THE PROBABILITY OF THE DIAGRAM

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Abstract

This paper will explore links between art and science by focusing on Richard Feynman's 1979 diagrammatically enhanced lectures. These lectures explore various theoretical understandings of the quantum world, revealing new possibilities that insert different realities into the physical world. These different realities will be compared with Gilles Deleuze's writing on diagrams revealed in the work of artist Francis Bacon. Feynman and Bacon were both drawn towards the diagram as a means to visualise and explore the probability of something occurring.

Keywords: Diagrams, Art, Quantum Mechanics.

The diagram

In this paper I want to demonstrate how Richard Feynman's diagrams produced a basis for visualizing phenomenon in the universe. The meaning of Feynman's diagrams, when visualising the effects of the atomic world, illustrate the summing of the probabilities of becomings. In comparison, the artist Francis Bacon, who built upon the diagrammatic stage, presents actualised becomings.

The diagram is used in the context of this paper as a drawing or graph that presents information or describes something. The diagram is seen as being analogous to a sketch that visualizes thoughts, concepts, directions and duration. In Gilles Deleuze's book *Francis Bacon: The Logic of Sensation*, a chapter is dedicated to the Diagram and is based around an understanding of Francis Bacon's methodology in his preliminary under painting as diagrammatic. Feynman and Bacon were both drawn towards the diagram as a means to explore and expose the probability of something occurring.

The diagram and intuition

In the *Introduction to Metaphysics* Henri Bergson, when discussing duration, states that 'an essential characteristic of the concepts and diagrams to which analysis leads is that, while being considered, they remain stationary. I isolate from the totality of interior life that psychical entity which I call a simple sensation' [1].

In this context the contents of the Richard Feynman diagram can be seen to represent frozen moments in time that are viewed as a single instance. As the diagram is subsequently adjusted and changed it becomes a depiction of 'not a single sensation but several successive sensations' [2] that become serialized moments. Bergson suggests that this is 'what science needs for its own proper development' [3]. Science needs to be able to quantify the sensations that are portrayed through the diagram.

This view is contested in Bacon where there is no single sensation that 'does not change every moment since there is no consciousness without memory' [4]. The ongoing relationship to the world around you is one where the memory is the swelling of the past mixed with the present, 'consciousness means memory' [5].

The wonder of the diagram is that it can do much more than simply plot the sensation or sensations, but allows for the addition of other abstract levels of complexity that allows for all possible paths to be made visual.

Bergson and quantum mechanics

The relationship between Bergson's theory of duration parallels that of the wave particle duality postulated in the beginning of the twentieth century.

What we find with Bergson's theory of duration is a fundamental pre-emption of Werner Heisenberg's uncertainty principle, which gave us the beginnings of quantum theory. If we were to take the findings that led to our current understanding of the wave particle duality, it is that a particle appears when it is measured and at all other times it acts as a wave.

The connection between the theories lies in the inability of duration to be seen as being any more than a state of consciousness. Bergson states that there is on 'one hand a *multiplicity* of successive states of consciousness, and on the other a unity which binds them together' [6]. In this context the multiplicity can be seen as the particles and that 'unity' stands for what would have been known as ether, but today would be referred to as the vacuum energy. The awareness of Bergson's theoretical understandings that have inspired a number of artists over the years are syncretically aligned to some of physics' most successful quantum theories.

The scientific diagram can never be the phenomenon, it can only be a series of expressions of moments or states. The dots, arrows and lines that individualise the probable position and direction of matter presuppose its singularity. The problem comes in describing the wave as a field that is everywhere and taking all possible routes to any given target. Bergson's concepts of duration, perception and the unconscious have pointed out to us that time is not the instrument of measurement but a place where past and present coalesce. The duality of time and space here is borne out by quantum theory and can be enriched by Bergson's theory of duration in showing the unmeasurability of a thing that remains in a fluid state.

