
The Influence of Poincaré's Thoughts on the Origins of Random and Chance in Works of Marcel Duchamp and John Cage

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Abstract

Chance is a broad concept which has become an important factor in linking science and art in the twentieth century. Simultaneously, concept emerged as a new scientific paradigm in Arts by Henry Poincaré and especially Marcel Duchamp, who has affected many artists such as John Cage, one of aleatoric music pioneers. This paper investigates the differences and similarities of the chance concept in the art of Duchamp and Cage and Poincaré's effects on them, that in this regard, employs a descriptive method and relies on library resources.

Results show that the viewpoint of Cage and Duchamp is the same in the indifference aesthetics, the provisional and the conventional nature, the importance of audience's perceptual spaces, and the non-existence of real infinity which is the result of the influence of the Poincaré's thoughts on both of them and is interpreted as 'systemic chance' or 'absolute chance.' Their difference also lies on Duchamp's scientific origins (Poincaré's thoughts) and Cage's spiritual origins (Zen Buddhism). Hence, the influence of Poincaré's thoughts on Cage can be divided into two periods: before Duchamp's death) Chaos theory, Topology, Non-Euclidean geometry, and N-dimensional spaces (and after that) eclipse Poincaré's Thoughts with Zen, Prajñā, and Satori, (which ultimately ends up solving Poincaré thought in Zen.

Keywords : Chance, Henri Poincare, Zen, Marcel Duchamp, John Cage

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“In fact, the whole world is based on chance, or at least chance is a definition on what happens in the world we live in and know more than any causality.”
 Marcel Duchamp (Judovitz & Duchamp, 2010: 125).

Introduction

Chance and the idea of chance-based art, peaked in the 1950s, was first broached in artistic forms of the early twentieth century. Chance was one of the most important strategies of Dada in order to destroy old aesthetic habits or to create new patterns of perception, freed artists from the rule of reasoning and created causality into the creative act itself) Watts & Cunnington, 1980: 1 Molesworth, 2006: 178) Arts followed the new science attitudes to the notion of chance as a possible key to a non-mechanical interpretation the universe that was soared into the quantum theory and indeterminacy principle, which together would annihilate any deterministic construct of the physical universe, especially in Henri Poincaré's thought (Watts & Cunnington, 1980: 4; Sheynin, 1991: 41).

For Poincaré, the notion of chance is conceived in a conceptual scenario where determinism always prevails (Junior, 2016: 177). Henri Poincaré's account of chance phenomena in terms of their complexity and instability is discussed (Galavotti, 2005: 5). In his thought: “[w]e take elements which at the first glance are unconnected; these arrange themselves in an unexpected order, and form a harmonious whole. We cannot believe that this unexpected harmony is a mere result of chance” (Poincaré, 2012: 100). The harmony our theories reveal cannot be understood either as an objective

feature of the world outside our mental capacities nor simply as a subjective emotional response projected upon nature by us. Poincaré argues that this harmony is part and parcel of our intellectual capacities and an ideal we follow in our enquiries. He claims that “[t]his harmony is at once a satisfaction of our aesthetic requirements, and an assistance to the mind which it supports and guides” (Ibid: 396-397). For Poincaré unification is the ultimate goal of science. It is in revealing ‘hidden kinships’ and ‘real relations’ in the phenomena that Poincaré finds the aim of science accomplished and our understanding of nature fulfilled (Ivanova, 2015: 120). Hence, the aim of science is prediction rather than, say, explanation. Poincaré believed that scientific laws are conventions but not arbitrary conventions. So, Conventions, yes; arbitrary, no.¹

These scientific paradigms at the beginning of the twentieth century had many effects on Marcel Duchamp, as an effective figure in this century Art, who embraced with an enthusiasm the idea of using chance procedures (Elder, 2015: 148; Henderson, 1984: 205-208). Attention to chance operations is continued in John Cage's works, his colleague, by reflecting the transformations of Dada in his music and communicating with visual artists specifically through Duchamp (Revill, 2014: 67; Eppley, 2017: 347). Therefore, it is not surprising that his ideas are rooted in the aesthetic ideology of the Dadaists, Duchamp and their attitude toward chance and randomness (Bernstein & Hatch, 2010: 14). In the 40s and early 50s, marks significant changes in Cage's musical style and aesthetic philosophy, with chance

and random operations appearing in his works (Jaeger, 2013: 25-26). In addition to reflecting Duchamp's ideas, the effect of Eastern philosophy, especially Zen Buddhism, is obvious as a constant and permanent factor in the substructure of all Cage's later works (from 1950's later) (Fetterman, 2012: 16-27).

Hence, we have two artists, Duchamp and Cage, who use chance operations in their works. In the attitude of chance, Duchamp was influenced by Poincaré's scientific thought, and Cage has been influenced by Duchamp and Eastern philosophy (Zen) simultaneously. Since there is no evidence that Cage studied Poincaré directly (Rau, 2005: 51) and Cage never saw science or the practicality of technology as contradictory to the spiritual and aesthetic dimensions of art (Ibid: 18), this study aims at explaining the chance concept in Duchamp and Cage while trying to observe the influence of Poincaré ideas on their changes. Therefore, the paper focused on similarities and differences in their application of the chance concept in their works, and the influence of Poincaré's thoughts on them, especially Cage. Thus, a descriptive method used to examine attitude of Duchamp and Cage toward chance and identifying their similarities and distinctions and the main focus of paper based on investigation the origins of chance and randomness in the works of these two artists in relationship with Poincaré ideas. The research data are based on Cage's original documents and library references, and the final analysis has been done with the intention of explaining the origins and various usages of chance and random operations in their

works.

Duchamp and Cage's attitude to chance

Marcel Duchamp (1887-1967) and John Cage (1912-1992), were two modern artists who embodied the very spirit of the avant-garde and lived on "the permissive borders of modernism." Though they came from two different generations and emerged from differing milieus, both were the products of the war that modernism declared on entropy in the name of progress and change (Roth & Katz, 1998: ix).

Given Duchamp's exploration of the limits of painting, in spite of his first fame as a painter renders his abandonment in 1913 of conventional painting and drawing. (Judovitz, 1998: 16) He explains "I was interested in ideas—not merely in visual products) "Chipp & Selz. (1968: 394) So, he starts experimenting with chance operations and announces his future discovery of the 'readymades' (Judovitz, 1998: 47) The readymade, which was first introduced by *Bicycle wheel* of 1913, was a direct development from Duchamp's engagements with chance. Through this idea that any object could become a work of art through selection by the artist, the readymade is transformed into a work of art through the selection and intervention of the artist (Jensen, 2011: 7). Duchamp emphasized that the choice of his readymades was "based on a reaction of visual indifference with at the same time a total absence of good or bad taste... in fact a complete anesthesia"² (Ruhrberg et al., 2000: 457).

