Dalí, Physics, and *The Persistence of Memory*: A Surreal Exploration of Modern Science

Ethan Li

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The artist Salvador Dalí produced many surrealist works throughout his lifetime, including the iconic *The Persistence of Memory*, which has often been interpreted as an expression of special relativity's idea of time dilation. This paper will explore whether Dalí's artwork can be used to instruct viewers in physics. I aim to show if Dalí was conceivably influenced by the theory of time dilation in his painting of *The Persistence of Memory* which, if executed successfully, would enable *The Persistence of Memory* to serve as an instrument of explanation for it, and, by extension, whether it is possible that Dalí's awareness of physics shaped the artwork. I will be relying on the theoretical analyses of Kuhn et al., the literary analyses in postmodern thought, and biographical writings from Gibson et al. as well as Dalí himself. This theoretical framing, personal information, and uniform knowledge of physics will be deployed in tandem with an analysis of the art itself. Ultimately, the reciprocal explanatory power between time dilation and Dalí's *The Persistence of Memory* supports the broad theory that Surrealism and physics are intertwined phenomena and provides a notable example.

Introduction

This paper will explore whether or not select works of art by Salvador Dali were influenced by modern physics. I will focus on a piece called *The Persistence of Memory* and whether or not it was conceivably influenced by time dilation, a phenomenon predicted by Einstein's theory of special relativity. I claim that it is, and will also seek to address skepticism about this claim: namely, accusations that my claim is either inaccurate or merely speculative. The link between modern physics and surrealist art has received significant attention due to the concurrency of their development and the presence of similar themes in the two. The current consensus is that the Surrealists were indeed influenced by 20th-century developments in physics. In 2015, the Gallery Wendi Norris in San Francisco hosted an exhibition titled *Science and Surrealism*; in an introductory essay on that exhibition, JD Talasek argues that "artwork is never created in a vacuum. Artists are influenced by their surroundings..."[1]. In 2020, ITMO University professor Sergei Stafeev gave a lecture titled "Salvador Dali and Science" as part of another exhibition[2]. Several other exhibitions, such as Tate Modern's 2021 exhibition "Surrealism Beyond Borders" and Dalí Museum's 2023 exhibition "Mathematical Surrealism: Dalí and the Fourth Dimension", as well as many biographers of Dalí[3–5], have also extensively noted the influence of modern physics in the content and symbolism of several works of Dalí and other Surrealists, and important people from both sides regularly interacted, especially with Salvador Dalí.

In his landmark publication *The Structure of Scientific Revolutions*, Thomas Kuhn offers this perspective:

"For many centuries, both in antiquity and again in early modern Europe, painting was regarded as the cumulative discipline. During those years the artist's goal was assumed to be representation. Critics and historians, like Pliny and Vasari, then recorded with veneration the series of inventions from foreshortening through chiaroscuro that had made possible successively more perfect representations of nature. But those are also the years, particularly during the Renaissance, when little cleavage was felt between the sciences and the arts. Leonardo was only one of many men who passed freely back and forth between fields that only later became categorically distinct[6]".

Kuhn argues that art and science were, in fact, almost the same in the early modern period. New inventions and techniques in painting and visual art were celebrated and commented on much like new discoveries in science, the two were considered closely related, and many people were proficient in both. Indeed, many artists in this period collaborated closely with contemporary scientific developments. Take, for example, Leonardo da Vinci, who Kuhn cites as a well-known polymath. Besides being the famed painter of the *Mona Lisa* among many others, he kept a collection of his notes and journals, comprising thousands of pages of drawings of various scientific inventions[7]. It is likely that he even incorporated his scientific knowledge into his artwork, using his vast collection of drawings to help make his paintings as realistic as possible. Other examples include famed artist of the Dutch Golden Age Johannes Vermeer, who likely associated himself with the many developments in optics during his time. A subject of continuing debate is whether

Vermeer employed instruments such as the camera obscura, camera lucida, and mirrors to aid in his extremely realistic depiction of light for which he has become famous, one of the most well-known applications of the so-called Hockney-Falco thesis[8]. During the Dutch Golden Age, many fields of science flourished, but especially optics: Antonie van Leeuwenhoek developed some of the earliest optical microscopes, while Hans Lipperhey obtained a patent for a refracting telescope. In fact, as fellow natives of the city of Delft who were alive at similar times, it is almost certain that Vermeer and van Leeuwenhoek knew each other throughout their lives, and thus that Vermeer would have been able to learn technical information about optics from van Leeuwenhoek[9]. Only in later centuries did the fields of science and art start to diverge from each other until they became considered two distinct, even unrelated, fields.

