Universal Specificity Investigation 2: Inducing The Cause of Kinetic Time Dilation

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The results from the previous investigation into the nature of time revealed that time properly conceptualized is the interval over which change occurs, and is not a property of the universe apart from physical changes to things in the Universe. Additionally, it was revealed that changes to this interval over which identical changes occur implies a difference between their conditions. For example, when an hourglass or grandfather clock relocates to a different altitude, the interval over which the sands drops or the pendulum swings changes because of the difference in gravitational force at the two altitudes. I now turn the conception of time dilation, in much the same manner that time was analyzed.

1. On the Nature of Time Dilation

What is time dilation? The common understanding is that, in two different reference frames, two observers will record a different passage of time using identical clocks [1][2]. For example, in the twins paradox scenario, each twins' measurement differs for how long it takes one twin to travel to Alpha Centauri and back. This conception of time dilation obviously assumes the common conception of time discussed in the previous investigation, where time is a property of the Universe and an aspect of spacetime.

How would our conception of time dilation change given the conception of time at the base of the theory of universal specificity, where time is the interval over which change occurs? The conception of time dilation would change to the following: *time dilation* is a change in the duration over which all change in a reference frame occurs. It would mean that, in the twins paradox example, each observer is measuring the same interval of time for the duration of the round trip travel, but using different units of measurement. If we accept that an hour is a standard unit of time set on earth, then it means what the traveling twin's clock is measuring as an hour is not really an hour, but something more than an hour. It is analogous to an hourglass or grandfather clock moving to a higher altitude; each would measure a local hour, but in reality it would be something more than an hour. The only difference in this case, is that only the hourglass and grandfather clock are affected, but in the time dilation case the duration of all changes occurring in a given reference frame are affected.

The term used for a corruption of units in this manner is *miscalibration*. We know what causes the hourglass and grandfather clock to become miscalibrated at different altitudes, but what causes all intervals for all physical changes in the traveling twins reference frame (or any reference frame) to change, thus, masking the clock's miscalibrated? That is the focus of this paper's investigation.

The form of kinetic time dilation best suited for studying this miscalibration, is estimated to be a ratio of time passage of two identical clocks in two different reference frames, and is formulated as follows:

$$\frac{dt}{dt'} = \sqrt{1 - \frac{v^2}{c^2}} \tag{1}$$

In this form, dt represents the time rate of change for an object traveling in an inertial frame, as measured by some clock in that frame; dt' represents the time rate of change for a stationary object, as measured by an identical clock in its inertial frame; v is the velocity of the traveling object relative to the stationary object; and c is the speed of light. This form allows me to focus on what causes this differential to a change.

2. The Cause of Time Dilation

In my investigation for this cause I have identified two plausible causes posited by others, and one abdication for any need for a cause. The abdication amounts to relying on the Lorentz Transform to predict any time dilation related measurements one can possibly verify, and indeed, this transform does just that. It describes *what* one can expect to observe with regard to time differential effects with exactitude. I aim to go further and discover *why* we observe them.

In addition to the two posited causes, I added two of my own—work done and specific work done—and the compiled list is as follows:

- Relative Velocity
- Acceleration
- Work Done
- Specific Work Done

Just to give a brief description of each: relative velocity is based on the realization that changes in time differentials only occur between two frames when there is a relative velocity between them; acceleration is based on an attempt to resolve the twin paradox by concluding that the traveling twin's time must slow down only during acceleration; work done is one of my contributions, and it is based on the realization that velocity, acceleration, and the need for the Lorentz Transformation are all caused by work done to an object; specific work done is like my other contribution, but requires work to scale by the mass of an object.

Ruling out Relative Velocity

It might seem reasonable to think velocity is the cause of changes in time differentials between two frames because it is the only variable in Equation (1).

As an extreme counter example, consider what happens when the twin paradox is modified such that both twins travel with the same speed profile, but in the opposite direction. These siblings can have any possible relative velocity with respect to each other; however, no difference is registered between what their clocks' measurements, as shown in Figure 1.