According to Duchamp himself, he

turned to chance as an amusement. He later became increasingly interested in the concept as an opportunity to escape the control, and avoiding his own judgment and taste. It was also an escape from traditional methods of perception and expression (Jensen, 2011: 4). A musical piece that Duchamp made using random methods was the *Erratum Musical* (Musical Misprint) of 1913. *Erratum Musical* is a score for three voices derived

Duchamp said: “the idea of ‘le hasard,’ which people were thinking about at the time [around 1913] struck me too. ... pure chance interested me as a way of going against logical reality; [one could do this] by putting something on a canvas, on a bit of paper, by associating the idea of a perpendicular thread a meter long that falls from a height of one meter onto a horizontal plane, making its own deformations, à son gré.... *My Three*

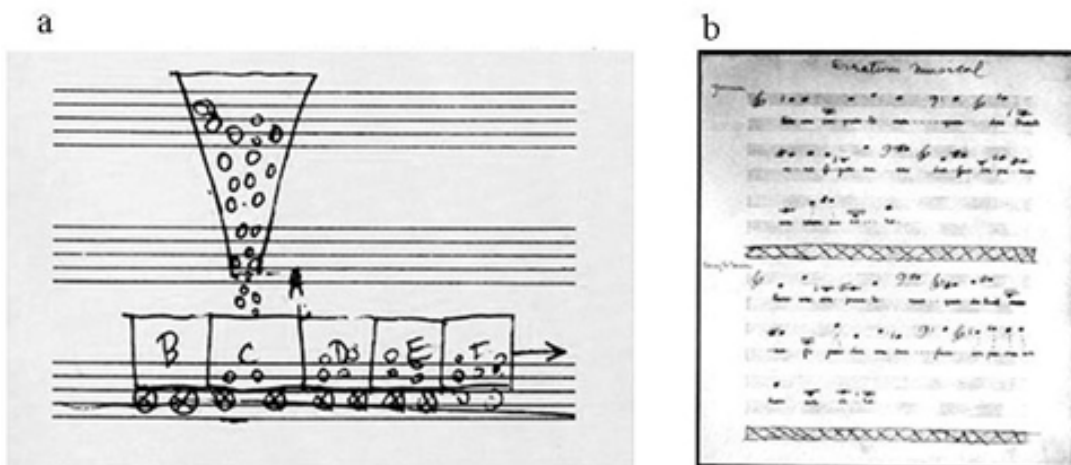


Figure 1: Marcel Duchamp, *Erratum Musical*, 1913; (a) Sketch, www.allmusic.com; (b) Score, (Judovitz, 1998: 50)

from a chance procedure. The musical score was set up for three voices, but without any instructions on how it should be performed (Figure 1). That choice was left to the performer, rendering a variety of possibilities in performance (Ibid). This piece was one of “Duchamp’s first attempts at what he would soon term ‘canned chance,’ entailing the domestication of the arbitrary through its systematic, predetermined deployment” (Demos, 2006: 104).

In an interview with Pierre Cabanne,

Standard Stoppages is produced by three separate experiments, and the form of each one is slightly different. I keep the line, and i have a deformed meter. It is, so to speak, a canned meter. It is diverting to preserve chance” (Moffitt, 2003: 308).

As Duchamp himself noted, *Three Standard Stoppages* (1913-14) (Figure 2) represents a radical turning point in his work, marking his abandonment not only of painting but also of the conventional notions of art (Judovitz, 1998: 47). In an interview of 1961, asked what he

considered to be his most important work, he replied: “As far as date is concerned I’d say the *Three Stoppages* of 1913. That was when I really tapped the mainspring of my



Figure 2: Marcel Duchamp, 3 Standard Stoppages, Paris 1913-14, Wood box 11 1/8 x 50 7/8 x 9” (28.2x 129.2 x 22.7 cm), the Museum of Modern Art, New York,

future. In itself, it was not an important work of art, but for me it opened the way - the way to escape from those traditional methods of expression long associated with art. For me the *Three Stoppages* was a first gesture liberating me from the past” (Kuh, 1962: 81). The key note of this works is “3 Standard Stops=canned chance” (Shearer & Gould, 1999: 2). This work categorized by Duchamp as “a joke about the meter.” Duchamp sets the viewer straight by graphically showing that the authority of the meter as a measuring device relies upon distortions that he corrects through chance operations (Judovitz, 1998: 48).

Duchamp’s idea of inventing a ‘playful physics’ appear in *The Large Glass* (Figure 3), which generally focuses on its iconography and chance methods. The work, a complex and ironic representation of human lovemaking as a mechanistic and endlessly frustrating process, was made using oil, lead wire, lead foil, dust

and varnish on two large panels of glass, which together make the piece nearly three meters high and two meters wide (Molderings, 2010: 113).

Although Duchamp was the European model for many of the new notions of art, he was old in 1950 -over sixty-, when John Cage made a major leap of imagination by entering into his experiments with the chance (Roth & Katz, 1998: 40). In 1942 and at the invitation of Max Ernst and Peggy Guggenheim, he came to New York, where he met Marcel Duchamp and wrote music for Duchamp’s part in Hans Richter’s film *Dreams That Money Can Buy* (1946) (Nicholls, 2002: 11; Lotringer, 1998: 55). Around the same time, with the look of Cage to Asia (especially Zen Buddhism and the Chinese classical oracle book, the I Ching), a spiritual and musical revolution emerged in him. Cage used the *I Ching* (Figure 4) to compose music in accord with nature’s manner of operation (Martin, 1976). Following the I Ching’s method of divining hexagrams by tossing three coins six times, Cage could locate



Figure 3: Marcel Duchamp, *The Large Glass* (*La Mariée mise à nu par ses Célibataires, Même*), 1915-23, Oil, varnish, lead foil and wire, and dust on glass mounted between two glass panels, 9 ft. x 1 1/4 in. x 5 ft, 9 1/4 ; Philadelphia Museum of Art

corresponding places on each grid and thereby define the necessary elements for each acoustical event within the final composition (Joseph, 2009: 215). He thus purposefully used the *I Ching* to attain purposelessness. Purposelessness, according to Cage, is a removing of one's own intentions and one's own desires to attain a particular goal (Martin, 1976). The result was worked such as *Music of Changes* (1951), *Imaginary Landscape No. 4* (1951), *4'33"* (1952), *Williams Mix* (1952-53), *Fontana Mix* (1958), *Variations* (1958-67) and works he wrote after 1950.



Figure 4: The chart of I Ching or The Book of Changes; It contains 64 symbolic hexagrams that diviners interpret.
www.thethreewisemonkeys.com

Cage also invented rule-based chance systems to render unfixed compositional techniques, a sort of programmed indeterminacy (Jensen, 2011: 8). In notating his early chance compositions, Cage employed two basic techniques. The earliest was the space-time method used in *Music of Changes, 4'33"* and the time-length pieces such as *26'1.1499" For a String Player* of 1953 (Figure 5(b)) In the summer of 1952. Cage devised a quicker means of generating a chance composition by placing the notes on the page either with random templates (well-known to point-drawing system), as in the *Music for Carillon No. 1* (Figure 5(a)), or where he found tiny pocks and bumps in the paper he used to write the work, as in the *Music for Piano* series of 1952-56 (Holzaepfel, 2001: 3; Pritchett, 1996: 113).