Marta De Menzes in her masters thesis *Visual representation in Art and Science: A study of Richard Feynman's and Joseph Beuys' Diagrams*, when writing on Feynman, states that his diagrams 'can be used as a mathematical tool is due to the following characteristics. First, the exchange of a photon represented by a wiggly line should not be taken as a classical particle following a single space-time path, but as the sum of all possible ways in which that photon could have gone from one particle to the other'. [7]

Feynman's diagrams

The Feynman diagram presents the probability amplitude when plotting the path of a single photon acting as a particle reflecting from a mirror's surface. In this diagram the wave-like states as reflected in the terms of the wave-particle duality is not put into focus. The change in state of the wave-particle duality is constant in all atomic structures, when measured they act as particles and when they are not being measured they act as waves. The particles in their wave-like state decide on which routes to take in their travels by summing up all possible options, in the same way that we might do when confronted with a queue at a shopping market. Neil Turok describes in his CBC Massey Lectures, '*The Universe Within: From Quantum to Cosmos*' [8] how we decide when shopping which checkout queue to join, suggesting that we do so by gauging how many people are in the lines, how far the queues are from our location, whether there are families, how many goods are in the basket and so on, and then choose a route. Particles do the same thing, based on William Rowan Hamilton's (1805 –1865) action principle that suggests particles survey all the possible routes to the future and chose the one that demands the least actions. Hamilton suggested that physical systems could even take a multitude of different routes with probability amplitudes for each part based on each action.

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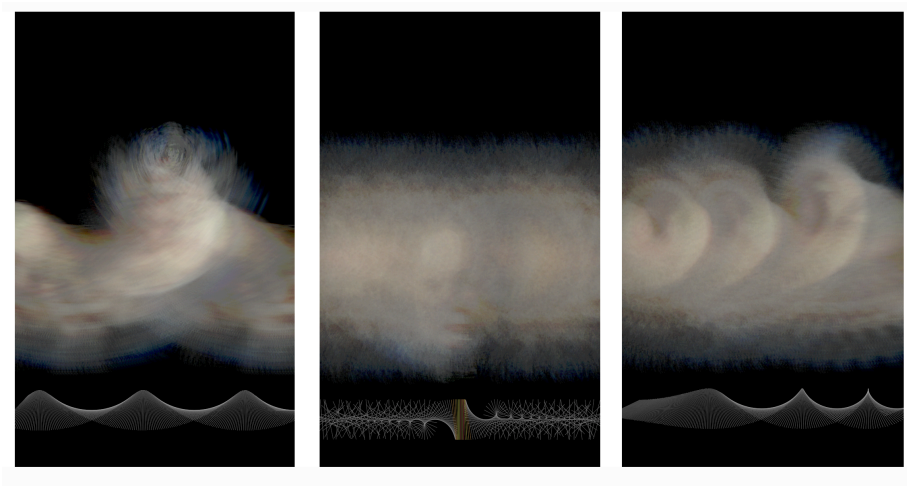

Multiverse (2013), Kevin Raxworthy and Paul Thomas, is an aesthetic translation of the scientific diagram, and draws a synchronistic relationship with the diagram in Francis Bacon's triptych portrait paintings.

As the complexity of quantum theories evolve, due to the amount of data that needs to be processed based on the probabilities of something occurring, the limits of what binary computing can do will be reached. In Feynman's case he changed the rules in science by using visualization as a means of more fully understanding the probability that some phenomenon can happen. In quantum computer it will be the atom itself that records and processes it own data, each cubit will allow for hundreds of calculations to happen simultaneously. How will the diagrams of quantum computing develop to complement and visualize this new future? What is the likelihood that artists today are synchronistical working on these visions of the future? In this context I want to draw comparisons between Feynman's diagrams and the diagrams (paintings) of Francis Bacon as theorised by Deleuze in *Francis Bacon: The Logic of Sensation*.

Feynman's diagrams were used to visualize the physics of the atomic world. The diagram was a way for Feynman to understand, innovate and develop schematic research for thinking through the complex problems being encountered at that time. The diagrams researched for this paper come from Feynman's 1979 lecture series were he used the traditional blackboard and chalk as part of his presentations. The research Feynman presented in the performative drawing of the diagrams demonstrated how the chalk marks are used in exploring concepts and articulating thinking to present the fundamental quantum probabilities of photons behaviour.

Feynman's diagrams were developed to articulate things in the atomic world that demanded a great deal of imagination and alternative thinking to explain. The diagrams tried to describe something that was different from anything encountered or experienced before within our field of reference. We want to see the physical world of quantum physics as resembling something we know, a strange familiarity with the world around us. Feynman used visual thinking as a necessity to work through his ideas. Some of his thoughts seem to emerge from the interaction with the blackboard itself, demonstrating in their visibility a schematic becoming.

