theorem, "Then the number of whole numbers, that of points in space, etc., constitutes what he terms a transfinite cardinal number —that is to say, a cardinal number greater than all the ordinary cardinal numbers." (Poincaré 1908: 144) Poincaré coined the term 'transfinite numbers', in which the whole is not larger than a part of it. In the context of two infinite sets, if we see that even numbers are only half of the natural numbers, in the sense that natural numbers are constituted by odd numbers and even numbers. We can try to match even numbers to natural numbers, assigning number 1 to number 2, number 2 to 3, number 3 to 6, and so on. Then, there will be a part, even numbers, which will be as large as the whole. WolframMathWorld defines it this way: "The *cardinal number* of any set is lower than the *cardinal number* of the set of all its subsets. A *corollary* is that there is no highest א (*aleph*)." In mathematics cardinality is defined as the size of a set. For instance, a set of these numbers [5,2,3] has a cardinality of 3 as it contains 3 elements, whereas the set of all odd numbers [1,3,5,7...] will have an infinite cardinality. This is the type of paradox that inspired Borges and transmuted it into fiction. Cantor developed the arithmetic of infinite sets, he chose the word *aleph* for cardinal numbers, and *omega* for ordinal numbers. This letter is the first letter of the Hebrew alphabet, Dauben suggests that "the aleph could be representing new beginnings" (Dauben 1990: 179) and Daghighi (2015) states that in Jewish theology, "the upper Yud in Aleph represents the hidden aspect of God (<u>Ein Sof</u> = סוף אין), whereas the lower Yud represents the revelation of God to mankind." Also, Daghighi links the word aleph to infinity, like Borges, "Ein Sof may be translated as 'no end', 'unending', 'there is no end', or 'Infinity'**!"** Borges (1949: 132) included the concept of 'aleph' in his short story "Aleph", explaining that "the whole is not greater than any of the parts", and the short story poses the

question of why the character Carlos Argentino chose this term. Bloch explains the connections between Cantor's aleph and its symbolic use in the work of Borges. Borges became familiar with Cantor's *aleph* through his readings of Poincaré. Bloch explains that "Borges' end leaf notations, dated 1939, indicate an interest in Lesage's discredited theory of gravitation and, more tellingly, in geometry and Cantor." (Bloch 2008: 145) Bloch also quotes Borges' words, "A great advantage of geometry lies in the fact that in it the senses can come to the aid of thought, and help find the path to follow, and many minds prefer to put the problems of analysis into geometric form." (Bloch 2008: 145). Bloch says that Borges' conclusions explain how Poincaré's readings reveal Borges' interest in "things living in higher-dimensional spaces." (Bloch 2008: 145)

Secondly, Bloch explains that, according to him, the other main book that contributed to Borges' inspiration from maths was Bertrand Russell's *Principles of Mathematics* (1903), which it seems he also read and annotated in 1939 as with Poincaré (from a 1939 printing). In the essay "When fiction lives in Fiction", Borges argues that he had been intrigued by the concept of infinity since his childhood, and that he read Russell's work on infinity,

> I discovered in one of Russell's works an analogous invention by Josiah Royce, who postulates a map of England drawn on a portion of the territory of England: this map- since it is exact- must contain a map of the map, which must contain a map of the map of the map, and so on to infinity. (Borges 1939: 160)

The technique of inserting a world within a world, a story within a story with repetitions and self-similar structures is a methodology Borges will use in his fiction, including "The Garden of Forking Paths". This could evidence how Borges anticipated the main concepts chaos theory, as he used fiction that had the main characteristics of chaos theory has in science. Also, this shows how Borges was interested in debates in mathematics and logics of the time, which he used to incorporate as elements of his unique literary style.