Of his music is that indeterminacy rather than process became the primary focus of his discussions. The fixation upon chance was understandable. The composer had reinforced associations made between his concept of process and non-intention, disorder, and unpredictability (Casey,

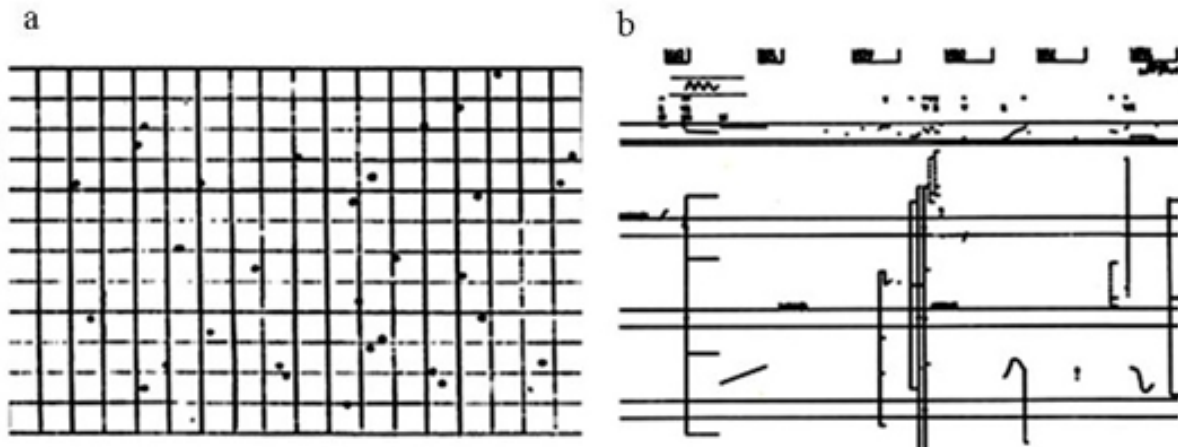


Figure 5: John Cage, (a) *Music for Carillon No. 1*, 1952 ,(Pritchett, 1996: 93); (b) *26'1.1499" For a String Player* 1953, www.fondazionebonotto.org

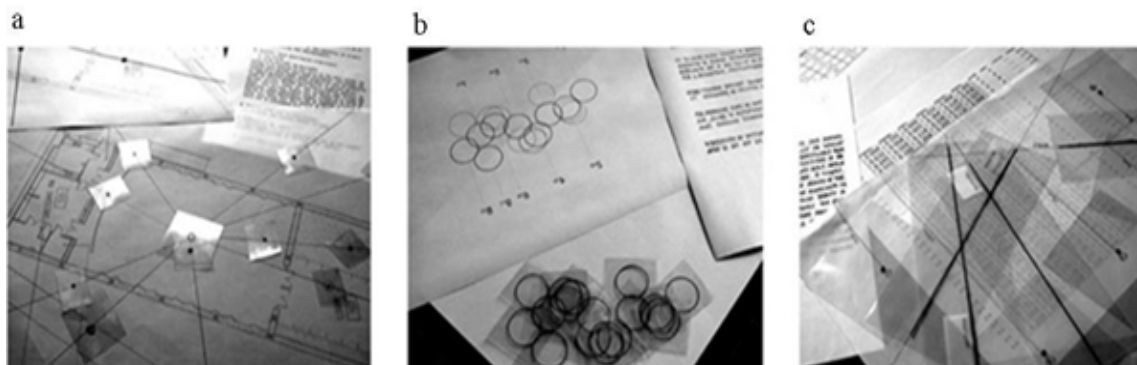


Figure 6: John Cage, (a) Variation No.2, 1961; (b) Variation No.3, 1962; (c) Variation No. 4, 1963; www.stableunstable.com

2016: 672-673). For example, Cage's 4' 33" is known as the most radically indeterminate in the repertoire of aleatoric music (Jeongwon & Song, 2002: 270). The composition consists of three passages amounting to 4 minutes and 33 seconds; the duration of each passage being determined by a chance operation (Jensen, 2011: 9). Cage's 4' 33" certainly invites the audience to engage, through its own sounds, in the making of the work as co-authors and performers (Jeongwon & Song, 2002: 270). That's a reminder of what Duchamp said: "The creative act is not performed by the artist alone; the spectator brings the work in contact with the external world by deciphering and interpreting its inner qualifications and thus adds his contribution to the creative act" (Duchamp, 1999).

The culmination of the idea of promoting the listeners to the status of assistant composer can be seen in Cage's variations (Figure 6), a varied collection of compositions prepared in very different ways. They take score forms that range from very precise instructions (*Variations I, II, III, IV, VI*) to reflections

on early performances (*Variations V*), handwritten sketches (*Variations VIII*) or only few words (*Variations VII*). The works encapsulate Cage's interest in maps, astronomy, system design, spatial sound production and multimedia (Hope et al, 2012: 1). Therefore, the orientation of the dots and lines is completely open, meaning that there are an infinite set of potential configurations of the score. The performances consist of any combination of configurations and therefore in theory *Variations II* may describe any possible musical work. In this sense it "represents the most flexible composition tool that



Figure 7: John Cage, *Not Wanting To Say Anything About Marcel, I*, 1969, www.wikiart.org

Cage ever invented” (Vickery et. al., 2012: 428). Other works of this decade (1960s), have been interpreted as anarchistic, such as *Musicircus* (1967), *Reunion⁴* (1968) and *HPSCHD* (1969) (Haskins, 2012: 2-7).

In 1969, following Duchamp’s death, Cage created *Not Wanting to Say Anything about MarceF* (Figure 7), comprising eight sets of plexigrams with randomly placed text and images, as a tribute to his

viewer, has not been on view at the Museum since 1970 (Norton Simon Museum, 2010).

When Cage began creating his first print series in Crown Point Press in 1978, done later in his life, he had been practicing the self-discipline of using the I Ching in his musical compositions for almost thirty years⁶ and its purpose, he often said, was “to sober and quiet the mind” (Rau, 2005: 172; Nicholls, 2002: 109).



Figure 8: John Cage, (a) *Seven Day Diary, Day Six*, 1978, National Gallery of Art; (b), *Changes and Disappearances No. 35*, 1982, National Gallery of Art; (c), *Dereau #3*, 1982, Published by Crown Point Press,

friend Marcel Duchamp. This innovative work, with its captivating construction and endless possible interpretation by the

The first project was in 1978, the etching *Score without Parts and Seven Day Diary* (Figure 8(a)) created from

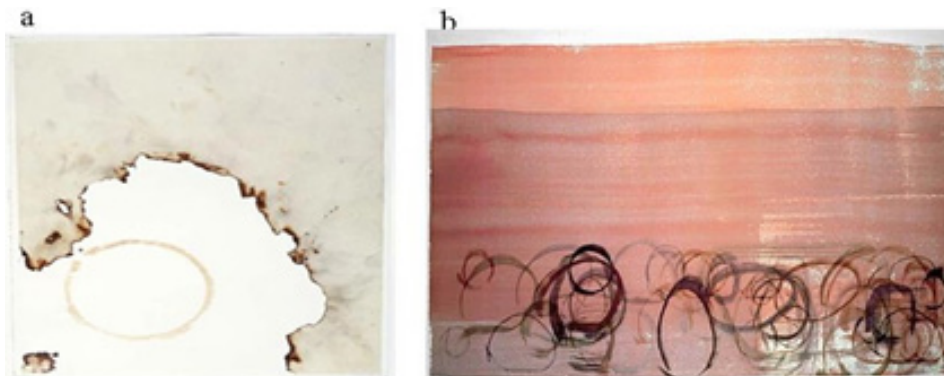


Figure 9: John Cage, (a) *Eninka #42*, 1986, Published by Crown Point Press; (b) *New River Watercolor, Series IV, #4*, 1988, Contemporary Arts Gallery, New York.