Methods

This paper aims to establish a connection between the artwork of Salvador Dalí, particularly *The Persistence of Memory*, and theories of modern physics. A qualitative literature review was used to gather evidence for such a connection. Examples of media collected included Dalí's personal writings, examples of his artwork where the influence of physics was particularly clear or well-established, biographies of the artist, and treatises on special relativity. Gathered media was then analyzed for evidence of the role of physics in Dalí's life and art.

Surrealism and Science

In this section, the history of Surrealism and its interaction with science will be examined. The earliest mention of surrealism is in 1917, when French poet Guillaume Apollinaire coined the term "surrealism" (literally "beyond realism"), first using it in a letter to the writer Paul Dermèe. Later, he employed the term to describe the ballet Parade as well as his own play *The Breasts of Tiresias*, which he subtitled a "surrealistic drama"[10]. After Apollinaire's death in 1918, various groups had formed that attempted to continue the legacy of surrealism. One such group was led by French author André Breton, who, in 1924, published his first Surrealist Manifesto, marking the formal foundation of Surrealism as an art movement. In it, Breton defined Surrealism in this manner:

"Psychic automatism in its pure state, by which one proposes to express — verbally, by means of the written word, or in any other manner — the actual functioning of thought. Dictated by the thought, in the absence of any control exercised by reason, exempt from any aesthetic or moral concern.[11]"

Automatism reflects a radical reassessment of the artmaking process: traditionally, the artist would need to be perfectly rational as they completed a work: without rationality or control, the artist would be incapable of deciding exactly how they want their final work to appear and what exactly they should do to achieve that. However, as Breton prescribed in his definition, many surrealists sought to suppress conscious control over how they created their art, allowing their subconscious to greatly influence the final product. Despite some changes in how surrealists have operated since the movement's foundation, automatism and an absence of reason in the artmaking process remain foundational to the surrealist movement. Since the subconscious dominates in surrealist artmaking, its art often contains unexpected elements or scenes that resemble dreams. This also opens up the possibility that the art may contain themes or influences that the artist would be unlikely to consciously acknowledge, or even ones that the artist does not know they have. Today, the artist perhaps most closely associated with Surrealism remains Salvador Dalí.

Born in Figueres in the Spanish region of Catalonia in 1904, Dalí was perhaps the most prominent link between the Surrealists and science, of which there were many. He became interested in science from an early age, even writing an article titled Sant Sebastià in 1927 for the journal *L'Amic de les Arts* that included descriptions of scientific techniques[12]. This interest in science was to be lifelong: throughout his life, Dalí maintained friendly relations with many active scientists and mathematicians, most importantly the Romanian mathematician Matila Ghyka[13], who was himself was inspired in his mathematical theories by Einstein's theories of relativity; Dalí even in fact possessed writings of Ghyka's[13]. Dalí was not alone in his enthusiasm towards 20th century physics. Other Surrealists were as fascinated by physics as Dalí, and included its themes in their works. It is even possible that Dalí and Einstein may have interacted in this period. During the 1920s, as a university student, Dalí was living at the Residencia de Estudiantes, a student accommodation facility in Madrid[12]. Built to encourage dialogue between the arts and sciences, the Residencia was one of the leading centers for intellectual exchange in the 1920s. Distinguished guests who often spoke at the Residencia de Estudiantes included not only other famous artists across all media such as Alexander Calder, Le Corbusier, and Igor Stravinsky, but also scientists, such as Marie Curie and none other than Einstein himself[12], thus making it highly plausible that Einstein's scientific theories were heard and internalized by Dalí to some degree. These interactions and social networks are shown in Fig. 1, where the relationships between important people (represented by ovals), ideas (represented by cloud-like shapes), artistic groups and works of art (both represented by rectangles) are shown around the relevant time period. As can be seen, the numerous connections between Dalí and scientific discovery provided that he would arguably come to be one of the Surrealists most influenced by science.