Borges constructs his works in a style that has affinity with mathematical aesthetics. On the one hand, he develops mathematical ideas in his stories; some of them even contain small mathematical lessons. For example, the concept of infinity and eternity clearly arises in many of his short stories by using repetitions in time. According to Rimmon-Kenan, "the most striking way in which action can transcend time is by the coincidence or repetition of the same occurrence in different temporal dimensions and/or in the lives of different people" (1980: 645) and repetitions across periods of time make "The Garden's" structure. Martínez, in his first class in *Borges and Mathematics* explores how the theme of infinite is frequent in Borges' work. A recursive object would be found in "Aleph" through Cantor's infinities and the little sphere that encompasses every image in the universe; in "Pascal's Sphere", he shows the infinite sphere of which the centre is everywhere and the circumference nowhere. Furthermore, Borges' "Book of Sand" book does not have a beginning or an

end, just as the fractional numbers between 0 and 1 are infinite and can be explained by using 'Cantor's Diagonal Argument.' Another example that Martínez provides is how "The Library of Babel" is described as useless, as all those books could have fit in a volume with infinite pages. Also, he mentions that in "On Exactitude in Science", Borges used growing maps, where the map of a province covered one city. Furthermore, Borges' interest in the infinite is clear in "The Garden of Forking Paths", which I will analyse in detail in the following section. I argue, that in "The Garden", Borges takes the idea of infinite one step further, time is an infinite labyrinth.

While the maze is important in "The Garden of Forking Paths", elsewhere in his work, Borges' other short stories' structures also use scientific concepts and logic to shape literary form. To illustrate, in "The Babel Library", the librarian's task of finding the right books through the intricate corridors of the place is compared to the task the reader needs to do to decode the symbolic language of the narratives: "the febrile Library, whose hazardous volumes run the constant risk of being changed into others and in which everything is affirmed, denied, and confused as by a divinity in delirium." (Borges 1944[2]: 78) According to Borges, written language is a desperate attempt of speakers to make sense of their ignorance because the alphabet has a limited amount of characters, thus there is limited number of messages a human can write. Borges states that "to speak is to fall into tautologies" (Borges 1944[2]: 79), as he believes verbal utterances always encapsulate feelings of unspeakable fear and wonder because they encompass all possible past meanings.

In the passage in "The Library of Babel", Borges linked the creative process of decoding the truth and meaning behind a text to the uncertainty mathematician has before solving an equation. To illustrate, according to Sieber, Borges' "labyrinth is a symbol of a system in which there are two simultaneous goals: emerging from the labyrinth and immersing oneself completely in the labyrinth." (Sieber 2004: 208). It means that Borges engages with the audience by creating an ambiguous maze. The readers know it is a fictional creation and that it has many dead ends, but still feel "hoodwinked" by the creation of such an intricate form and are intrigued about how the puzzle will unfold. In the moment of writing, Borges executes it through an aesthetic unfolding. These are recurring themes across Borges's work that come together in one story, "The Garden of Forking Paths". I propose to begin my study here. It will encompass both his revolutionary mathematical ideas about bifurcation that he anticipated and the formation of his mathematical thought through the logical structure of the plot. Mathematical elements clearly arise and I will read them through the lens of chaos theory and its links to literature the literary criticist Katherine N. Hayles identified in 1990 in her ground-breaking book, *Chaos Bound: Orderly Disorder in Contemporary Literature and Science*. She points out that both chaos theory and literature have the following main characteristics that also appear in Borges' short story: firstly, the novel constitutes an assemblage of sentences to

define order out of a chaos-bound environment, secondly, there is an absence of an empirically subject or origin, finally, the short story uses iteration as a narrative device.

2. THE GARDEN AND ITS BIFURCATIONS

"The Garden of Forking Paths" is a short story that was first published in the collection "El jardín de los senderos que se bifurcan" (1941), republished in *Ficciones (Fictions)* in 1944 and translated into English in 1962 by Anthony Kerrigan. These dates link the story closely to the period of reading of Poincaré and Russell that I have discussed above (he had 1939 copies of both authors' works).