Figure 10: An even bigger brush. John Cage, Peter Lau, and Ray Kass. Image owned by Ray Kass and Virginia Tech Photographic Services. Via www.johncage2012.com.

notated instructions, and based on various combinations of drawings by Henry David Thoreau. Cage drew it with his eyes closed, not free from structure, but it conformed to a strict structure developed using random and chance operations. Finally, Thoreau's drawings informed the last works produced in 1978, *Signals* (Ibid: 113-115).

Between 1979 and 1982, Cage produced a number of large series of prints: *Changes and Disappearances* (1979–80) (Figure 8(b)), *On the Surface* (1980–82), and *Déreau* (1982) (Figure 8(c)). These were Cage's last works using engraving. In 1983, he began to use various uncommon materials such as foam, cotton batting, etc., followed by fire and stones (*Eninka, Variations, Ryoanji*, etc.)

It is not difficult to see the influence of Duchamp in Cage's compositional work if one thinks of Duchamp's *Erratum Musical* (Jensen, 2011: 8-9). However, for Cage's tastes: "There are too many things that could happen that don't interest me, such as pieces of paper sticking together and the act of shaking the hat ... I enjoy details

and like things to be more complicated." Despite a superficial similarity, Cage soon recognized that his compositions had far surpassed those of Duchamp in the complexity of the processes used (Joseph, 2009: 214-215).

According to Jensen, chance in Duchamp's attitude is "as a selection from possibilities" and "as an amusement" and in Cage's attitude is "the Passage from open composition to open-end realization" and "was not so much about embracing chaos and the irrational." Thus, Duchamp's understanding of chance was something far from random. Chance and randomness are usually considered as synonymous; however, chance has a broader scope than randomness. Broadly speaking, both are used to qualify events that are unpredictable in the sense that they have no particular aim or direction (unbiased events) and that they occur in an irregular and disordered (haphazard) (www.plato.stanford.edu). According to Werner Meyer Eppler's⁷ definition, "a process is said to be aleatoric [chance] [...] if its course is determined in general but depends on chance in detail" (Meyer-Eppler, 1958, 55).

So, Duchamp's way of invoking chance was a very rigid approach, that he himself termed 'canned chance' (Jensen, 2011: 2), as Cage said "Most people who believe that I'm interested in chance don't realize that I use chance as a discipline. They think I use it as a way of giving up making choices. But my choices consist in choosing what questions to ask" (Millar, 2010). Therefore, Like Duchamp, Cage had a rigid and controlled way of working with chance. He always insisted

on the instructional frame. In all his experimentations with chance, it seems that Cage sought a balance between the rational and the irrational. He did so by using random events within the context of a very controlled system (Jensen, 2011: 10). But the difference is in determining the parameters and the perception of the audience. In Duchamp's method, the parameters are pre-defined by the artist and the outcome or realization of the work are out of the artists control, but in Cage's method, some parameters are pre-defined by the artist and others are assigned by the audience with Cage's indeterminate, open-ended approach. This concept of the artwork process in Cage's view is similar to Duchamp's 'idea of the fabrication.'

Generally, chance has always been related to a rebellious attitude against conventions and standards (Jensen, 2011: 2). Referring to the poet Jackson Mac Low's view of chance, it can be divided into two categories: 'systematic' and 'impulsive' chance (Mac Low, 1978). 'systematic chance' means using objective methods of random orders such as in using dice, cards, random-digit tables, or the I Ching. 'Impulsive chance', on the contrary, can be defined through the example of the painter Jackson Pollock: "He has often been said to have worked by chance, but his was a highly controlled kind of chance, that had to do with his personality and how he flung things around. He was real careful where he was flinging things even though the exact placement and area of the drip or squiggle of paint was not entirely defined by him consciously" (Fetterman, 2012: 20). Furthermore, chance, aleatory, and indeterminacy in

music are usually considered the same. From this perspective, chance music can be classified into three types: 1- the use of random procedures to produce a determinate, fixed score: this type includes scores in which every parameter is fixed before their performance. 2- mobile form: In this group of indeterminate music, chance elements involve the performance. The events are provided by the composer, but their arrangement is determined by the performer. 3- indeterminate notation: where traditional musical notation is replaced by visual or verbal signs suggesting such as graphic notation and texts (Griffiths, 2001; Jeongwon & Song, 2002: 269).

All of these triple chance can be determined in the works of Duchamp and Cage which may be their central point in systematic approach to Chance. So, With these definitions and previous references, anyone can consider the attitude of Duchamp and Cage towards chance as a 'systematic chance', although there is an obvious difference between them but in the following sections, we will see their underlying differences.

The Boundaries of Random and Chance Operations in Poincaré's Thought and Zen Philosophy

Considering to the direct influence of Cage from Duchamp and Zen in chance concept, and his indirect influence of Poincaré's scientific thoughts, in this section we examine the relationship between Poincaré and Zen in order to find the similarities and differences between them.

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Henri Poincaré (1854-1912), as a “monster of mathematics” in his era, studied the different fields of pure and applied mathematics such as fluid mechanics, optics, telegraphy, electricity, cosmology, topology, non-Euclidean geometry and quantum and relativity theories. He also worked on automorphic functions of one complex variable (Fuchsian functions) and on analytic functions of several complex variables (Abelian functions) and in the field of celestial mechanics he studied the three-body spaces and later the n-body spaces (Fotiadis, 2015: 347; Benaroya, Han & Nagurka, 2013: 498). The development of such mathematical constructs as complex numbers, quaternions, n-dimensional geometry, and non-Euclidean geometry during the course of the nineteenth century had forced mathematicians to reexamine a number of their fundamental assumptions. No longer could they believe that mathematics represented a true picture of the world—that mathematical progress was a matter of uncovering the hidden laws of nature. They were forced to admit that certain aspects of mathematics are the constructs of human reason. One could no longer deny the existence of such mathematical entities as n-dimensional spaces with $n > 3$ or of non-Euclidean spaces in which Euclid’s parallelism postulate does not hold. Such spaces may not have physical analogues, but mathematically, they are no less real than three-dimensional Euclidean space (Adcock, 1984: 250).