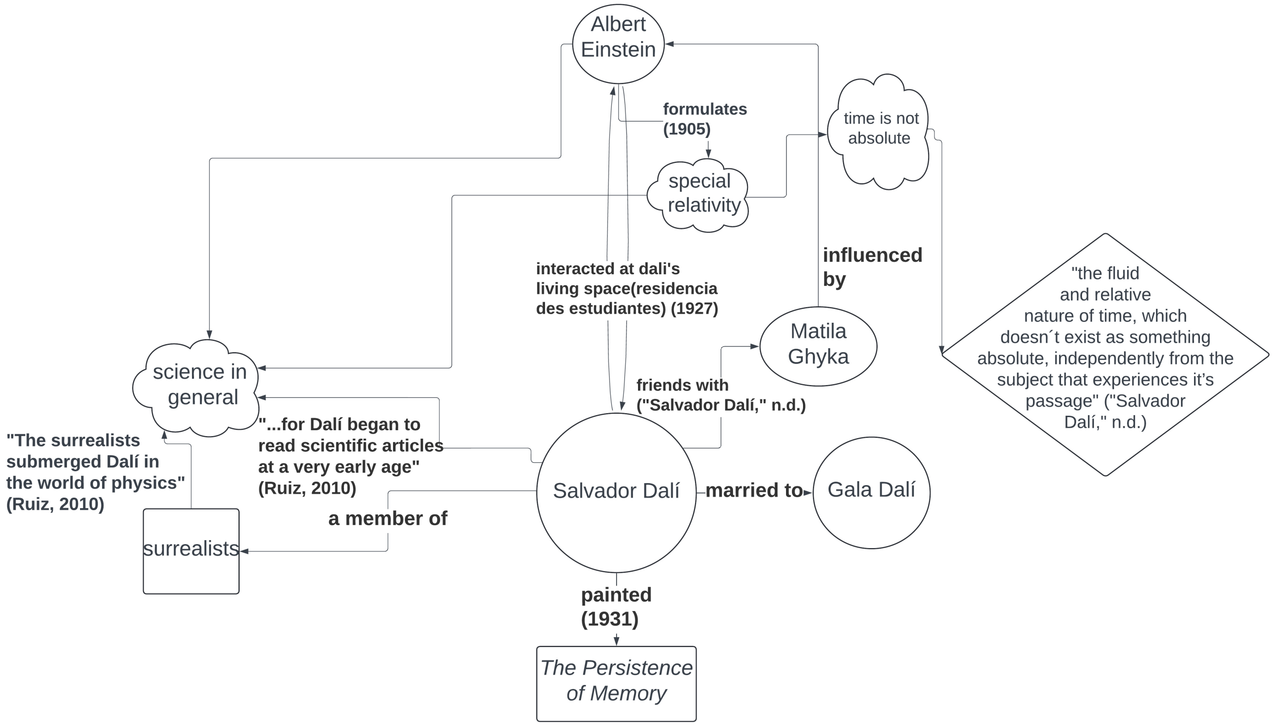

Fig. 1 Social network diagram of Dalí's relationships to science

Results and Discussion

Relativity in *The Persistence of Memory*

In the following section, time dilation is first defined before *The Persistence of Memory* is introduced and its contents examined to arrive at an interpretation of time dilation. In 1905, a young Albert Einstein, then an employee at the Swiss Patent Office, wrote and published four scientific papers in the journal *Annalen der Physik* that comprised some of his first. All four of these papers would go on to become some of the largest and most transformative contributions to modern physics, so much so that they have been collectively referred to as his *annus mirabilis* papers (Latin for "miracle year"). One of these papers introduced his famous theory of special relativity.

Special relativity is built off of just two postulates:

1. In all inertial (not accelerating) reference frames, the laws of physics are the exact same.
2. The speed of light is the same for all observers, regardless of the speed of the light source or observer[14].

It is this second postulate that provides an explanation for time dilation. To begin with, normally, speeds and velocities are additive. If a reference frame is already moving forwards, and an object develops a forward's motion in that frame, then relative to someone stationary, the object will appear to move forwards even faster, as the speed of the moving reference frame and the speed of the object in that frame add together.

For example, consider a car driving forwards at 30 mph. If an occupant of the car were to throw a ball forward at 10 mph relative to the car, it would travel forwards at $40 = 30 + 10$ mph *relative to the ground*. If the ball were thrown backwards at 10 mph relative to the car instead, it would travel forwards but at $20 = 30 + (-10)$ mph *relative to the ground*, since the velocity of the ball now points opposite that of the car. In fact, if the ball could be thrown at 30 mph backwards, a person on the ground would see the ball merely stay in place as it falls straight towards the ground without moving horizontally at all*.