"The Garden of Forking Paths" takes the form of a spy's story, which is a statement by Dr. Yu Tsun. Dr. Tsun is a Chinese professor of English in the United Kingdom during World War I and a spy for the German Empire during World War I in the UK and Captain Richard Madden is looking for him. He knows that his arrest is coming soon, and his aim is to convey the knowledge to the German Empire of the location of a British artillery park before he is captured. To do so, he runs away from Madden and goes to Dr. Stephen Albert's house. Albert, who is a very wise sinologist, finds out that Tsun is Ts'ui Pên's descendant and explains that he has been studying his ancestor's work for a long time. Ts'ui Pên is the ancestor of Dr. Tsun, who is one of the main characters in the short story. Ts'ui had created an intricate novel and a labyrinth, but no one could make sense of either because they were unfinished and mysterious. However, Albert reveals that he has found a solution to this: the book and the labyrinth are the same thing. Albert goes on to show Tsun his ancestor's (Ts'ui Pên) book "The Garden of Forking Paths", which has been interpreted as being a metaphor for time. After this revelation, they see Madden approaching the house. Tsun draws a revolver and kills Albert. Tsun is arrested and sentenced to death by hanging. By murdering Albert, he has revealed the location of the artillery park he was meant to unveil to the Germans.

The concept of infinity is crucial in "The Garden", as Ts'ui Pên's labyrinth has an infinite structure. In the story, Stephen Albert, meets Dr. Tsun and learns about Tsun's ancestor's life his and main tasks: to create an "infinite maze" and a book that could also be "infinite." (Borges 1944[1]: 88) Towards the dénouement of the story, Albert tells Tsun that the book is a riddle whose theme is time in the sense Dr. Tsun imagined. Dr Tsun envisioned the labyrinth as "a maze of mazes, of a sinuous, ever growing maze which would take in both past and future and would somehow involve the stars." (Borges 1944[1]: 85) Therefore, the infinite diverging and converging series of time is the basis of this short story, which "embraces every possibility" (Borges 1944[1]: 91).

While Rimmon-Kenan the argued that the governing principle of "The Garden" are analogies among fictional levels through repetitions, in this paper, I claim that those parallels amongst literary levels are analogous to iteration and self-similarity in chaos theory. Thus, I propose a methodology to explore how chaos theory principles and time constitute the backbone of "The Garden's" depictions of death, dreams and loss. Indeed, I will suggest that "The Garden" and other Borges' fiction have a labyrinthine, self-similar structure. Chaos theory can be used to predict the weather, the stock market or natural shapes. It models non-linear patters where the image of the whole can be found within any part of it. Self-similarity is symmetry across scale. It implies recursion and it is a result of an iterated function. Because self-similarity in structure and iteration words is so common in Borges, he is often considered as predicting postmodernism. He uses an aesthetic approach common to postmodernists and mathematical thought that will be further developed by subsequent writers.

The concept of infinite and intricate time frames and places in a labyrinth which are mentioned both in the short story "The Garden of Forking Paths" and the book with the same name within the short story foresaw the 'many-worlds' interpretation. In quantum theory, there is an experiment to prove the concept wave-particle duality of light: a source of light illuminates a plate, the wave is split in two waves through two slits to interfere, producing bright and dark bands and later they are combined into a single wave. Differences in the path, create an interference pattern, if a person places a detector at the slits, each photon will pass through just one slit, instead of through both (as particles would normally behave – only a particle goes through 1 slit). When a detector is not present, an interference pattern is formed and light appears to behave as a wave. This experiment shows the principle of wave-particle duality and how the interference pattern does not happen if a person is observing. This way the wave will collapse, instead of splitting due to uncertainty, this wave of probability was described by Schrödinger. The multiple possibilities that describe the quantum indeterminacy of the photon collapse into just one possible location. Baulch explains that for literary narratives, this behaviour is analogous to the "reader's multiple expectations of various possible courses of action in a narrative. In narratives that conform to a single-valued notion of reality, these multiple possibilities vanish, leaving a single, real, or actual narrative for the reader to follow." (2003: 60) "The Garden of Forking Paths" envisions possible worlds or possible variations of the world even with incompatibilities, Fang killing or not killing a stranger and the two epic versions of the chapter. It seems that, according to Borges, time is the key, as one possibility would collapse into the others and the true reality will become apparent. However, the realm of fiction arises when Ts'ui Pên's madness leads him to embrace all possible destinies by building a failed labyrinth, as his work is chaotic and incoherent.