Poincaré, also, was the first person to detect a chaotic deterministic system. He wrote in his book, *Science and Method*: “A

cause so small as to escape our attention, determines a considerable effect that we cannot help but see. We then say that this was the result of chance. If we knew the laws of Nature exactly and the precise situation of the universe at the initial moment, we could then accurately predict the situation of this same universe at some future moment. ... It can happen that small differences in the initial conditions create very large ones in the resulting phenomena. A tiny error in the initial state leads to an enormous error in the final state. Prediction becomes impossible” (Poincaré, 1914: 68). As essential point made by Poincaré is that chance and determinism are reconciled by long-term unpredictability. Poincaré knew well how effective probabilities are for describing the physical world. He knew that chance is part of everyday life (Ruelle, 1993: 48).

In Zen philosophy, we also face a similar viewpoint. Zen sees the actual world as chaos or *Hun-Dun*, the old Chinese character of chaos. In this thought, if we explain the word ‘chaos’ with other terms, then chaos becomes, in a sense, ordered. In this sense, creativity and cosmos as the expression of chaos are not related dualistically, but are reality and its concerns. The relation of chaos and cosmos in Zen can ultimately be understood as absolutely contradictory as well as absolutely self-identical (Kawamura, 1994: 67-68). The real world of chaos, where the mind is open to absolute limitless openness in complete transparency, is attained as cosmos in each individual and can be expressed in every manner possible. On the other hand, for Zen, the *Void* (Mu), or emptiness (or *Sunya*

in Sanskrit), is a *maelstrom*, or chaos around our puny constructed order; but this maelstrom is at heart a 'source'- the source, in fact, of the universe. The *Void* is thus associated with *Hun-Dun*, whose allegorical hospitality allows the order to thrive (and who can be destroyed by an overzealous attempt to polarize order and chaos as value-laden opposites). The *Void* is a positive, plenary that gives birth (as the etymology of the Sanskrit term, *Sunya* indicates) to order and the 'ten thousand things' (Kundert-Gibbs, 1999: 19-20). Yet, the mind, the *Kokoro*, can only emerge as chaotic-cosmos in the field where the vertical and horizontal dimensions intertwine perfectly (Kawamura, 1994: 82).

In this regard, Poincaré points out the two sorts of minds that are equally necessary for the progress of science; both the logicians and the intuitionists have achieved great things that others could not have done. Analysis and synthesis have then both their legitimate roles (Poincaré, 1969: 205). There are two similar concepts in Zen: *Vijñāna* (translated as consciousness, mind, and discernment) is discursive knowledge; and *Prajñā* (wisdom, discriminating knowledge and intuitive apprehension) is insight into the true nature of reality and grasping reality in its oneness. In fact, *Prajñā* is subject and at the same time object (Damien, 2003). In reasoning mind (*Vijñāna*), we look for things like 'true' and 'false,' but the intuition mind (*Prajñā*) reflect whatever appears exactly as it is, without obscuration, and in the present moment, which ultimately leads to a state of awareness beyond everything,

called Satori (enlightenment). Poincaré, as a precursor of intuitionism⁸, also stated "But how have we attained rigor? It is by restraining the part of intuition in science, and increasing the part of formal logic... we have attained perfect rigor". He said elsewhere: "In these complicated edifices raised by the masters of Mathematical Science, it is not enough to affirm the solidity of each part and admire the mason's work; one must understand the architect's plan. Now, to understand a plan, one must see all its parts at once, and only intuition can give us the means to take in all at a glance" (McLarty, 1997: 97-103) which knew it 'sudden illumination.'

On the other hand, to find out more about the concept of chance and random, we define the two concepts of 'indifferent hypotheses' and 'conventions' in Poincaré's thought and its relation to Zen.

Chance and probability are important concepts in Poincaré's epistemology, that is, determinism always prevails while probability, in turn, is always based on a set of conventions and hypotheses that seek to overcome the uncertainty that surrounds scientific knowledge (Junior, 2016).

There are what Poincaré called 'indifferent hypotheses' that the analyst assumes at the beginning of his calculations, and that is neither true nor false but whose role is to be positioned in a structure. As such they are very different from geometrical conventions (Heinzmann, 2009: 16). This indicates the term of "*anattā*⁹ dhammā sabbe" means "all Phenomena are not-self" or "All *dhammas* are without soul. Here, *dhamma* means all phenomena. In this

context, the term *anatta* is not restricted to the individual, but it goes beyond it and sometimes it includes all the phenomena (Thero: 91; Peacocke, 2006: 1), which leads to *Prajñā*. There is no difference between matter and energy. Everything is, in truth, happening. There is also not a multiplicity of events. There is just one event, with multiple aspects, unfolding. Zen, more than anything else, is about reclaiming and expanding the present moment.

Therefore, from such a position, there are numerous ways of describing the world; no one can be said to be truer than any other(s). one way can only be said to be more useful than another under a certain set of circumstances. Such arguments can lead to arbitrariness, as Poincaré himself was well aware. Since he believed that there was an external world and that it could be discovered through science, he eschewed extreme conventionalism, or ‘nominalism,’ as he called it (Adcock, 1984: 250; Heidelberg & Schiemann, 2009: 111). He wrote in his book, *The Foundations of Science*, “These conventions are the work of the free activity of our mind, which, in this domain, recognizes no obstacle. Here our mind can affirm, since it decrees; but let us understand that while these decrees are imposed upon our science, which, without them, would be impossible, they are not imposed upon nature” (Poincaré, Halsted & Royce, 2014: 28). Thus, chance, says Poincaré, knows how to mix things but not how to disentangle; So, if we see a homogeneous blend it is likely there is a hidden order behind the phenomenon, hence the ‘selected fact’ appears as chance

(Williams, 2014: 46).

Ultimately, the aforementioned points indicate Poincaré and Zen’s subscription to the presence of “order in chaos.” Both see the universe as a dynamic phenomenon, in constant flux, and nature as essentially a mechanism of chance and probability. One should not be ignorant of their differences. The main difference is the ‘subject.’ There is no definable and specific subject in Zen, while there is always a scientific subject in Poincaré thought. Therefore, their intuition is different in the underlying layers.

Roots of chance on the art of Duchamp and Cage

According to the previous sections, John Cage, through his close relationship with Marcel Duchamp, would have found Duchamp’s works all the more suitable as indexes of his own interest in uncovering convergences of thought from diverse sources, aesthetic, scientific and spiritual (Rau, 2005: 53). Moreover, in the early years of the twentieth century, the striking scientific developments of the period included a great increase in popular and professional attention to non-Euclidean geometry. Henri Poincaré, one of the leading scholars of the subject, was also a widely read theorist of the scientific discovery process, keenly concerned with the role of the intuition and the subconscious (Holton, 2001: 127). For this reason, researchers such as Adcock, Shearer, and Henderson all examine the many instances of Duchamp’s detailed, systematic replay of Poincaré’s ideas and illustrations of non-Euclidean and 4th-dimensional geometry in which he creates

pseudo-scientific models that challenge aesthetic determinism in the way that what Poincaré had done regarding scientific determinism.