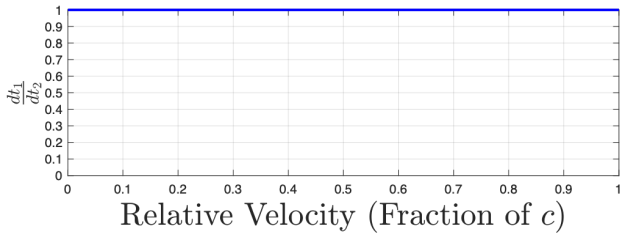

Figure 1. **Velocity changes, but time differential remains unchanged.**

Invoking the method of agreement, where the effect remained invariant when the plausible causal factor changed, proves inductively that relative velocity is necessary, but insufficient, to cause a change in the time differential between two reference frames.

Ruling out acceleration

In the twin paradox, one twin accelerated and the other did not, and the accelerated twin's clock slows down from the established standard set on earth—acceleration seems to be the difference that makes the difference. This approach, therefore, concludes that the time differential is less than unity only during acceleration. Einstein even attempted a twin paradox resolution assuming that the gravitational time differential was responsible for the kinetic time differential during acceleration; however, this plausible factor has been disproved in many sources [3][4][5][6].

Ruling out Work and Inducing Specific Work

The remaining plausible causal factors are similar to the acceleration argument, except in this case acceleration is what causes the time differential to change. Meaning the time differential remains constant until work (or specific work) is done, which implies time differentials have an "inertia." This conception of the time differential remaining constant for an inertial frame is termed *inertial time differential* (ITD).

That being said, let's put the remaining two factors to the test. Two simple thought experiments reveal that a change in specific work is the precise cause.

Proof:

First, I evaluate the effects of force applied over some distance.

Case 1: Consider a planet that barley accelerates to some final velocity when some work is done to it versus the same work done to a tiny marble, which causes that marble to zoom to a much higher velocity. Using the Lorentz Transformation reveals that the marble experiences a slower clock than the planet; therefore, invoking the method of difference, where each object experienced a different effect than the other, while having the same work done, proves inductively that work done does not cause changes in ITD.

Now, I evaluate the effects of specific work done.

Case 2: Consider the same two objects as before, but now they have the same specific work done to them. Using the Lorentz Transformation reveals the same time differential between the two; therefore, invoking the method of agreement, where each object experienced the same effect, while having the same specific work done, proves inductively that specific work done causes the change in ITD ■.

It has been inductively proven that an object undergoing a non-zero net specific force applied over some distance causes its ITD to change. If one considers the amount of specific work done in the earlier counter example to velocity, one sees why the time differential between those two reference frame had to be unity even though there is a relative velocity between them—they both had the same specific work done.

Of note, work done is conservative, which means when any object returns back to its original state, the net specific work done is zero, regardless of the path taken, and regardless of what mass is added to or taken from that object along the way. This is why objects in the same reference are always synchronized temporally. You will never see two twins in the same frame, where one is progressing "through time" at half the speed as the other.

Deriving The Causal Math Model

Knowing that specific work done causes kinetic time dilation, I would like to derive a precise math model capturing this relationship.

If we assume that kinetic energy and work represent reciprocals of the same causal phenomenon—a non-zero net force causes a change in kinetic energy, and changing the kinetic energy (e.g., a rocket engine sending hot gas away very fast) creates a force—then Equation (1) transforms nicely into specific work as shown in Equation (2).

$$\frac{dt}{dt'} = \sqrt{1 - \frac{v^2}{c^2}} = \sqrt{1 - \frac{2\Delta e_K}{c^2}} \tag{2a}$$

$$= \sqrt{1 - \frac{2\int a(r)dr}{c^2}} = \sqrt{1 - \frac{2w}{c^2}} \blacksquare \tag{2b}$$

Equation (2) is of course using the Newtonian specific kinetic energy model. It is unclear at this point that it is valid to use this model over the relativistic specific kinetic energy model, which is $\Delta e_K = (\gamma - 1)c^2$, where $\frac{1}{\gamma} = \sqrt{1 - \frac{v^2}{c^2}}$.

Equation (1) does not transform nicely into terms of specific work if we are to use the relativistic kinetic energy model. This brings into question the derivation of relativistic kinetic energy model, and if it was also based on a proper conception of time, which is the topic of the next investigation.

3. CONCLUSION

In conclusion, the cause of kinetic time dilation has been induced, but we lack confidence in our math model capturing this relationship since there is some ambiguity as to which

kinetic energy model to use. Determining which model is correct is the focus of the next investigation.

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