Borges inhabited the realm of fiction and dreams and anticipated the concept of the many-worlds interpretation. He became familiar with the theory of time called Serialism, which was coined by the British soldier, aeronautical engineer and philosopher John William Dunne in 1927. Borges wrote the essay "Time and J. W. Dunne", published in *Non Selected Non-Fictions* (1940), on Dunne's concept of precognitive dreams and how dream searches derive both from the past and from the future. Borges does not think Dunne's thoughts are scientifically true, "Dunne's method to attain an infinite number of times simultaneously is less convincing and more ingenious", (Borges 1940[2]: 218), and O'Connell also states that "his quasi-mystical ideas about time and human perception, however, have little basis in the king of hard-headed empirical investigation."(O'Connell 2009: 223) However, Dunne's philosophical explorations catalyse Borges' thoughts about the nature of time, "I feel the passage of time and time itself are a single mystery and not two." Dunne explores the concept of infinity in dreams, and discusses how they can lead to the cognitive experience of being in different time frames at the same time. Borges engages with Dunne's concept of time by arguing that,

> Dunne, surprisingly, presumes that eternity already belongs to us, as corroborated by the dreams we have each night. In them, according to him, the immediate past and the immediate future intermingle. Awake, we pass through successive time at a uniform speed; in dreams we may span a vast zone. To dream is to orchestrate the objects we viewed while awake and to weave from them a story, or a series of stories. (Borges 1940[2]: 219)

Dunne conjectures express the idea that in our dreams we can break through the barriers of time. Then, Borges explains how he feels the nature of time is mysterious and that Dunne's main mistake is to pretend to replace the object of time itself by a visual image. It means that Dunne assumed dreams became life as such. Although his theories are not based on scientific evidence, and Dunne does not intend to do so, this concept was quite provocative at the time they were published and provided Borges insightful reflections that inspired to create his fiction. O'Donnell concludes that although they were attracted to "perverse guises […]" their "own creative imaginations" (2009: 235) bring them together.

In fact, later on, scientists developed the concept of 'many worlds' interpretation in quantum physics. In 1956, Hugh Everett III wrote his PhD thesis on the Universal Wave Function, which in the 1970s was renamed by Bryce Seligman DeWitt as many-worlds. In "The Garden" Borges describes a novel by Ts'ui Pên whose plot bifurcates at every point in time, with all the possible worlds coexisting in a 'super-space' and 'super-time' coalescing in a moment. Borges' labyrinth is not physical, but temporal.

> Differing from Newton and Schopenhauer, your ancestor [Ts'ui Pên] did not think of time as absolute and uniform. He believed in an infinite series of times, in drizzly

growing, ever spreading network of diverging, converging parallel times. This network of time - the strands of which approach one another, bifurcate, intersect or ignore each other through centuries. (Borges 1944[1]: 91)

In Borges' world, the universe is conceived as infinite Chinese boxes and parallel to the many-worlds interpretation. It is great to read how here Borges uses the word 'infinity' in the Greek sense, meaning chaos and disorder. O'Donnell explains how the word *apeiron* can be translated as "without boundary" (2009: 229)