We now attempt the thought experiment again, but with a laser pointer that will be turned on instead of a ball. Surprisingly, no matter what direction the laser is aimed or how fast the car is driving, both an occupant of the car and an observer standing on the ground would measure the speed that the light propagates

* For real-life demonstrations of this phenomenon, see sources[15,16]

from the laser as c, the speed of light. Even if the car were driven at $0.999c$ and the laser were pointed backwards from the car, both the car and ground observers would agree that light from the laser pointer travels at speed c, whereas classically, we would expect that only the car's observer would agree and the ground observer would instead see a beam traveling at $0.001c$.

Using the second postulate of special relativity, we can derive the fact that when an object moves relative to another, its length in the direction of motion will decrease and the rate at which time passes for it will slow down. Under normal conditions, we experience space and time as constant. A ruler will remain the same length no matter where we are or how fast we are traveling, and a stopwatch will always take the same amount of time to count to one second. However, this is only because speeds humans deal with are much less than the speed of light by factors of millions.

Now, consider a perspective of something moving so fast that it is at a significant fraction of the speed of light, such as the *Millennium Falcon* of *Star Wars*.

To visualize this, we set up a thought experiment: a ruler and stopwatch are given to us, and a ruler of exactly the same length (when measured at rest with us) and a perfectly synchronized stopwatch (i.e., whenever it is at rest with and at the same location in space as our stopwatch, it will always show the same elapsed time) are given to Han Solo. We remain stationary with our instruments, while Solo takes his aboard the *Millennium Falcon*, and then flies it past us in a straight line at close to the speed of light.

If we were somehow able to measure the length of Han Solo's ruler, we would find it to be shorter than our own. Similarly, Solo's stopwatch would appear to tick by slower than our own, and these effects become more drastic the faster the *Millennium Falcon* flies by. Everything moving along with the *Millennium Falcon* would be similarly affected: the ship itself would appear to be shorter than if it were not moving, and Han Solo himself would appear to age slower than us. These two effects are known as *length contraction* (responsible for Solo's ruler appearing shorter) and *time dilation* (responsible for his stopwatch running slower).

To be mathematically precise, assume that the *Millennium Falcon* moves with speed v, the rulers have length L when at rest, and the time between two adjacent ticks of the stopwatches when at rest is Δt. Then, as the *Millennium Falcon* flies by, we measure the length of Han Solo's ruler to be

$$L' = \frac{L}{\gamma}, \quad (1)$$

and the time between ticks of his stopwatch to be

$$\Delta t' = \gamma \Delta t, \quad (2)$$

where γ is a positive number called the *Lorentz factor* calculated as[17]:

$$\gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} \quad (3)$$

where c is the speed of light.

We thus see that, as the *Millennium Falcon* streaks by us, no matter how fast it moves, lengths shorten and time intervals increase by precisely the same factor γ, ensuring that whichever reference frame or in whatever direction one attempts to measure the speed of light from, they will always find the same value. Furthermore, note that if the *Millennium Falcon* is not moving, then $v = 0$ and $\gamma = 1$, verifying that Solo's ruler and stopwatch are identical to ours if at rest, and as v approaches c, then γ blows up to infinity, verifying our observation that the faster the *Millennium Falcon* moves, the more extreme its length contraction and time dilation appear to be.

