# Distance Learning in Einstein's Fourth Dimension

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**Abstract**

This article blends the concepts of spacetime from theoretical physics and Einstein's Relativity Theory to discuss the spatiotemporal nature of distance education. By comparing and contrasting speed-of-light space travel with the speed of computer processing, the leap is made to consider the fourth dimension and its phenomena for the Web traveler. Learning events are compared with events in time to depict the theory presented.

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Our belief that time flows, according to physicist Paul Davies, is really an illusion because in fact, time does not flow at all. Davies quotes J.J.C. Smart, an Australian philosopher, who once wrote: "Talk of the flow of time or the advance of consciousness is a dangerous metaphor that must be taken literally...Certainly we feel that time flows. This feeling arises out of metaphysical confusion…It is an illusion." Davies agrees with Smart and adds:

> In other words, the "river" of time is not really there. That may seem as absurd as claiming that material objects are not really there, but Smart is on firmer ground on this one…Since Einstein, physicists have generally rejected the notion that events "happen" as opposed to merely *exist* in the four-dimensional spacetime continuum.[1]

So much for my river-of-time metaphor, as it was soon to be discarded when I began to comprehend that under Einstein's relativity theory there was no absolute time or space, that time was relative to the observer and the perception of past, present and future were individualized—not measured on the master clock of time. Instead, time is relative to me as the observer and dependent upon my individual speed of motion. My river-of-time metaphor was outmoded, and Plato had provided an explanation for this illusion of a flowing time centuries earlier in his work, *Timaeus*,[2] where he explained why humankind had the need to manufacture this misperception of a flowing, all-encompassing, linear time:

> They are all parts of time, and the past and future are created species of time, which we unconsciously but wrongly transfer to the eternal essence; for we say that he "was," he "is," he "will be," but the truth is that "is" alone is properly attributed to him, and that "was" and "will be" only to be spoken of becoming in time, for they are motions, but that which is immovably the same cannot become older or younger by time, nor ever did or has become, or hereafter will be, older or younger, nor is subject at all to any of those states which affect moving and sensible things and of which generation is the cause. These are the forms of time, which imitates eternity and revolves according to a law of number. Moreover, when we say that what has become is become and what becomes is becoming, and that what will become is about to become and that the non-existent is non-existent-all these are inaccurate modes of expression...[3]

Davies explained that Plato's search to understand eternity brought about his views of a "half-real" world of daily experiences, when the state of eternity was what actually existed. In a human state, the view of time as moving was a concrete explanation for an abstract phenomenon like eternity, which was too difficult to comprehend from a practical, worldly sense. From a day-to-day perspective, it is difficult for a person to contemplate eternity and its impact on a 24-hour schedule, when instead the human needs for eating, sleeping, work and play take precedence over conscious attention to the "forever." Davies noted that the "temporal versus eternity" debate continues in all great religions around the world, so heated at times that it has even led to violence and persecution.

I liken these concepts to the experiences that I have had with others during a traumatic moment. I have found that in moments of tragedy or great distress, one's sense of time is experienced differently for each observer. Often, after the event, and we are able to reflect on the experience, I have found that each individual has a different sense of what occurred than I did. During the event, we each tended to focus on a differing aspect of the experience and our sense of time. What may have seemed like an endless moment to one person, occurred in a fleeting second for another. These snapshots of traumatic experiences often frame the experience as we serve to remember it in hindsight. Is one person's sense of "eternity" right over another's because our perceptions differ? Is one person's past another person's present because simultaneous experience does not really exist since there is no such thing as absolute time?

The change in our perception and the worldview about the nature of time all started in the 17th century when Christiaan Huygens (our pendulum clockmaker) came up with the idea of the wave theory of light and its transport through a vaporous substance known then as ether (aether). Sir Isaac Newton (best known for his universal gravitational theory) added his thoughts in the next century, when he determined that light was made up of particles, but was unable to blend the contradictory elements of light waves and particles. Then, in the 19th century, a Scottish physicist, James Clerk Maxwell, building on the ideas of British physicist Michael Faraday, determined that both electric and magnetic forces move through space at the speed of light and the principles of electromagnetism were born.

By the first year of the 20th century, Max Planck discovered that energy is made up of fundamental units that he named quanta, which became the basis for quantum theory. Planck maintained that his discovery pertained only in the relationship between light and matter. German-born, American physicist Albert Einstein observed the photoelectric effect that explained away the 17th century ether, and maintained that light was two contradictory things at the same time—both particles and waves. Planck and Einstein would remain at odds for several years, until Einstein's theory of light gained acceptance. Planck received the Nobel Prize in 1919 and quantum theory was to become one of the major breakthroughs of the 20th century. Einstein received the Nobel Prize two years later.