Despite the fact that after Tsun's conversation with Albert Tsun senses a jungle of parallel worlds, they have the property of succession. Even if the time periods are intertwined, nostalgia still plays an important part in how time is conveyed. Borges expresses that the achievement of an expectation implies to "exclude or postpone all the others", therefore, eternity is something we should aim for, but it is impossible to achieve. (*A History of Eternity* 1999: 136) In fact, harshness of life collapses with the nature of dreams, a life is wholly in the past and is a mental state. It has an illusory nature and irretrievable, by presenting death, Borges nullifies time. It seems that the only way humans can have a glimpse of a god-like experience of eternity. In spite of the fact that Borges was agnostic, it seems that characters only have a glimpse of the eternal before dying. This is seen in the passage where Tsun kills Albert. Tsun says, "It seemed to me that the dew-damp garden surrounding the house was infinitely saturated with invisible people. All were Albert and myself, secretive, busy and multiform in other dimensions of time. I lifted my eyes and the short nightmare disappeared." (Borges 1944[1]: 92) These Godlike instants, are called by James Irby "the central dilemma of the contingent and the absolute." (1962: 249) As Yu is preparing the revolver, he states, "the future exists now." (Borges 1944[1]: 92) This means that, in Pên's preordained book, Yu is meant to kill Albert; in another world, Albert kills Yu; in another, Madden kills them both, and so on.

Bifurcation of time lines can be studied in physics too. In the study of dynamical systems, a bifurcation diagram shows the possible long-term values of a system as a function of a bifurcation parameter in the system. The physics professor Claudius Gros states that, "the nature of the solutions to a dynamical system, as defined by a suitable first order differential equation […], may change abruptly as a function of some control parameter a. The most commonly observed transitions in dynamical states are 'bifurcations'." (*Complex and Adaptative Dynamical Systems* 2015: 53) Bifurcation is a phenomenon which occurs when a small change in the control parameters create a qualitative change in the measured output of a system. One can visualize this with a simple experiment in which weight is slowly added onto a table. Since mass is slowly increased, for most of the time nothing will happen. However, once a critical point is reached, the table will break and exhibit a qualitative change in the system. Chaotic bifurcations are usually represented with a logistic map, which shows how chaotic behaviour arises from simple non-linear dynamical

equations. Each of these nodes is a period-doubling bifurcation. The bifurcation diagram shows the forking of the possible periods from one, to two, to eight, to sixteen, etc. Similarly, "The Garden of Forking Paths" depicts a series of infinite bifurcating times, where time is not linear and forks, converges and diverges in a growing network. Albert suggests the example of a stranger as a character, knocking on Fang's door (another character) and the possible outcomes of this encounter, also, he poses the example of Tsun being his friend or his enemy in other possible pasts. Furthermore, when Albert read passages of Tsun's ancestor's manuscript he reads two versions of the same epic chapter. Chaotic behaviour in the text would arise through an infinite iteration. For this reason, the contradictory chapters from Pen's *Garden of Forking Paths* can be graphically represented in a chaotic bifurcation diagram.

