Universal Specificity Investigation 3: Inducing The Cause of Kinetic Time Dilation

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Previous investigations into the theory of universal specificity found a proper conception of time missed in common practice; which led to the realization that a universally stationary frame (USF) must exist; which finally led to the discovery that the average effective speed of light, c_0, is identical in all directions for any inertial reference frame, and is a function of that frame's velocity, v, relative to the USF, as shown in Equation (1).

$$c_0 = c\sqrt{1 - \frac{v^2}{c^2}} = \frac{1}{\gamma}c \tag{1}$$

c_0 being less than c means that light's travel duration takes longer (all else being equal). The reason the longer duration goes undetected is because of a phenomenon known as time dilation, which causes the apparent average speed of light to be c in any direction for any inertial frame. I now turn to deriving a proper conception of time dilation that is consistent with the proper conception of time.

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 twin paradox scenario, each twin experiences a different passage of time when one twin travels 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—i.e., from the perspective that time itself has changed.

How would the conception of time dilation change if it were based on 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 common change in the interval over which any change in a reference frame occurs. It would mean that, in the twin paradox example, each observer is measuring the same interval of time for the duration of the round trip travel, but using different base units (just units for short) in their measurements. If we accept that an hour is a standard unit of time set on earth, and that earth is stationary in the USF, then it means the "hours" the traveling twin's clock is measuring are not really hours, but something more than an hour.

This is analogous to an hourglass or grandfather clock moving to a higher altitude; each measurement of an "hour" 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.

In the hourglass and grandfather clock case, the miscalibration[2] of these clocks is easily detected and quantifiable by known means. 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, making his clock miscalibrated? This investigation aims to discover the cause of time dilation.

2. The Cause of Time Dilation

The form of kinetic time dilation best suited for studying its cause is estimated to be a ratio of time rate of change as measured by two identical clocks in two different reference frames, and is formulated as follows:

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

In this form, dt' represents the time rate of change measured by a moving clock, moving at some velocity, v, relative to the USF; dt represents the time rate as measured by an identical clock in the USF; and c is the speed of light in the USF. This form allows me to focus on what causes this differential to a change.[3]

It is important to note that orthodoxy holds that Equation (2) applies for any inertial reference frame arbitrarily selected to serve as "stationary," not just the USF (because of relativity of simultaneity, see Investigation 1), where v is the velocity between any two frames, and time dilation exists between any two frames with relative velocity. In that context, Equation (2) will be referred to as orthodox Equation (2).

List of Plausible Causes

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.

[2] *Miscalibration* in this context means a measuring instrument's employed base units depart from the base units intended to be used.
[3] By implication, clocks tick fastest in the USF, since this differential is only ever less than or equal to unit.

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 any 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 is important to note that this posited cause is not not just the velocity between the USF and another frame, but between any two frames that have relative motion between them. 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 the Orthodox Equation (2).

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 their clocks' measurements, as shown in Figure 1.

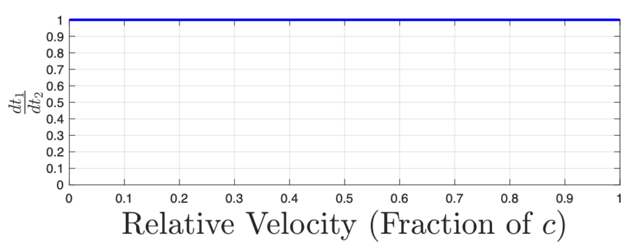

Figure 1. **Invariant time differential vs velocity.**

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 compared to the other twin's clock 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," 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 work done.

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 is not the precise cause we seek.

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 change to their ITD; 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 frames had to be unity even though there is a relative velocity between them—they both had the same specific work done. See relevant properties of specific work done in the appendix.

Deriving The Causal Math Model

Knowing that the cause of kinetic time dilation is the net total specific work done, starting from the USF—or just specific work done for short—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 (2) transforms nicely into specific work as shown in Equation (3).

$$\frac{dt'}{dt} = \sqrt{1 - \frac{v^2}{c^2}} = \sqrt{1 - \frac{2\Delta e_K}{c^2}}$$
$$= \sqrt{1 - \frac{2\int a(r)dr}{c^2}} = \sqrt{1 - \frac{2w}{c^2}} \;\blacksquare \qquad (3)$$

Equation (3) is of course using the Newtonian specific kinetic energy model. It is unclear at this point if this also represents the relativistic specific kinetic energy model, since this model has yet to be derived. Digging into how the relativistic specific kinetic energy model might be derived, however, will have to wait until the next investigation.

3. Conclusion

In conclusion, time dilation is a common change in the interval over which any change in a reference frame occurs. The cause of kinetic time dilation has been induced to be a change in specific kinetic energy; however, we lack confidence in our math model capturing this relationship since there is some ambiguity as to the proper derivation of the relativistic specific kinetic energy model. Deriving this model is the focus of the next investigation.

Appendix

The properties of specific work discussed in this appendix are as follows:

- Specific work done can be positive or negative.
- Specific work is the sum of its orthogonal components.
- Total specific work done is the sum of a set of isolated incidents of specific work done.
- Specific work done is conservative.

In any isolated incident of specific work done, it is positive when an object is accelerating with respect to the USF, and negative when an object is decelerating. The reason is that the components used to calculate specific work are vectors, e.g., net specific force and the direction of travel, as shown in Equation (4).

$$w = \mathbf{a} \cdot \mathbf{r} \qquad (4)$$

Additionally, any isolated incident of specific work done is the sum of each spatial dimension's specific work done, as shown in Equation (5).

$$w = w_x + w_y + w_z$$
$$w = \mathbf{a_x} \cdot \mathbf{r_x} + \mathbf{a_y} \cdot \mathbf{r_y} + \mathbf{a_z} \cdot \mathbf{r_z} = \mathbf{a} \cdot \mathbf{r} \;\blacksquare \qquad (5)$$

When it comes to combining a set of isolated incidents of work being done, the total specific work done is the sum of the set of isolated incidents. As an example, suppose earth's reference frame is the USF for the twin paradox scenario. The twin accelerating away from earth is the result of positive specific work done. The twin decelerating to a stop at the turnaround point is the result of negative specific work done. The net effect at this point of the scenario is that the positive and negative specific work combines and cancels exactly—total specific work done is zero. The same goes for the return trip.

The net effect of all these properties is that specific work done is conservative to any inertial reference frame. This means when any object returns back to its original inertial reference frame, then the total specific work done is zero, regardless of the path taken. Additionally, when any object goes from one frame to another, the same amount of specific work is done, regardless of the path taken. This is why objects in the same frame are always synchronized temporally—e.g., it is impossible for one twin to "progress through time" slower than the other, when they are both in the same reference frame at the same time.

Specific work being conservative means we do not need to know the entire history of work done to evaluate the total specific work done. All that is required is to evaluate what specific work is required to change from one reference frame to another.

References

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