Einstein's famous theories included his Special Theory of Relativity (1905) and General Theory of Relativity (1916). "Einstein's theory of relativity dethroned Newtonian absolute time—a time that is the same for all observers, however far apart and however rapidly in relative motion, " according to Julian Schwinger, author of *Einstein's Legacy: The Unity of Space and Time.* The relativity theories proposed that time and space were not separate, but relative to one another with respect to motion. Stephen Hawking, British theoretical physicist and mathematician whose main field of research has been the nature of space and time that was popularized through his book *A Brief History of Time*, explained Einstein's historical impact in the December 31, 1999, issue of *Time* magazine, which proclaimed Albert Einstein as the "Person of the Century":

> This required abandoning the idea that there is a universal quantity called time that all clocks measure. ***Instead, everyone would have his own personal time.*** The clocks of two people would agree if they were at rest with respect to each other but not if they were moving. This has been confirmed by a number of experiments, including one in which an extremely accurate timepiece was flown around the world and then compared with one that had stayed in place. If you wanted to live longer, you could keep flying to the east so the speed of the plane added to the earth's rotation. However, the tiny fraction of a second you gained would be more than offset by airline meals.[4]
> [Emphasis Mine]

Having our *own personal time* would serve to revolutionize a higher education delivery system based on physical clock time. Online, as I am able to learn on my own personal time, I can grasp a concept, master a principle, or apply a learning outcome on my own time—not within the same clock hour or even same clock minute as my learning partner, not even forced to comprehend an idea because its five minutes to eight and the lecture ends at 8 p.m. Together, in asynchronous time, we can reflect upon our learning, discuss the connections that we have made between concepts and place them in the context of our own learning, from our own location. The learning is then not distant, but centrally occurring from within the spatiotemporal location of where we both live and work. Would this not be a remarkable occurrence? Is this not the opportunity that online learning offers students? If my learning partner comprehends the thought at 8 p.m. and I do the same at 2 a.m., we can return to the asynchronous communication that we started at 7 p.m. (basing clock time on our own time zones) that evening turned morning on our own schedule. By 8 a.m. the next day, the instructor has entered the dialogue and commented on our discussion, when she may have not had time to stay after the lecture in the physical setting to continue the dialogue because she had another class to instruct.

With the discovery that space and time were not separate and that time is relative to the observer, Einstein revolutionized the existing worldview established by other revolutionary transformers like Copernicus and Newton. At the heart of his special theory of relativity was the realization that all measurements of time and space depend on judgments as to whether two distant events occurred simultaneously. This led him to develop a theory based on two postulates: 1. The principle of relativity, that physical laws are the same in all inertial reference systems; 2. The principle of the invariance of the speed of light, that the speed of light in a vacuum is a universal constant.

Leonard Shlain, author of *Art & Physics: Parallel Visions in Space, Time & Light*, explained Einstein's postulates quite simply: "Einstein turned everything upside down by declaring that space and time are relative and only the speed of light is constant." Shlain graphically depicts the perception that time slows as one approaches the speed of light, as the present moment expanding from a wedge between the past and future to one encompassing the past and future (See Figure 1)[5]. This slowing and expansion of time demonstrates what I have been referring to as *time dilation*.[6] From the learner's perspective, traveling at the speed of his or her own computer processor and Internet connection speed, the present moment dilates like the iris of the eye taking in light. The past, present and future all merge into a larger present moment. In the human eye, the pupil, which dilates and contracts according to the light that enters it control the amount of light entering the eye. Like the pupil, our perception of the length of the present moment is dependent upon the velocity that we are traveling. The closer that speed approaches the speed of light, the more the present moment expands and is experienced. Time slows and expands, allowing for learning to occur in that personal time of the learner's present moment. One learner's expanded present moment is not the same as another, but central to the experience of the learner as he or she is connected online. Once that online connection is disconnected, the light-speed travel is over and the learner is again experiencing time as a resident of Earth.