Shortly prior to painting *The Persistence of Memory*, Dalí had developed what could be called his own version of Breton's psychic automatism, which he called the "paranoiac-critical method"[18]. Described by him as a "spontaneous method of irrational knowledge based upon the interpretive-critical association of delirious phenomena"[18], it consisted of Dalí inducing himself to have trances or hallucinations, the subjects of which he frequently used to inform his art. Whereas automatism merely suppressed rational thought when creating art, the paranoiac-critical method represented an advancement in Breton's original formulation: it not only depended on irrational thought, but it also allowed him to irrationally link various objects and ideas together in his mind[19]—links that rationally would not be made—in a manner reminiscent of pareidolia, "no longer [considering] surrealist phenomena and images by themselves but, on the contrary, as a coherent whole of systematic and significant relations"[18]. Thus, in the altered state of consciousness that was induced in the paranoiac-critical method, Dalí would be given free rein to imagine a nearly endless number of fantastical scenarios, combinations, and possibilities. Given how much Dalí had been immersed in the latest scientific discoveries at this time, his use of the paranoiac-critical method very likely brought scientific influences to the surface in his art, even if he did not consciously recognize them at the time. *The Persistence of Memory*—created using the help of the paranoiac-critical method and which has remained to this day one of the most iconic Surrealist works—was painted in 1931, 26 years after Einstein published his theory of special relativity. Despite being only 9.5 by 13 inches, *The Persistence of Memory* is filled with details. In the background, a rocky cliff is visible, a part of the coast of Catalonia, Dalí's home region in Spain; Dalí often included such Catalonian landscapes in his paintings. Slightly ahead of the cliff, a small white dot is visible that, upon closer inspection, is an egg, a commonly occurring symbol of life and fertility in Dalí's paintings. To the left of the background, a large, flat mirror rests next to the seashore, reflecting the twilight sky. In the foreground, there are three main elements: on the left, there is a brown, rectangular platform. Growing off of the platform is a small, leafless tree. In the center, there is a fleshy object with long eyelashes lying on the ground that Dalí uses to represent himself. Hanging off the edge of the platform, on the single branch of the tree, and draped over the fleshy object, are three pocket watches, identical except for the outer trim of the watch on the platform, which is gold instead of silver like the others. Though still recognizable, they are notably limp and unnaturally stretched. At the lower left corner of the painting is another pocket watch. Unlike the other three, which are blue, this one is bright orange, remains rigid, and is being devoured by ants, evocative of decaying meat[20].

Fig. 2 Salvador Dalí, *The Persistence of Memory*, 1931. Oil on canvas, 24 cm × 33 cm

These soft watches have arguably become the most famous aspect of this painting: objects that are normally hard and unchanging have inexplicably become soft and contorted into impossible positions. One might expect that if the softness of the watches was merely an artifact of just the watches, then at least the hands should still be rigid and functional, springing up from the watch face, but in all three watches, the hands as well have become viscous and stuck to the faces of their respective watches, unable to move properly, suggesting that it is not only the watches, but that time itself, which usually unstoppably passes by at a constant rate, seems to have slowed down drastically or even stopped moving altogether. This is similar to time dilation: just as it predicts that time in moving reference frames should appear to be stretched out, passing slower relative to an unmoving observer, the watches, instruments that allow us to see and measure time, sag on their supports, stretching outwards. The watches' loss of rigidity is therefore analogous to the loss of the absolute nature of time in special relativity. This salient feature of the painting strongly resembles time dilation, and can act as a visual allegory, a window through which we, at rest, can glimpse the effects of the *Millennium Falcon*'s relativistic speeds on its inhabitants. It is, by its very nature as a surrealist artwork, able to transcend logic with its odd subject matter. Even if we disregard Dalí's intellectual history with science, that does not change the fact that *The Persistence of Memory* resembles time dilation, offering a much more intuitive explanation than any mathematical analysis. To further corroborate this claim, details outside of the watches themselves will now be evaluated. For example, consider the watches not individually, but relative to each other: the three melted watches appear virtually identical to each other. This can be interpreted analogously to the reciprocity of time dilation: It is important to note that v in the formula is relative speed: not only is the *Millennium Falcon* moving with speed v relative to us, but, symmetrically, if Han Solo were to look out the window, he would see us moving away, also at speed v. Therefore, just as we observe the *Millennium Falcon* to be length contracted and time dilated, Solo sees exactly the same effects applied to us. Intuitively, we expect that since we see Solo's stopwatch running slow, he should see ours as running quicker, but this is not true. In his 1997 textbook on relativity, Adams provides an analogy: if two people stand far apart, each will appear very small to the other because of perspective[21].