What could be seen was that with the aid of the diagram, 'entire new calculational vistas opened for physicists' [9]. This enabling of physicists to explore the potential of diagrams that can be used in calculations, extended the scope of their significance. The diagram took on a new status, but in allowing for the visualisation of probabilities they were not extended into the more subjective relationships with that of the diagrammatic qualities to be remediated through art.

The diagram: Deleuze and Bacon

Feynman's diagrams in this context form a symbiosis with Deleuze's understanding of Francis Bacon's work. Deleuze uses the concept of the diagram when he is commenting on Bacon's tendency to 'make random marks (lines-traits); scrub, sweep, or wipe the canvas in order to clear out locales or zones (color-patches); throw the paint, from various angles and at various speeds. Now this act, or these acts, presuppose that there were already figurative givens on the canvas (and in the painter's head), more or less virtual, more or less actual.' The process of painting here is to form the basis for the problems to be made real. Visualized through acts of scrubbing, sweeping and wiping, the diagram forms the basis from which the work evolves. The modes of embodied engagement with the material reveal aspects that distort, contort and expose, enabling the potential for a shift in experience. The marks in the diagram are in direct relationship with the physics and effects of the materials, not to solve a problem but rather to reveal the actuality of something existing within the marks.

Deleuze writes 'It is as if, in the midst of the figurative and probabilistic givens, a *catastrophe* overcame the canvas' [10]. The probabilistic is what is being explored here and what is revealed is an intuitive understanding of the world of quantum mechanics. This foundational work defines a way of visualizing thinking and sensation as though the diagram of the problem was already manifested in Bacon's head and the process of visualizing this creates a fundamental flow 'like the emergence of another world.' ([11]

Bacon's intuition

In Bacon's well documented personal library there is a publication on the 'Phenomena of Materialisation.' In the introduction there is a passage that explores the concept of the 'abandonment of the materialistic conception of the universe which, even thirty years ago, was in sole possession. Modern physics regards matter as a form of motion, and is dominated by the idea of energy. Psychology also is gradually emancipating itself from the purely physiological conception of mental life; and under the leadership of the philosopher Bergson, it tends to acknowledge the superiority of the psychical over the physical. Thus the circumstances are much more favourable to the investigation of great new problems and facts than they were some decades ago' [12].

This particular reading of the diagram creates a difference of intention, from the scientific towards the intuitive. This 'survival of the past' into the present moment means that we are not trapped in 'instantaneity' but can unfold and allow the concept of duration to 'swell' [13]. Within this concept of duration we formulate a 'perceptual becoming' that allows the diagram to oscillate between different states. Out of these different states the diagram creates a potentiality of outcomes that can be visual but not

visualised. In other words, the abstract quality of Feynman's diagram expresses so much to the physicist in that it identifies points in time that act like frozen moments. These frozen moments can be seen not as instances but as part of the swelling; the basis for the creation of an art work where the work of artists like Bacon are challenging the diagrammatic nature of comprehending life. The artwork attempts to create human interaction with the possibility of becoming and being in the world. The artwork responds to the various inputs and stimuli but is indicative of a state of becoming that can only be viewed in its semi abstract state as a conscious stream.

Deleuze suggests that Bacon visualises what Wittgenstein calls the possibilities of facts. It is this very possibility of the painting that ties in with Feynman's diagrams. The possibilities of facts are not in themselves facts. The Feynman diagram that demonstrates how the spin of the photon reflects from a mirror uses the probability amplitude to perform a process of discovery. When creating the diagrams on the blackboard, Feynman wipes away, moves between, etc to lay out the diagrammatic foundation of the problem. What Bacon revealed by producing the visualization of the probabilities in the scrubbing, sweeping and wiping is a presence in the work exposed for all its flaws and possibilities. The faces in Bacon's triptychs with their smears and voids gives us a view of the world never seen, 'more or less virtual, more or less actual' [14].

The readings of the two forms of constructing the diagram presented here are intended to show the symbiotic and complex relationships between science and art. The two men were striving for the probability or possibility that something was happening in the world that was emerging from our continual probing and imagination when it comes to comprehending the aspects of the universe. The exploration of the probability of light by both Feynman and Bacon goes some way to showing synchronicity with art paralleling science.

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3. Bergson [1].

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