Map of the forking paths

Background image: bifurcation diagram of the logistic map.
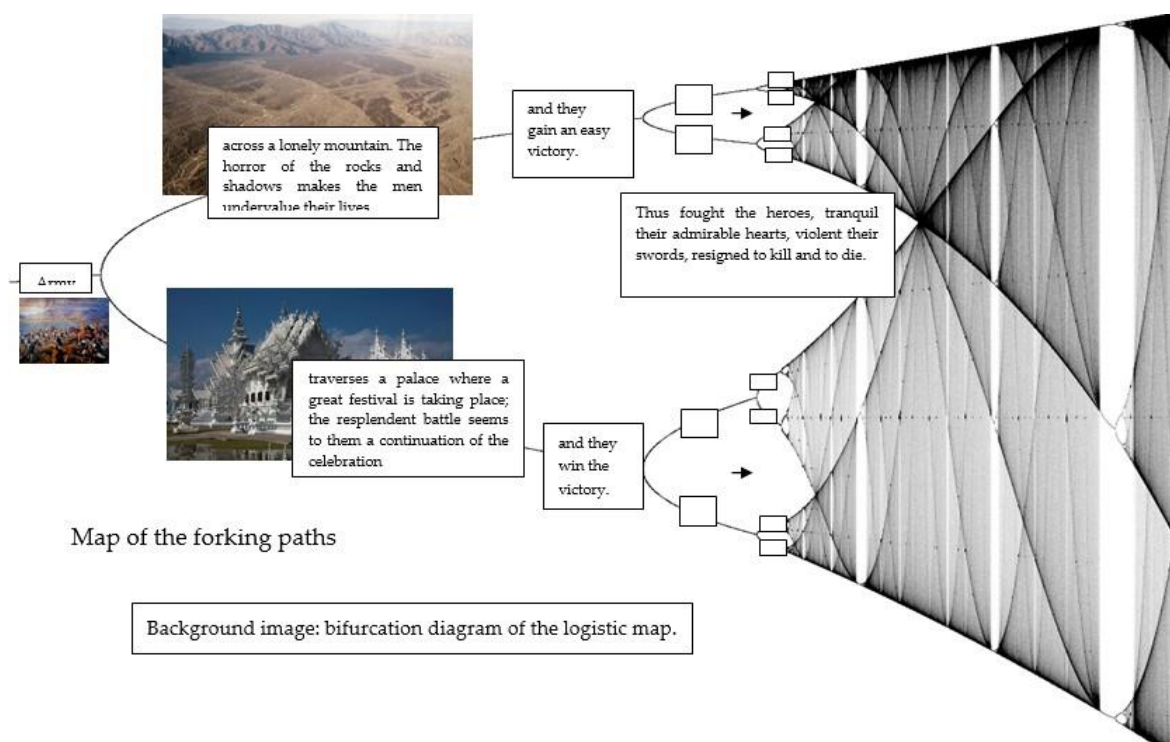
I illustrate the nonlinear behaviour of time that T'sui Pên describes with this bifurcation diagram. Albert reads two versions of the same epic chapter that begins with an army and forks into different outcomes,

In the first, an army marches into battle over a desolate mountain pass. The bleak and sombre aspect of the rocky landscape made the soldiers feel that life itself was of little

value, and so they won the battle easily. In the second, the same army passes through a palace where a banquet is in progress. The splendour of the feast remained a memory throughout the glorious battle, and so victory followed. (Borges 1985: 90)

It describes two possible times - the army walking through the rocks or marching through a palace. The tale embraces all these different possibilities but both gain a victory. The simultaneous two possibilities of the epic story proliferate and fork through time; they are infinite and convergent at the same time. In the final outcome Albert reads the armies' paths converge in one future, "Thus the heroes fought, with tranquil heard and bloody sword. They were resigned to killing and dying." (Borges 1944[1]: 90) However, it is only an intermediate state, from which the paths could fork again infinitely, not necessarily with similar outcomes both showing a chaotic behaviour.

Secondly, "The Garden of Forking Paths" aims to present a logically coherent narrative that bears an unfolding of purely abstract original ideas through recurring patterns. Not only time in "The Garden", is infinite, but also recursive. These two main properties lead me to apply chaos theory principles as a methodology to understand how the structure of the story is constructed and how they will convey further philosophical remarks on death and loss. The three main principles that are common to chaos theory and "The Garden" are: firstly, iteration and folding are the main structural devices employed by establishing analogies among fictional levels. Secondly, the story is a deterministic system by means of the moment-bound nature of the events. Thirdly, it is sensitive to initial conditions because small changes produce different effects in the plot.