Some may doubt this claim and regard it as a stretch: after all, Dalí himself claimed that the melting watches were inspired by melting Camembert cheese[22]. While this is true, a direct causal influence of relativity theory is not needed for *The Persistence of Memory* to be a powerful explanatory tool for special relativity. There are several other reasons that Dalí's claim above may not be the whole story: first, although Dalí never consciously admitted a direct influence of relativity theory on *The Persistence of Memory*, he was aware of and highly interested in it, having written about it on several occasions: in 1930, he published an article titled "The Sanitary Goat" in which he argued that certain concepts from relativity theory could be applied to psychology[23], and soon after, in another of his writings titled *Conquest of the Irrational*, called physics "the new geometry of thought"[18] and referred to the molten watches as "paranoiac-critical camembert of time and space"[18]. Because Dalí would later directly acknowledge the impact of scientific theories on his work, it is likely that at this point in time, any influence physics had on his work was still primarily subconscious, only brought out through the paranoiac-critical method. Second, since the landmark publication *The Death of the Author* by French literary critic Roland Barthes, the way we understand works of art has fundamentally changed, so that we now longer depend on the author as the sole legitimate source of explanation about a work: rather, as Ross argues, "By allowing for a synthesis of ideas, we open ourselves to a variety of possibilities for creative interpretation and productive conversations about art and aesthetics"[24], and that "even the author is fallible in their own interpretations of a text"[24]. Therefore, we must incorporate context into our analysis of *The Persistence of Memory*'s deeper meanings.

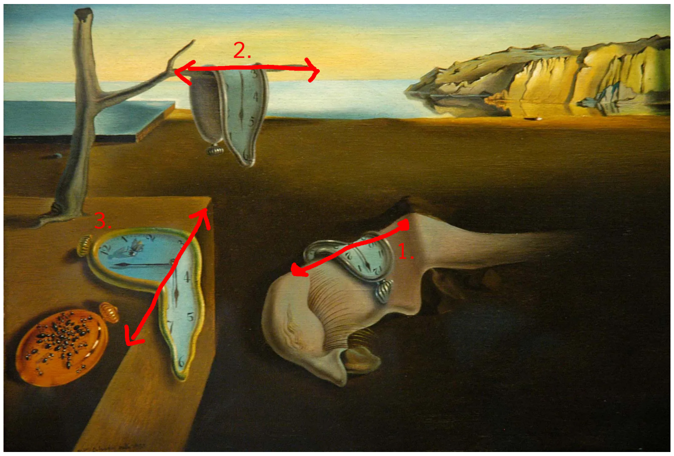

Fig. 3 The three watches are progressively more rotated the closer to the viewer they are (Dalí, 1931, with modifications made by the author)

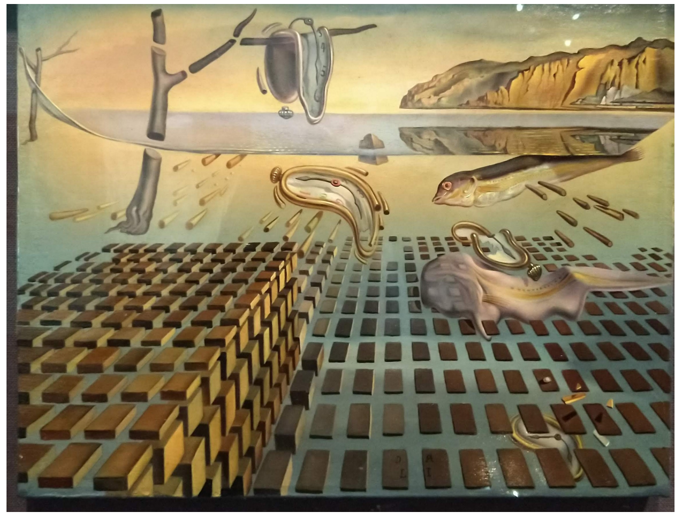

Fig. 4 Salvador Dalí, The Disintegration of *The Persistence of Memory*, 1952-1954. Oil on canvas, 25.4 cm × 33 cm

Although Dalí almost certainly did not intend so, an interesting coincidence related to relativity theory can be seen in the orientations of the three watches: they are rotated sequentially in a manner startlingly similar to Terrell rotation. Discovered almost 30 years after the creation of *The Persistence of Memory*, Terrell rotation (see Fig. 3) describes the actual visual appearance of something moving at relativistic speeds[†].

We finally turn our attention to the bright orange watch in the lower left corner. It is the only watch in the painting that is still rigid. Even still, it is by no means normal, for it is being swarmed by ants. In fact, the watch's solid orange-red color and the ants may be evocative of a piece of meat that has been left to rot. This suggests that the watch has been exposed to the elements for a very long time, while the three melted ones appear relatively untouched, as if they have aged or been exposed to the elements less than the orange watch. Again, with time dilation, this is physically possible. This is exemplified by the famous twin paradox: there are two identical twins, one of whom stays on Earth while the other travels into space in a high-speed rocket. The spacefaring twin will return to Earth to find that the other twin has aged more, and the faster the rocket travels, the greater the difference in age. The orange watch in *The Persistence of Memory* is thus like the earthbound twin, which has decayed (aged) much more than the spacefaring twin, exemplified by the blue watches, which have experienced extreme time dilation.