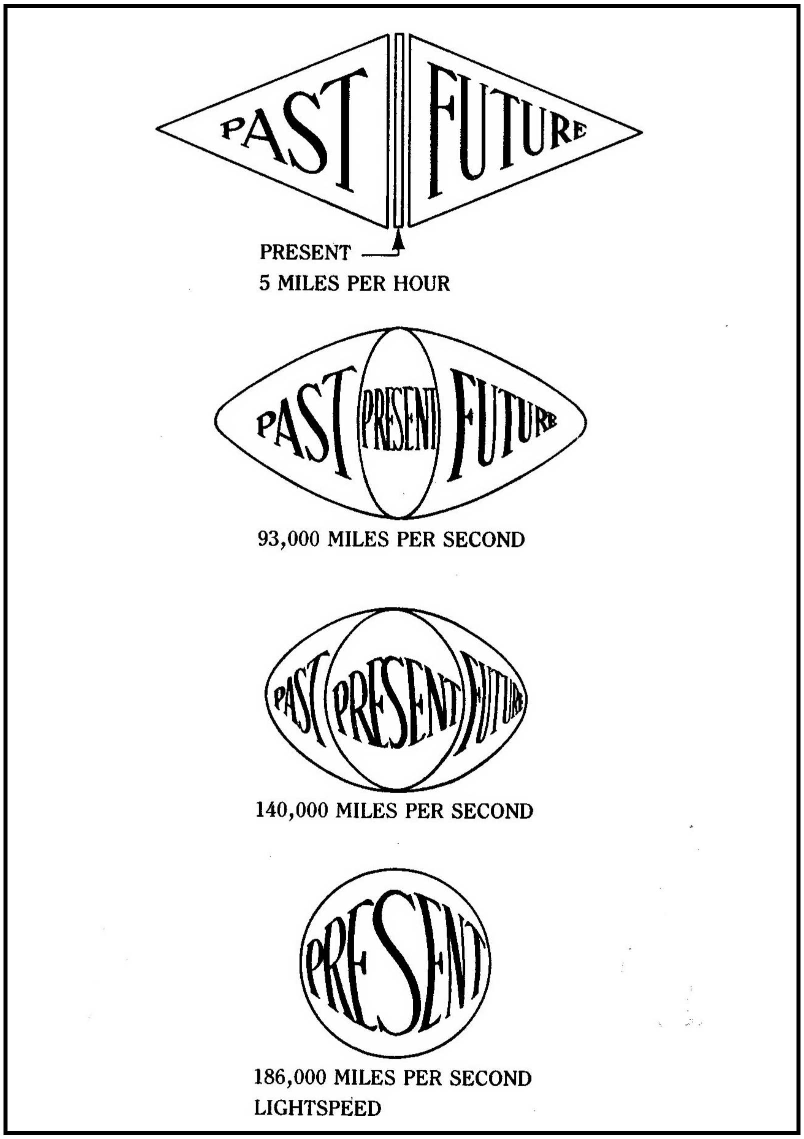


**Figure 1.** Leonard Shlain depicts how time slows as one approaches the speed of light. The present moment expands from a narrow sliver until it encompasses both the past and the future. At lightspeed, time ceases to change because it contains all change.

Schwinger explained that, based on the Einstein theories, a complication results from the Newtonian concept that simultaneity was a possible occurrence. However, Carl Sagan refers to the "ruminations" of Einstein changed the world through his thought experiments (what he called *Gedanken* experiments) by envisioning what travel at the speed of light would mean from an observer's perspective on Earth. In *Cosmos*, Sagan offered the following example to demonstrate that based on Einstein's theories, simultaneity was not possible for two observers traveling at different speeds and located at different points in space:

> Imagine that I am riding a bicycle toward you. As I approach an intersection I nearly collide, so it seems to me, with a horsedrawn cart. I swerve and barely avoid being run over. Now think of the event again, and imagine that the cart and the bicycle are both traveling close to the speed of light. If you are standing down the road, the cart is traveling at right angles to your light of sight. You see me, by reflected sunlight, traveling toward you. Would not my speed be added to the speed of light so that my image would get to you considerably before the image of the cart? Should you not see me swerve before you see the cart arrive? Can the cart and I approach the intersection simultaneously from my point of view, but not from yours? Could I experience a near collision with the cart while you perhaps see me swerve around nothing and pedal cheerfully on toward the town of Vinci?[7]

Sagan goes on to point out the curious nature of these questions and the understanding of new laws in the universe that they uncovered:

> In order to understand Einstein's revolutionary new thinking that changed the world of physics, some natural law needed to be obeyed: Einstein codified these rules in the special theory of relativity. Light (reflected or emitted) from an object travels at the same velocity whether the object is moving or stationary: *Thou shalt not add they speed to the speed of light*. Also, no material object may move faster than light: *Thou shalt not travel at or beyond the speed of light*. Nothing in physics prevents you from traveling at or beyond the speed of light as you like; 99.9 percent of the speed of light would be just fine. But no matter how hard you try, you can never gain that last decimal point.[8]
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> [Emphasis Original]

For the world to be logically consistent, Sagan said, that "cosmic speed limit" described above has to be effective. "Otherwise, you could get to any speed you wanted by adding velocities on a moving platform," he concluded. Schwinger adds that Einstein's simultaneity paradoxes demonstrate the entanglement of space and time in this new thought.