As previously mentioned, in Duchamp's *Musical Erratum*, one of his first attempts at 'canned chance,' an sketch of some notes had drawn from a hat. But even this playful scene was somehow too subjective, even romantic, for Cage's tastes (Kostelanetz, 2003: 224). Despite the simplicity of this piece, Cage's compositions such as *Music of Changes*, *Imaginary Landscape No. 4*, *4'33"*, *Music for Carillon No. 1*,..., and his *Paintings with using tools* such as *I Ching*, *Star Map*, *stone...* (Figure 4 & 10), are reminder of Duchamp's hat. Because of setting chance with these tools, chance operations of Duchamp and Cage can be called 'systematic chance'. So, their use of chance was no embrace of chaos. Cage said: "The difference between our attitude toward chance probably came from the fact he was involved with ideas through seeing, and I was involved through hearing. I try to become aware of more and more aspects of a situation in order to subject them as individually to chance operations" (Kostelanetz, 2003: 224). However, in Duchamp's *Erratum Musical*, the idea of the readymade and the found object and the creative act was resonated strongly with Cage's *4'33"*. Furthermore, 'systematic chance' of Duchamp and Cage can be equated with Poincaré's 'absolute chance'¹⁰: "According to quantum mechanics, there are elementary physical processes which are not further analyzable in causal chains, but which consist of so-called 'quantum jumps'; and a quantum jump is supposed to be an absolutely

unpredictable event which is controlled by neither causal laws nor by the coincidence of causal laws, but by probabilistic laws alone" (Fetterman, 2012: 20).

Duchamp involving with the scientific argumentation in *the three Standard Stoppages* and his 'idea of the fabrication' can be seen in many of Cage's works, whether in his notations or in his musical performances. In addition, many of the scientific aspects of this work such as topology, non-Euclidean geometry, and n-dimensional spaces, reflected in many works of Cage.

From the topological point of view, Poincaré explains that "in this discipline, two figures are equivalent every time it is possible to have one correspond to the other by means of a continuous deformation, whatever the law governing the deformation may be, provided that continuity is maintained" (Ashton, 1966: 246). Many of Cage's works can be viewed from this perspective. A most striking instance is the Cage's transparent and layered scores which he were made according to the chance operations. For example, *Fontana Mix* (1958), *Cartridge Music* (1960), *Variations* (1958-67) which were the passage from open composition to the open-ended realization of scores, as well as, his eight sets of plexigrams that reminds Duchamp's one. Hence, according to the moving structure, the idea of the fabrication of scores and the use of dots, lines, and geometric shapes, We are faced with 'deformation' and 'continuity' that can be interpreted as topological transformations and non-Euclidean geometry. Also, the multiple layers and transparency of these scores



make them open to all perspectives or 'interpretations' and create the fourth-dimensional spaces, like Duchamp's *Large Glass*, as reminded of Poincaré's idea that: "there is an analysis situs of more than three dimensions" (Poincaré, 2010: 19). Another important point is the reflection of 'indifference aesthetics'¹¹, a total absence of good or bad taste (false or true) and employing neutrality as their springboard. Cage had also reinforced in these pieces, associations made between his concept of process and non-intention, disorder, and unpredictability; although these were not so much about embracing absolute chaos and the irrational. What comes from the evidence, Cage have shared Poincaré's attitude to the provisional and conventional nature of scientific aspects and aesthetics. In total, they suggest that there is a freedom involved in choosing between alternatives. Therefore, many of the Poincaré's scientific effects on Duchamp are visible on Cage's works reviewed until this time.

But after Duchamp's death, by changing Cage's attitude toward the surrounding, his tool of expression changed from music to painting. When he created his first print series (1978), he had the experience in using *I Ching* and chance operation about thirty years. His paintings, most of all, represent Zen's philosophy, as he began to divine what it would mean to apply his compositional processes to visual art and his first attempt to convey visually the Zen sense of the fullness of the *void* (*Mu* or emptiness) and the space in between. In Cage's paintings, the rocks are earth; the smoke, fire; the washes, the oceans, and mist. Cage explained, "I'm producing a

situation like what happens in nature" (Nicholls, 2002: 115).

In Cage's big sets of prints (1979-1982), included *Changes and Disappearances*, *On the Surface*, and *Déreau* (1982), we encounter with complex works, which pay tribute to his faith in both nature and human inventiveness. The intentional visual complexity of these prints also creates a screen for Cage's discomfort with self-expression, intention, and self-criticism. It is not until Cage begins drawing around stones in his Ryoanji works that he begins to resolve these issues. After these works, Cage changed practically everything in his approach.¹² His watercolors at the Mountain Lake Workshop (1988-1990) shows the culmination of the Zen-like chance operations and of the intuition mind presence (*Prajñā*) which emphasizes on the present moment and complete totality or oneness, bring up enlightenment (*satori*).

Therefore, concerning Cage's systematic chance and process-oriented way of working, the presence of Poincaré's scientific perspective of nature and chance, eventually, in Cage's last period paintings, we are faced with solving (or transforming) the Poincaré ideas in Zen. The dominant analysis is more Zen-like than scientific.

Conclusion

The present study depicts the influence of Poincaré's thoughts on Marcel Duchamp and John Cage. The following items might be pointed out regarding the contributing factors to the chance concept and its operations, common in the artistic attitude of Duchamp and Cage:

- a total absence of good or bad (false or true) values and attain to purposelessness or 'indifference aesthetics': removing one's own intentions and one's own desire to attain particular goal, by using chance tools such as I Ching, point-drawing, hat.

- The acceptance of the provisional and conventional nature in everything: a freedom involved in choosing between alternatives such as using ready-mades, layered scores, along with the ideas of invention and fabrication.

- Emphasis on the audience and his perceptual spaces: involving the audience by creating open-end structures of realization and his interpreting, using indeterminate approach and the creative act.

- Non-existence of real infinity: universal probabilistic mechanism of chance indicates a unity, such as attention to the process of constructing a piece instead of the final result, because in the process of construction, the performer becomes one with the piece itself, and then with the world around it.

These common items represent the effects of Poincaré on both of Cage and Duchamp. Chance in Poincaré's thoughts have described as "sensitive dependence on initial conditions," that is, "small differences in the initial conditions produce very great ones in the final phenomena," Which represents 'absolute chance.' Important to the initial conditions for the production of a work of art through the chance tools in the viewpoint of Cage and

Duchamp, depends on Poincaré's thought, is interpreted as "systematic chance" and is equated to "absolute chances."

From the chance concept perspective, Duchamp's idea of rigid chance and Cage's idea of disciplined chance, have many things in common, but Duchamp was directly influenced by Poincaré's scientific ideas¹³ and Cage by Zen Buddhism and their main differences rooted in their origins.

The influence of Poincaré's thoughts on Cage can be divided into two periods: before and after Duchamp's death. Before, Cage's musical attitude correspond with Poincaré scientific terms, including topology, non-Euclidean geometry, and n-dimensional spaces as well as topological concepts of 'deformation' and 'continuity'. In addition, Cage's works makes fourth-dimensional spaces through 'interpretations' of the multi-layers and transparency scores. After Duchamp's death, instead of previous Poincaré's scientific concepts of chance, he focused on the Zen chance operations and the intuition mind presence (*Prajñā*) which leads to *Satori* (enlightenment), especially in his last paintings. Therefore, Cage, unlike Duchamp, adapted Poincaré's thought to Zen Buddhism and ultimately created his own definition of chance and randomness.