For some, this idea that Dalí's paintings represent visual explanations by a non-expert of modern physics may sound far-fetched. Especially since this essay has so far only covered one painting in detail, some may claim that the idea is speculative at best, or that *The Persistence of Memory* is but an isolated incident. This is, however, easily refuted. Consider, for example, a much less known recreation of *The Persistence of Memory*, which Dalí painted from 1952 to 1954. Aptly titled *The Disintegration of The Persistence of Memory*, the main elements in *The Persistence of Memory* are still present, but everything has now been broken down: the platform and ground have been fractured neatly into almost perfectly identical cuboids and the leafless tree has been snapped into multiple pieces. Everything in the painting is disconnected and levitating, even the cliffside in the background, which has lifted off of the ground and floats above the ocean.

All of this breaking down made people wonder if *The Disintegration of the Persistence of Memory* was an allegory for atomic theory. And it almost certainly is, given that Dali himself claimed that the bombing of Hiroshima in WWII "shook [him] seismically" and that "Thenceforth, the atom was [his] favorite food for thought"[3]. Some have gone even further and claimed that not only is *The Disintegration of the Persistence of Memory* an allegory of atomic theory, but also quantum mechanics. Representing a step above atomic theory, which predicts that all the matter we see is actually made of many indivisible particles (atoms), quantum mechanics makes this prediction for not just matter, but a range of physical quantities such as the energy of a light source and the location of an electron around an atom. While quantities like energy and location are normally thought of as continuous, quantum mechanics predicts that in certain scenarios, they can only have certain values. For example, one of the earliest findings of quantum mechanics is that light, and

† One might naively assume that in the experiment with the *Millennium Falcon*, length contraction would dictate that the ship, if moving straight towards us, would appear squashed in the direction of motion by a factor of γ. This is, however, not true. Because of the difference in time it takes light from different ends of the moving *Millennium Falcon* to actually reach our eyes, it would not appear squashed at all. It would actually still appear to be at its rest length, but rotated to the side, even if it is in actuality not rotating at all, and thus exposing a fundamental difference between measuring and seeing in special relativity. For more information, see[25,26]

all electromagnetic radiation, is not continuous. Instead, it is made of indivisible particles that we now call photons. A single photon carries an amount of energy given by the Planck relation

$$E = hf \tag{4}$$

where E is the energy of the photon, h is Planck's constant—a fundamental physical constant equal to about 6.626×10^{-34} J·s (joule-second), and f is the photon frequency. This means that any light source emitting a single frequency of light must, at any point in time and over any time interval, be emitting an integer multiple of hf worth of light energy.

Even for light sources like the Sun or indoor lightbulbs that emit many different frequencies, there must still be an integer number of photons being produced over any given time interval. Just like how the objects in *The Disintegration of the Persistence of Memory* have been broken down into identical discrete fragments, matter can be broken down into discrete atoms, and light into discrete photons.

This interpretation is supported by Dalí himself, who in 1958 described quantum physicist Werner Heisenberg as his "father"[5]. This time, it is clearly evident that Dalí did have science in mind as he painted *The Disintegration of the Persistence of Memory*, and that claims suggesting his art and physics can reciprocally explain each other are not at all far-fetched.

Conclusion

Modern physics includes concepts which many may find difficult to understand. Topics such as relativity theory and quantum physics have superseded the classical physics people are used to in daily life to such a degree that their predictions become highly unintuitive and confusing, and the equations they utilize very tortuous and complex, requiring knowledge of highly advanced mathematics. It is possible for someone to study these theories and equations for years without being able to gain an intuitive visualization for what they represent. As has been found through these presented examples, art is a good remedy to this issue. Because art is a creative, human activity, it is quite easy for an artist to represent abstract ideas in a format that is both highly visual and easy to digest. In the case of Salvador Dalí, his surrealist style and his exposure to modern physics as it developed in the early to mid-20th centuries provides an excellent tool to foster understanding of modern physics.

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