Prior to Einstein's first paper on relativity in 1905, simultaneity was accepted as absolute, "that there was a unique event at location A that was simultaneous with a given event at location B," according to the *Stanford Encyclopedia of Philosophy*. However, Schwinger explains that the nature of simultaneity is only possible if the observers are at the same point in space and moving at the same rate along the same line of space. Yet, "events at *different* points of space, that are simultaneous for one observer" are not simultaneous for another observer that is moving relative to the first. Davies explains this in his book, *Other Worlds: Space, Superspace and the Quantum Universe*:

> The concept of simultaneity—the same moment in two different places—has no universal meaning. What is judged to be 'now' by one observer can be in the past or future as determined by another. At first sight, such a conclusion seems alarming. If one person's present is another's past and yet another's future, couldn't they signal each other and enable the future to be foretold? What would then happen if the informed observer acted to change this already-observed future? Fortunately for the consistency of physics, it does not seem that this situation can occur.[9]

From my perspective, the term simultaneity and simulation, such as in computer simulations, are definitely aligned. Computer simulation is the process of imitating a real phenomenon with a set of mathematical formulas that allow a computer to portray a natural event such as weather, physical reactions or even biological processes. Einstein conducted his thought experiments using the only computer he had access to at the time—his brain.[10] In it, he was able to simulate the paradoxes in the simultaneity and space-time concepts that he discovered. Like a computer simulation can test a new theory, Einstein was able to test his theories in the same way that the real process would have been conducted. Although astronauts and rockets had not yet been fully conceived of in 1905, so his thought experiments included trains that traveled at the speed of light since the railways were the primary means of transportation in his era.

Simultaneity is central to the idea of learning on clock time, as learners are all located in the same physical location, in the same clock hour, focusing on the same learning objective. In fact, simultaneity has been expected to the point that learners should be able to master the same learning objectives in the same amount of time spent in a specific subject matter. For example, in a 12-week college quarter, an on-ground student attending a traditional academic setting may spend four clock hours per week in a single course for the 12-week period. In those 48 contact hours, a student is expected to master the learning outcomes for the course, regardless of the knowledge or skills that the student brought to the course. If a student does not attend one of those class sessions, he or she is considered "absent" from the learning for four clock hours. However, in online education, learners are located at differing physical and temporal proximities, dispensing for the need of simultaneity and learning measured according to the time spent in that classroom seat. Whether the learner learns in the non-simultaneous setting is measured differently, based on what is learned, rather than whether the contact time is met for the class period. Since time online becomes relative to the learner, the present time is individualized depending upon when, where and how the learner focuses on the learning objective.

Although proven repeatedly as the technology of science has permitted throughout the past century, a world of relative time is one that many individuals never envision even though it exists. In spite of this space-time revolution that impacted science in the 20th century, there are still those who have entered the 21st century and believe in the absoluteness of synchronous time, the comfort of time in a universal sense. Alan Lightman, MIT professor, and author of the novel *Einstein's Dreams*, depicts the reassurance many people feel from a non-relative sense of time:

> A world in which time is absolute is a world of consolation. For while the movements of people are unpredictable, the movement of time is predictable. While people can be doubted, time cannot be doubted. While people brood, time skips ahead without looking back. In the

> coffeehouses, in the government buildings, in boats on Lake Geneva, people look at their watches and take refuge in time. Each person knows that somewhere is recorded the moment she was born, the moment she took her first step, the moment of her first passion, the moment she said goodbye to her parents.[11]

This desire to hang on to a universal, absolute time is not surprising. I know from my experiences that the linear, forward-directional sense of time gave me hope at different points along my river of time. But at the same time, the individuals who cling to this notion are often the same ones who maintain a belief in the "too late" phenomenon, such as it's "too late" to go back to school, "too late" to pursue the dream, the life passion. This is an unfortunate side effect of hanging on to the 19th century view of time as linear and universal, as the same for all instead of the relative view of time to the individual as demonstrated in Einstein's theories.

In his relativity inspired work, using an imaginative eye through fictitious Einstein dreams, Lightman also depicts what the world looks like through this sense of an immediate, non-linear time. If everyone has their own *personal time* (as Hawking termed it earlier), then the world is not based on an orderly cause and effect congruency, but one of immersion in the present:

> In this world, artists are joyous. Unpredictability is the life of their paintings, their music, their novels. They delight in events not forecasted, happenings without explanation, retrospective.
>
> Most people have learned how to live in the moment. The argument goes that if the past has uncertain effect on the present, there is no need to dwell on the past. And if the present has little effect on the future, present actions need not be weighed for their consequence. Rather, each act is an island of time, to be judged on its own. Families comfort a dying uncle not because of a likely inheritance, but because he is loved at that moment. Employees are hired not because of their resumes, but because of their good sense in interviews. Clerks trampled by their bosses fight back at each insult, with no fear for their future. It is a world of sincerity. It is a world in which every word spoken speaks just to that moment, every glance given has only one meaning, each touch has no past or no future, each kiss is a kiss of immediacy.[12]