Endnotes

1. For more information, see: iep.utm.edu.
2. Theoretically, Duchamp's aesthetic of chance was closely bound up with the category of the possible. His new artistic techniques of 1913 and 1914—from the unclassifiable Three Standard Stoppages in their original form as three 'canvases' to the equally unclassifiable 'readymade

sculptures' of a bottle rack and a bicycle wheel on a kitchen stool—were based on a new kind of aesthetic that centered around the notion of the 'possible' (Molderings, 2010: Xiv).

3. Erratum Musical was conceived the year after the American composer John Cage (1912–92) was born, and 30 years before he made his own contribution to aleatoric music.

4. Nicolas Slonimsky wrote in the 1978 edition of Baker's Biographical Dictionary of Musicians: "He [Cage] also became interested in chess and played demonstration games with Marcel Duchamps [sic], the famous painter turned chessmaster, on chessboards designed by Lowell Cross to operate on aleatory principles with the aid of a computer and a system of laser rays." The following brief description, by the Duchamp biographer Calvin Tomkins, is close to being accurate, as far as it goes: "Entitled Reunion, the event consisted of Cage and Duchamp (and then Cage and Teeny) playing chess on a board that had been equipped with contact microphones; whenever a piece was moved, it set off a gamut of amplified electronic noises and oscilloscopic images on television screens visible to the audience" (Cross, 2006: 35-36).

5. The title refers to a comment Jasper Johns made to Cage when artists were encouraged to respond in memoriam to Duchamp's death. Johns said, in effect, I don't want to say anything, and Cage used this for his title.

6. Cage produced a substantial body of visual work during the fourteen years before his death in 1992. It included over 670 prints, 150 drawings and 114 watercolor (Rau, 2005: 1).

7. Aleatoric music became known to European composers through lectures by acoustician Werner Meyer-Eppeler at the Darmstadt International Summer Courses for New Music in the beginning of the 1950s.

8. Poincaré contrast three kinds of intuitionism: banal, expansive, and restrictive. The banal merely says research and teaching require something beyond formal rigor—perhaps 'motivation'. Expansive intuitionism claims the actual content of mathematics goes beyond any formalization. The restrictive rejects some standard mathematics as inaccessible to intuition. Poincaré was an

expansive intuitionist (McLarty, 1997: 97; Pombo, 2012).

9. Anatta: non-self, non-ego, absence of self, existing, real ego-entity or soul as some abiding substance.

10. Karl Popper distinguished between two type of chance: 'absolute chance' and 'causal chance.' Popper defines 'causal chance' as: "... due to the independence of two causal chains which happen, accidentally, to interfere at some place and time, and so combine in bringing about the chance event ... anybody furnished in advance with sufficiently full information about the relevant events could have predicted what was bound to happen. It was only the incompleteness of our knowledge which gave rise to this kind of chance" (Fetterman, 2012: 20).

11. For more information, see: Roth, M., & Katz, J.D. (1998), *Difference/indifference: Musings on Postmodernism, Marcel Duchamp and John Cage*: G+B Arts International.

12. For more information, see: Nicholls, D. (2002), *The Cambridge Companion to John Cage*, Cambridge University Press, p. 118.

13. Linda Dalrymple Henderson lays out a multitude of possible influences on Duchamp's works coming out of new technologies and scientific paradigms at the beginning of the twentieth century. They include x-ray, electromagnetism, chemistry, wireless telegraphy, and non-Euclidean and 4th-dimensional geometry and topology especially as explained by Henri Poincaré. Rhonda Roland Shearer and Craig Adcock make strong cases for Poincaré's ideas as central to Duchamp's ideas and methodology. Adcock notes that "For Duchamp, Poincaré's philosophical discussions of the conventional nature of geometry were a way of reinforcing his own speculations about the provisional nature of aesthetics." He goes on to demonstrate numerous ways in which Duchamp employs Poincaré's ideas and tropes in specific works including *The Large Glass*, *Tu'um* and *3 Standard Stoppages*. Adcock states that "[Duchamp] believed that the meaning of a work of art was elastic and ad libitum: 'What ever happens could have been completely different.'" (Rau, 2005: 50-51).

References

- Adcock, C. (1984), "Conventionalism in Henri Poincaré and Marcel Duchamp", *Art Journal*, 44(3), pp. 249-258.
- Ashton, D. (1966), "An Interview with Marcel Duchamp", *Studio International*, 171(878), pp. 244-247.
- Benaroya, H., Han, S.M., & Nagurka, M. (2013), *Probabilistic Models for Dynamical Systems*, Second Edition, United States: CRC Press.
- Bernstein, D. W., & Hatch, Ch. (2010), *Writings through John Cage's music, poetry, and art*, Chicago: University of Chicago Press.
- Casey, R. (2016), "Cage and Tudor as Process", *Contemporary Music Review*, 35(6), pp. 670-685.
- Chipp, H.B., & Selz, P. (1968), *Theories of Modern Art: A Source Book by Artists and Critics*, California: University of California Press.
- Cross, L. (2006), "Reunion: John Cage, Marcel Duchamp, Electronic Music and Chess", *Leonardo Music Journal*, 21, pp. 19-23.
- Damien, K. (2003), *A Dictionary of Buddhism*, New York: Oxford University Press.
- Demos, T.J. (2006), "The Language of", *Avant Garde Critical Studies*, 18(1), pp. 91-116.
- Duchamp, M. (1999), *The creative act*, Brussels: sub rosa.
- Elder, R.B. (2015), *DADA, Surrealism, and the Cinematic Effect*, Ontario: Wilfrid Laurier University Press.
- Eppley, C. (2017), "Beyond Cage: On Sonic Art History & Historiography", *Parallax*, 23(3), pp.342-360.
- Fetterman, W. (2012), *John Cage's Theatre Pieces*, United Kingdom: Routledge.
- Fotiadis, D.I. (2015), *Handbook of Research on Trends in the Diagnosis and Treatment of Chronic Conditions*, United States: IGI Global.
- Galavotti, M. C. (2005). *Philosophical introduction to probability*, Stanford: CSLI publications.
- Griffiths, P. (2001), *Aleatory*, *The New Grove Dictionary of Music and Musicians*, second edition, edited by Stanley Sadie and John Tyrrell, London: Macmillan Publishers.
- Haskins, R. (2012), "John Cage and Anarchism: Notes on Sources and Musical Evocations", *Terz* 5, www.terz.cc/magazin.php?z=246&id=264, 10 Oct. 2017.
- Heidelberger, M., & Schiemann, G. (2009), *The Significance of the Hypothetical in the Natural Sciences*, Germany: Walter de Gruyter.
- Heinzmann, G. (2009), "Hypotheses and conventions in Poincaré", M. Heidelberger/G. Schiemann, *The Hypothetical in the Natural Sciences*, pp. 169-192.
- Henderson, L. D. (1984), "The Fourth Dimension and Non-Euclidean Geometry in Modern Art: Conclusion", *Leonardo*, 17(3), pp. 205-210.
- Holton, G. (2001), "Henri Poincaré, Marcel Duchamp and Innovation in Science and Art", *Leonardo*, 34(2), pp. 127-134.
- Holzaepfel, J.(2001), "David Tudor, John Cage, and Comparative Indeterminacy", Presented at the Getty Research Institute Symposium, *The Art of David Tudor*.
- Hope, C., James, S., & Vickery, L. (2012), "New digital interactions with John Cage's Variations IV, V and VI", *Proceedings of Australasian Computer Music Conference (ACMC)*, pp. 23-30.
- Ivanova, M. (2015), "Conventionalism, structuralism and neo-Kantianism in Poincaré's philosophy of science", *Studies in History and Philosophy of Science Part B: Studies in History and Philosophy of Modern Physics*, 52, pp.114-122.
- Jaeger, P. (2013), *John Cage and Buddhist Eco-poetics: John Cage and the Performance of Nature*, London: A&C Black Publishing.
- Jensen, J. F. H. (2011), "Aesthetics of Chance", www.pissinginthewind, 10 oct. 2017.
- Jeongwon, J., & Song, H. S. (2002), "Roland Barthes' 'Text' and aleatoric music: Is 'The birth of the reader' the birth of the listener?", *Muzikologija*, (2), pp. 263-281.
- Joseph, B. W. (2009), "Chance, indeterminacy, multiplicity", *The anarchy of silence: John Cage and experimental art*, pp. 210-238.
- Judovitz, D. (1998), *Unpacking Duchamp: Art in Transit*, California: University of California Press.
- Judovitz, D., & Duchamp, M. (2010), *Drawing on Art: Duchamp and Company*, Minnesota: University of Minnesota Press.
- Junior, J.D.V. (2016), "Chance and Probability in Poincaré's Epistemology", *Philosophia Scientiæ*, 20(2), pp. 177-196.