Iteration is the governing structural principle of Jorge Luis Borges' "The Garden of Forking Paths." Chaos theory provided a new way of looking at natural shapes through recursive symmetry, and literature can also reflect complex shapes that are scale dependent in the shape of a labyrinth. According to Barrenechea, Borges use of labyrinths "stirs an inevitable uneasiness." (1965: 60) She explains that the labyrinth-universe metaphor gives "the concept of chaos its grandeur and horror." (1965: 61) In "The Garden", just as in "The Library of Babel", the labyrinth-universe metaphor is amplified by using it in four forms. According to Barrenechea,

> the ancestor's labyrinth imagined first in the form of vast boundaries, the cyclically interpreted novel, the same novel later relieved in a plurality of destinies, and the suggestiveness of the path which leads him to the crime, from the station to the house. (1965: 61)

At another level, the idea of a physical labyrinth gives comparisons to other philosophical and metaphysical labyrinths, "the steps a man takes from the day of his birth to the day of his death, trace an inconceivable figure in time" (1952: 128), pointing at Man's inability to decipher a "divine" message. Barrenechea points out that Borges' use of labyrinths shows how he was not

influenced by the age of Existentialism, because he had "not been stayed by the anguish of choice or by the mutilation it implies." (1965: 35) The use of a labyrinth is a symbol of infinity, chaos and how men are lost in the universe. The structure of "The Garden" reflects these chaotic properties. I am applying Hayles' methodology for reading literary works with the lenses of chaos theory: Borges' labyrinthine garden structure reflects a shift of focus, from the individual to the different recursive levels in an iterative process. Instead of focusing on the events that happen to each character in the story, which might be random, reading through the recursive symmetries across narrative levels confirms the overall structural pattern.

In terms of structure, there is a parallel between complex structures described by chaos theory and the structure of the narrative in "The Garden". "The Garden" has a self-similar structure, we can find recursive similarities among the narrative levels and characters. Firstly, there are parallels between the three main characters: Yu Tsun, Stephen Albert and Ts'ui Pên. That is, in Gérard Genette's (1972: 238-51) terms, an analogy between the three 'diegetic levels.'[1]

The extradiegetic level is Liddell Hart's account of the war, narrated by the same editor and responsible for quoting Tsun's dictated narrative. The diegetic level accounts for the events that Yu Tsun narrates. The metadiegetic level is the story within a story, which is Ts'ui Pên's story told by Stephen Albert.

Secondly, there are two main self-similar structures among the narrative levels. Firstly, the title of the short story is "The Garden of Forking Paths". Likewise, Pên's novel is called "the Garden". In addition, Albert's garden abounds in zigzagging footways and is also called "The Garden of Forking Paths". Finally, we know that Tsun grew up in a symmetrical garden of Hai Feng. Through the process of iteration, the concept "The Garden of Forking Paths" appears in different contexts and acquires different meanings and helps postulate meaning. The second recurring pattern is about the chain of murders. Pen was murdered by the hand of a stranger. Stephen Albert was killed by a stranger. Yu Tsun is himself about to be hung for this crime. Therefore, it can be argued that self-similar structures provide a new way of looking at "The Garden". The scale-dependent labyrinth works not only as a symbol and but also as a structural device.

Repetitions in "The Garden", bring sometimes juxtapositions of opposing terms, contrasts abound especially towards the end of the story (Borges 1944[1]:

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[1] I adopt Genette's three "diegetic levels": The extradiegetic level is the level of the narrative's telling. The diegetic level is the level of the characters, their thoughts and actions. The metadiegetic level or hypodiegetic level the part of a diegesis that is embedded in another one.

92). We have the contrast between dreams, "infinitely saturated with invisible people", and reality "there was only a single man". The contrast between the present and the future follows, "the future exists now". Finally, the contraposition of failure and success is highlighted when Tsun is going to die, "I have been condemned to hang. Abominably, I have yet triumphed!" The juxtaposition of terms that are opposite in meaning is a system studied by critical theory. From a Derridean perspective, there is no true opposition between a pair of conceptions. Derrida deconstructs Rousseau's hierarchical dualities, such as nature/culture. He demonstrates that the original privileged term is an illusion. For example, he argues that "the opposition between nature and culture which I have previously insisted on seems today to offer a value which is above all methodological." (Derrida 1978: 278-96) There is a critique of logocentrism, where one term is not subordinated by the other; rather, by mutually opposed intents, both views are correct and neutralized. Borges engages this post-structuralist view because he identifies the opposites through diegetic levels and at the same time renders them interchangeable. In Albert's example, Fang resolves to kill the stranger. This is analogous to the events of the diegesis, where the stranger kills Albert. The narrative events are parallel, but the action and its effects are opposite.