In his 1983 book, *God and the New Physics*, Paul Davies explains that Einstein was able to demonstrate that time is "elastic and can be stretched and shrunk by motion." As a result, every individual carries around a sense of personal time that does not necessarily agree with everyone else's perception of time. In this sense, our time never feels distorted; however, compared to another it may not be synchronized.[13] According to the laws of relativity, time is not fixed; according to Davies, it is *dynamic*. "It can stretch and shrink, and warp and even stop altogether at a singularity. Clock rates are not absolute, but relative to the state of motion or gravitational situation of the observer."[14] As a result, we all live within our own personalized "now" that is not simultaneous with another person's now. Each person's past and future is another person's present. This can be perceived as a paradox, because we are so conditioned, and even physically feel this illusion that time is passing. However, at times of personal crisis or extreme emotion, we can physically experience the sense that time has stopped. Often times, this experience is captured in our minds as still snapshots of our environment at the moment of the experience, where it was as if time stood still.

Ohio State Sociology Professor Laurel Richardson agrees with Davies and explains that people everywhere interpret their lives according to time, but their lives are not always lived according to a linear, sequential perception of it but from a more complex and comprehensive perspective. According to Richardson,

> Time is the quintessential basis for and constraint upon the human experience…Sometimes time is experienced as a concordant whole, such as when reading a familiar poem, where the whole piece is experienced despite the fact that some of it has already been read and more is yet to come. Other times, time is experienced as discordant, such as when regret about the past or fear of the future impinge on the present. This discordance cannot ever be totally overcome because human knowledge includes the knowledge that one's days are numbered. The future always becomes the past. The future is always death.[15]

Further she quotes philosopher Edmund Husserl, founder of phenomenology, who said that clocks and calendars measure out our days and years, but people do not necessarily experience time in that linear "succession of instants or a linear linking of points in space but as extended awareness of the past and the future within the present."[16]

In respect to my own "concordant whole" moments, as Richardson puts it, where time seemed to be a secondary aspect to experience, I liken the relationship between clock time and experiential time to forming a personal definition for relativity. In those moments when I have experienced a convergence, a coming together of thought, experience and relationships, when it seemed for an instant that I had a comprehensive idea beyond the number of chronological years that I had lived and breathed on this earth, I have used poetry as the writing vehicle to portray the personal elements of time and thought through space. Those relative moments are difficult to capture in a chronological narrative, but are better expressed in literary writing through the use of figurative language since the very aspect of chronology does not always apply to the holistic sense of the moment in time when an idea or concept is fully grasped in the context of the individual's lived experiences. I have found that it does not do justice to record them in a diary labeled with the date and time of the writing. As Davies said, time, like these experiences, is dynamic and the record of dynamic events is never easily captured in a whole sense through a linear narrative explanation. The whole of the experience, the extended awareness, and the connections between past, present and future are relational and recursive—not easily mapped on a flat, horizontal timeline.

Before Einstein published his General Theory of Relativity in 1916, Hermann Minkowski, a one-time professor of Einstein's who had once described him as a "lazy dog," was inspired by Einstein's Special Theory and determined that events occurring in space (having three dimensions from Euclidean geometry) and time (as the fourth dimension) were occurring separately but within a unified continuum. Minkowski devised a four-dimensional geometry, known as the spacetime continuum that depicted the world point of an observation. Abraham Pais, author of the scientific biography of Einstein, *Subtle is the Lord,* offers a basic description of Minkowski's theories:

> According to Minkowski, every event in the universe is an event in four-dimensional space-time. One of these events was your own birth. You

> came into the world at a certain place, of three dimensions, and at a certain time. Nothing less than a four-dimensional space-time will do to describe that wonderful event.[17]

Minkowski's contribution to Einstein's work allowed Einstein to complete the General Theory of Relativity, contribute new theories on the origin of the universe, conceptualize black holes and wormholes, and to open the door for a concept of time travel. In 1908, Minkowski gave his infamous 'space and time' lecture in Cologne and began with these words:

> The views of space and time which I wish to lay before you have sprung from the soil of experimental physics and therein lies their strength. They are radical. Henceforth space by itself, and time by itself, are doomed to fade away into mere shadows, and only a kind of union of the two will preserve an independent reality.[18]