- Kawamura, E. (1994), "Chaos and cosmos in Zen", *Diogenes*, 42(165), pp. 67-83.
- Kostelanetz, R. (2003), *Conversing with Cage*, United Kingdom: Taylor & Francis.
- Kuh, K. (1962), *The artist's voice: talks with seventeen artists*, United States: Harper & Row.
- Kundert-Gibbs, J.L. (1999), *No-thing is Left to Tell: Zen/Chaos Theory in the Dramatic Art of Samuel Beckett*, New Jersey: Fairleigh Dickinson University Press.
- Lotringer, S. (1998), *Duchamp Werden*, In *Crossings: Kunst zum Hören und Sehen: Kunsthalle Wien, 29.5.-13. 9.1998* [exhibition catalogue], edited by Cathrin Pichler, 55-61, Germany: Ostfildern bei Stuttgart.
- Mac Low, J. (1978), "The Poetics of Chance and the Politics of Simultaneous Spontaneity, or the Sacred Heart of Jesus (Revised & Abridged)", *Talking Poetics from Naropa Institute*, 1, pp. 171-192.
- Martin, E. M. (1976). "The Asian Factor in John Cage's Aesthetics", <http://www.blackmountainstudiesjournal.org/volume-iv-9-16/holly-martin-the-asian-factor-in-john-cages-aesthetics/>, 10 Oct. 2017.
- McLarty, C. (1997), "Poincaré: mathematics & logic & intuition", *Philosophia Mathematica*, 5(2), pp. 97-115.
- Meyer-Eppler, W. (1958), "Statistic and psychologic problems of sound", *Die Reihe*, 1, pp.55-61.
- Millar, J. (2010), *Every day is a good day: the visual art of John Cage*, United States: Hayward Gallery Publishing.
- Moffitt, J.F. (2003), *Alchemist of the Avant-Garde: The Case of Marcel Duchamp*, New York: State University of New York Press.
- Molderings, H. (2010), *Duchamp and the aesthetics of chance: art as experiment*, Columbia: Columbia University Press.
- Molesworth, H. (2006). "From Dada to Neo-Dada and back again", *The MIT Press*, 105, pp. 177-181.
- Nicholls, D. (2002), *The Cambridge Companion to John Cage*, United Kingdom: Cambridge University Press.
- Norton Simon Museum (2010), "Not Wanting to Say Anything About Marcel: An Artwork by John Cage", <https://www.nortonsimon.org/exhibitions/2010-2019/not-wanting-to-say-anything-about-marcel-an-artwork-by-john-cage/>, 10 Oct. 2017.
- Peacocke, J. (2006), *Pa iccasamuppāda—beyond linear causality and dualism*, United Kingdom: Taylor & Francis.
- Poincaré, H. (1914), *Science and Method*, translated by F. Maitland, preface by B. Russell, London: Thomas Nelson and Sons.
- _____ (1969), "Intuition and logic in mathematics", *The Mathematics Teacher*, 62(3), pp. 205-212.
- _____ (2010), *Papers on Topology: Analysis Situs and Its Five Supplements (Vol. 37)*, United States of America: American Mathematical Soc.
- _____ (2012), *Science and Hypothesis*, United States of America: Dover Publications.
- Poincaré, H., Halsted, G.B., & Royce, J. (2014), *The Foundations of Science*, England: Cambridge University Press.
- Pombo, O. (2012), *Conceptions of intuition in Poincaré's philosophy of mathematics*, Lisbon: Faculty of Sciences, University of Lisbon.
- Pritchett, J. (1996), *The Music of John Cage (Vol. 5)*, United Kingdom: Cambridge University Press.
- Rau, P. O., "John Cage: Prints, Drawings and Watercolors, 1978-1992", Ph.D. Diss., Virginia Commonwealth University, Richmond, 2005.
- Revill, D. (2014), *The roaring silence: John Cage: A life*, New York: Skyhorse Publishing, Inc.
- Roth, M., & Katz, J. D. (1998), *Difference/indifference: musings on postmodernism, Marcel Duchamp and John Cage*, United Kingdom: Psychology Press.
- Ruelle, D. (1993), *Chance and Chaos*, United States: Princeton University Press.
- Ruhrberg, K., Honnef, K., Schneckenburger, M., Fricke, C., & Walther, I.F. (2000), *Art of the 20th Century*, London.
- Shearer, R. R., & Gould, S. J. (1999), "Hidden in Plain Sight: Duchamp's 3 Standard Stoppages. More Truly a "Stoppage"(An Invisible Mending) Than We Ever Realized", *disponible sur le site: Tout-Fait: The Marcel Duchamp Studies Online Journal*(1).
- Sheynin, O.B. (1991), "The notion of randomness from Aristotle to Poincaré", *Mathématiques et sciences humaines*, 114, pp. 41-55.

Thero, Ven Dr Medawachchiye Dhammajothi, "The Philosophical Links between 'Anatta'to 'Vijñāna'", Unifying Buddhist Philosophical Views, 89.

Watts, H., & Cunnington, P. (1980). Chance, a perspective on Dada (No. 9), California: UMI Research Press.

Williams, M.H. (2014), Teaching Bion: Modes and Approaches, United States: Karnac Books.

Vickery, L., Hope, C., & James, S. (2012), "Digital adaptations of the scores for Cage Variations I, II and III", Proceedings of International Computer Music Conference, pp. 426-432.