I argue that "The Garden of Forking Paths" is a deterministic system due to the moment-bound nature of the events that are narrated. At all diegetic levels, the narrator emphasizes that "everything happens to a man precisely, precisely *now*." (Borges 1962: 20) It means that the actions occur only in the present, have no past and no future and, thus, cannot be changed. Therefore, passing of time "changes and transfigures everything; nothing remains of what being from other eras saw, enjoyed, or suffered." (Berrenechea 1965: 102) Borges expresses the human anguish about forgetting, and how when people die, they take memories with them. In his *Poems*, Borges states,

> I am touched by the frail wisdoms
>
> lost in every man's death
>
> his habit of books, of a key, of one body
>
> among the others. ("Deathwatch on the Southside" 1969: 71)

In "The Garden", Borges engages with the determinism, when ideas of how time changes everything and how restoration of the past is impossible are conveyed. Deterministic expressions of finality abound: "implacable death", (Borges 1944[1]: 82) "a future as irrevocable as the past" (Borges 1944[1]: 84) "irrevocable decision", (Borges 1944[1]: 87) "the details are irrecoverable." (Borges 1944[1]: 88) The irrevocability of the actions emphasizes the deterministic nature of the system's future states. Chaotic systems are deterministic. If the initial state was known, the future could theoretically be predicted.

Knowledge about the future state of the chaotic system is limited by the precision with which the initial conditions are measured. This is a feature that accounts for both chaos theory and Derridean deconstruction; the inability to specify with accuracy the initial conditions of the system. In Derrida's (1978: 280) words, it was necessary to believe that "there is no centre… that the centre had no natural site." In "The Garden" the abstract concept that underlies the story is concealed by means of a riddle. Albert says,

> 'The Garden of Forking Paths' is an enormous guessing game, or parable, in which the subject is time. The rules of the game forbid the use of the word itself. To eliminate a word completely, to refer to it by means of inept phrases and obvious paraphrases, is perhaps the best way of drawing attention to it. (Borges 1944[1]: 91)

This quotation shows a way in which Borges' engages and includes an original procedure that revitalises the genre of crime fiction, and also, how another element of unreality is added to the story. In the Garden, Borges, instead of using his frequent technique of speaking of undefined places, things or conditions, he chooses not to mention the main theme of the plot. By choosing not to use the word 'time' we can say that either the aim is to amplify the indefinition of 'time', or that it was forgotten to be mentioned, which is also another recurrent technique in Borges' fiction. The absence of the word 'time' makes temporal relationships timeless and infinite, "Forgetfulness projects its temporal infinity." (Berrenechea 1965: 135) Although the solution of the riddle is almost inaccessible, Albert, after many years of arduous studying was able to decipher it. Borges' work, though, describes an elusive Platonic world, where the world is arranged by a certain order that can only be deciphered by a few.

We can conclude that the use of scientific terms and the principles of chaos theory in literature help reduce indeterminacy in texts. By doing so, the new methodology of chaos theory has been shown to be successful in finding new ways of understanding the narrative and in recognising the behaviour of time in "The Garden of Forking Paths", as complex and dynamic. It also provides a new critical language that may help to define postmodernist inherent philosophical indeterminacy. Chaos theory and its implications help to provide a renewed perspective on postmodern critical discourse. My thoughts align with O'Donnell's views on Borges' engagement with Dunne's serialism. Although Borges doesn't seem to be the type of man who would be persuaded with Dunne's claims, he seems to have been "utterly captivated by the way in which these ideas facilitated an artistic line of approach to such fundamental mysteries. […] A speculative starting point from which to begin" his "fictional explorations" (2009: 225).

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