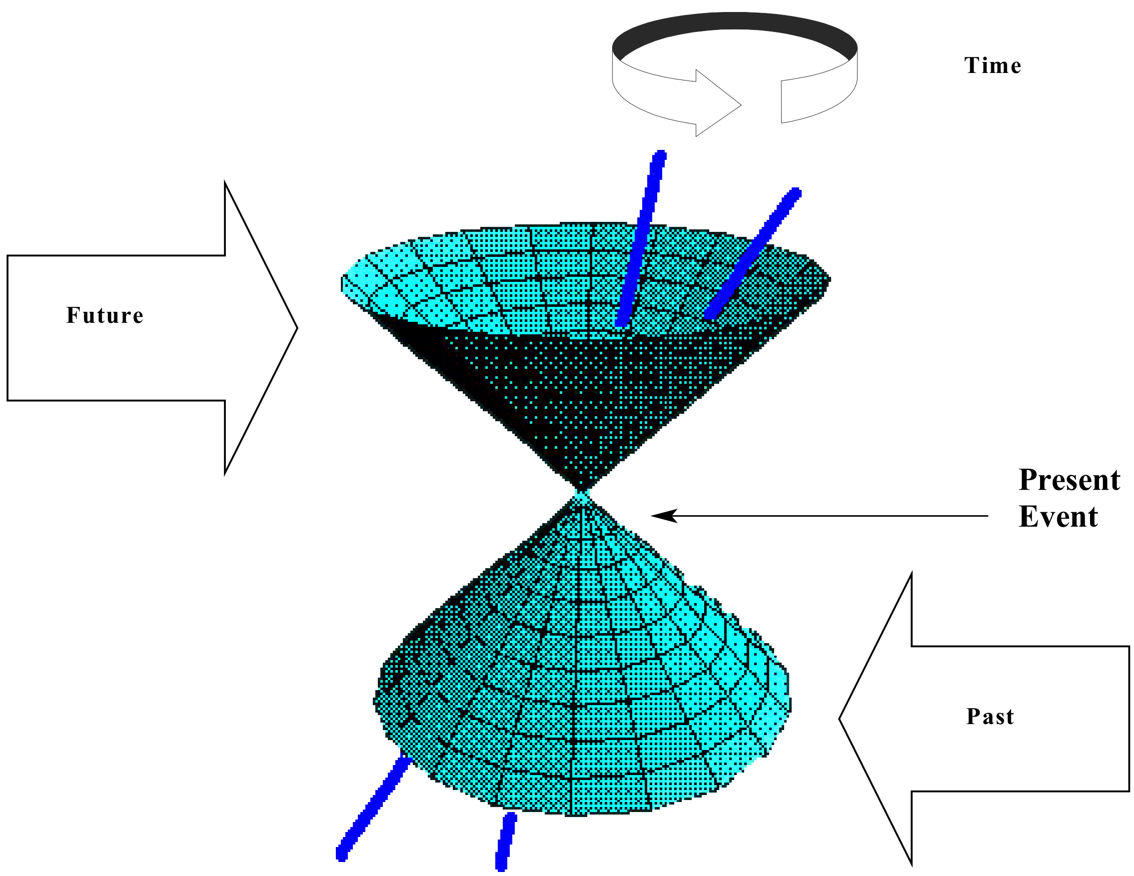


**Figure 2. Einstein-Minkowski Space-Time**

Within the three dimensions of space, Einstein's relativity theory offered the fourth dimension of time and its impact forever changed the world's perception that reality existed in the objective. Instead, as Shlain describes, "the so-called objective world changed size, form, color and sequentially when a subjective observer changed speed and direction relative to it." The worldview built upon absolutes and a causal order was shattered by these new ideas, and with the addition of an "observer-dependent" new world order, a certain degree of subjectivity was implicit.[19]

Perhaps it is easier to comprehend the fourth temporal dimension if we first back up to consider the three dimensions of space. The idea of dimension became an item of fascination and contemplation at the close of the 19th century, with Edwin A. Abbott's novel, *Flatland: A Romance of Many Dimensions*, where Abbott describes a two-dimensional world of beings residing on a geometrical plane:

> I call our world Flatland, not because we call it so, but to make its nature clearer to you, my happy readers, who are privileged to live in Space. Imagine a vast sheet of paper on which straight Lines, Triangles, Squares, Pentagons, Hexagons, and other figures, instead of remaining fixed in their places, move freely about, on or in the surface, but without the power of rising above or sinking below it, very much like shadows--only hard with luminous edges--and you will then have a pretty correct notion of my country and countrymen. Alas, a few years ago, I should have said "my universe": but now my mind has been opened to higher views of things.[20]

In Nahin's work, he uses a quote from a 1926 short story, "The Vanishing Man" to reflect on what the third spatial dimension would appear like to the two-dimensional characters in Flatland:

> Now suppose that a being in two dimensions—a flat creature, like the moving shadows of a cinematograph—were suddenly to grasp the concept of a third dimension [as in Edwin Abbott's 1880 classic fantasy *Flatland*] and so step out of the picture. He might move only an inch, but he would vanish completely from the sight of the world.[21]

Sagan points out that in the world of two dimensions, a three–dimensional object can only be seen as a cross-section at the point of intersection in the flat plane. To the two-dimensional figures, a three-dimensional object such as an apple entering a two-dimensional plane would at first appear as a point and then grow into a wider and wider circle as it crossed through Flatland, and then disappear. This aberration would startle the two-dimensional individuals who had no conception that a three-dimensional world existed. Nevertheless, the three-dimensional apple does exist, in a world that the Flatlanders could not see or even imagine.[22]

Using the familiar experience of the high school class reunion, Michio Kaku, professor of theoretical physics at the City College of the City University of New York, offers another account of how startling the impact of relativity theory would be to those not contemplative of the existence of higher dimensions in his book *Hyperspace*:

> I was graphically reminded of the relativity principle when I was invited to my twentieth high-school reunion. Although I hadn't seen most of my classmates since graduation, I assumed that all of them would show the same telltale signs of aging. As expected, most of us at the reunion were relived to find that the aging process was universal: It seemed that all of us sported graying temples, expanding waistlines, and a few wrinkles. Although we were separated across space and time by several thousand miles and 20 years, each of us had assumed that time had beat uniformly for all…Then my mind wandered and I imagined what would happen if a classmate walked into the reunion hall looking exactly as he had on graduation day. At first, he would probably draw stares form his classmates. Was this the same person we knew 20 years ago? When people realized that he was, a panic would surge through the hall.[23]

Like Lightman's dream account of the comfort and familiarity of time clicking away on a universal timepiece, the participants in Kaku's class reunion would be impacted dramatically by relativity if they saw first hand the spatiotemporal nature of reality. Whether the classmate had traveled on Sagan's speed-of-light bicycle or Einstein's speed-of-light train, the outcome would have been the same. As Kaku points out, "he may have entered a rocket traveling at near light speeds. For us, the rocket trip may have lasted 20 years. However, for him, because time slowed down in the speeding rocket, he aged only a few moments from graduation day."[24]

By basing the event within the perception of the observer, Einstein changed the worldview from a clockwork universe to a relativistic universe. Repeatedly, as the 20th century progressed, Einstein's relativity theory was upheld in experiments such as the one where an atomic clock was placed aboard the supersonic jet, the Concorde, and another identical atomic clock placed on ground. The Concorde travels faster than the speed of sound, which through air is at about 344 meters per second—roughly a million times more slowly than the speed of light. Even though the variance in time between the two atomic clocks is quite small, time dilation does occur and is a measurable difference at this speed. The clock on the Concorde shows less time has elapsed than its counterpart on the ground.

The popular notion of the fourth dimension of time and time dilation first gained attention by a novel released in 1895, several years before Einstein's relativity theory gained public recognition and understanding. In the first chapter of his classic work, *The Time Machine* (and as depicted in the 1960 film version), H.G. Wells' main character, the Time Traveler, explains the fourth dimension of time, in relation to the tangible three dimensions of space which in the story's setting of 1899 was not even yet a mathematical abstraction. The Time Traveler prepares his New Year's Eve guests for the surprise presentation of his invention of a time machine. The Time Traveler defined the fourth dimension quite simply:

> Really, this is what is meant by the Fourth Dimension, though some people who talk about the Fourth Dimension do not know they mean it. *There is no difference between Time and any of the three dimensions of Space except that our consciousness moves along it.*[25]
> [Emphasis original]

Many readers have considered *The Time Machine* to be an elaborate work of fiction meant only for the fantastic imagination of the science fiction connoisseur, and many Wells' critics vocalized their distaste for years following its publication. Paul Nahin, in his book *Time Machines: Time Travel in Physics, Metaphysics, and Science Fiction*, summarizes the initial criticism that Wells received:

> One of the initial reviews of *The Time Machine*, by the literary editor of the *Spectator*, called the time machine concept "hocus pocus" and the tale itself a "fanciful and lively dream," and the *Daily Chronicle's* reviewer used the word *bizarre*. Indeed such reactions continued for decades.[26]

However imaginative Wells' work was perceived to be in the early years of the 20th century, it resounded loudly with the changing paradigm of his era brought upon by the emergence of a new worldview founded upon relativity and its resulting subjectivity. However, Nahin points out that no matter how much the debunkers wanted to discredit Wells, his book has never been out of print and other physicists have referenced his work in their further publication on relativity. In the story, Time Traveler goes into the future to foresee what the world is like years ahead of the eve of the 20th century. As Davies points out, the concept of an actually existing "elastic time" was quite a shock when Einstein presented it in 1905. The best demonstration of its effect was held at CERN (home of the WWW) in 1977:

> A good check on the effect was made at the particle accelerator laboratory at CERN in Geneva in early 1977, where a beam of high-speed muons[27] was created and stored in a magnetic ring so that their lifetime could be measured. It confirmed the amount of time dilation predicted by the theory of relativity, to an accuracy of 0.2 percent.[28]

Even before wormholes[29] were used to catapult actress Jodi Foster to connect with her deceased father in the movie *Contact* (based on Carl Sagan's novel of the same name) movie makers and authors used Einstein's relativity theory to again entertain the notion of time travel in a real scientific sense, not just a fantastic one. In his work, translated from the Russian work with a similar title, L.D. Landau and G.B. Rumer give examples of the existing paradoxes found in time travel presumptions:

> A journey on a circular railway with a speed close to the speed of light allows us in principle to make H.G. Wells' "time machine" come true in a limited sense. Disembarking at our place of departure, we find that we have moved into the future. True, with this time machine we can

> transport ourselves into the future but are unable to return to the past. This is its great difference compared to Wells' machine.
>
> It is futile even to hope that future developments of science will allow us to travel into the past. Otherwise, we would have to accept the possibility in principle of quite absurd situations. Traveling into the past, we could, for example, find ourselves in the position of being people whose parents have not yet seen the light of day! On the other hand, a journey into the future involves only apparent contradictions.[30]

Even if time travel is only possible in theory, relativity changed the world from a concrete, absolute world of order to one of subjective interpretation by the observer. As Davies describes it, "No longer could one talk of the time—only my time and your time, depending on how we are moving. To use the catch phrase: *time is relative*."[31]

**Endnotes**

[1] Davies, Paul. *About Time: Einstein's Unfinished Revolution*. (New York: Touchstone, 1995), 253.

[2] According to Ian Marshall and Danah Zohar, authors of *Who's Afraid of Schrödinger's Cat* (William Morrow 1997), *Timaeus* and the book of Genesis are both central sources to the Western creation myth. Eastern religions teach that primary reality is without features, so there is nothing to be said about nothing. 12.

[3] Plato. *Timaeus*. (Translated by Benjamin Jowett. 360 B.C.E. <http://classics.mit.edu /Plato/timaeus.html> 3 March 2000.)

[4] Hawking, Stephen. "A Brief History of Relativity." 31 December 1999, *Time*, 67.

[5] Shlain, Leonard. *Art & Physics: Parallel Visions in Space, Time & Light*. New York: William Morrow, 1991. Figure 9.3, 125.

[6] According to *A Dictionary of Physics* (Oxford 1996), time dilation is defined as the principle, predicted by Einstein's special theory of relativity, that intervals of time are not absolute but are relative to the motion of the observer.

[7] Sagan, Carl. *Cosmos*. (New York: Ballantine, 1980), 166-167.

[8] Sagan, 167.

[9] Davies, Paul. *Other Worlds: Space, Superspace and the Quantum Universe*. New York: Penguin Books, 1988. 38.

[10] More description about the human brain computing capacity is found in chapter 4.

[11] Lightman, Alan. *Einstein's Dreams*. (New York: Warner Books, 1993), 41-42.

[12] Lightman, Einstein's *Dreams*, 37.

[13] Davies, Paul. *God and the New Physics*. (New York: Simon & Schuster, 1983), 120.

[14] Davies, *God and the New Physics*, 123.

[15] Richardson, Laurel. "Narrative and Sociology." John Van Maanen, Ed. *Representation in Ethnography*. (Thousand Oaks: Sage, 1995), 207-208.

[16] Richardson, 208.

[17] Pais, Abraham. *Subtle is the Lord…The Science and Life of Albert Einstein*. New York: Oxford University Press, 1982.

[18] Pais, 152.

[19] Shlain, Leonard. *Art & Physics: Parallel Visions in Space, Time & Light*. New York: William Morrow, 1991. 136.

[20] Abbott, E.A. *Flatland: A Romance of Many Dimensions*. 2nd Rev. Ed. (1884) <http://eldred.ne.mediaone.net/eaa/FL.HTM#top>. A note on the text of the electronic version of the second edition of Abbott's novel explains that when Abbott refers to the fourth dimension, he is referring to a spatial dimension not time. In four spatial dimensions, time is the fifth dimension. The fourth dimension of space is also known as hyperspace. For the purposes of this work, the fourth dimension refers to the temporal dimension.

[21] Nahin, Paul J. " *Time Machines: Time Travel in Physics, Metaphysics, and Science Fiction*. 2nd ed. New York: Springer, 1999. 136.

[22] Sagan, 218.

[23] Kaku, Michio. *Hyperspace*. New York: Doubleday, 1994. 85.

[24] Kaku, 86.

[25] Wells, H.G. *The Time Machine*. (New York: Random House, 1931), 2-3.

[26] Nahin, 22.

[27] A class of elementary particles that eventually decay into electrons.

[28] Davies, *About Time,* 58.

[29] In the *Forward* to Nahin's book, Kip Thorne (The Feynman Professor of Theoretical Physics at the California Institute of Technology) takes credit for feeding the concept of wormholes for use in the film to Sagan, using a wormhole's two mouths to convert to a time machine.

[30] Landau, L.D. and G.B. Rumer. *What is Relativity?* (N. Kemmer, Trans.) New York: Basic Books, 1961. (Original Work, *What is the Theory of Relativity*, published in 1959) 8.

[31] Davies, *About Time,* 33.