Making Time with Pretty Girls and Hot Stoves

(An essay written for FQxi) Don Limuti 10/23/2008

We make appointments in time and pay our rent and mortgages in a more or less timely fashion. We know we have had birthdays in the past and expect a few more in the future. Time seems to be very solid and real.

Yet we know that everything we experience is done in the present and the only real time we have is now. All our concepts of past and future are illusory. They are a kind of processing we do with stored "pictures" in something we call a mind. With this view time seems to be something ethereal and unreal.

1. Can Time Be Both Real and Unreal?

Heinz Pagels in his book *The Dreams of Reason* has described something that can help explain this split. According to Heinz as we evolved as a species our language and thought progressed from a first person viewpoint (I am) to a third person viewpoint (it is). We went from subjective to objective from mysticism to science. Heinz thought this shift was a great achievement in the advancement of humanity. This is in contrast to the view of many philosophers who consider it an unfortunate entry into western civilization.

Heinz's is even more interesting when he makes the following two statements: "I believe that the reductionist-materialist view of nature is basically correct. I also believe that the transcendental view which affirms the priority of mind over nature, is correct".

To do this Heinz uses Kant's theory of epistemic dualism. Heinz translates this theory as: "In *principle* the world can be reduced to the properties of primary elements of material existence *(and is completely determined).* In *practice*, as any scientist will be the first to admit, such a reduction is, in detail, impossible to achieve. Hence the necessity for practical reason, which sees the mind as autonomous and the person as a free moral agent, an agent that for most practical purposes is independent of the brain."

The practical aspects of time are those that most people use in dealing with the problems of life. This is where we essentially treat time as an object.

The theoretical aspects of time are those of scientists and philosophers. Scientists usually consider time to be in Einstein's words "that which is measured by clocks". Some philosophers, particularly those who promote the unity of everything, consider time to be an illusion, a misinterpretation of the now.

I am going to use Heinz's insight as a starting point for making a table that expresses the dichotomy of the two viewpoints *I am* and *it is*. The table shows middle ground positions between the extreme positions. Obviously this table is not scientifically rigorous, but it will help to make a smother transition into the nature of time and its reality and unreality.

Table 1: Some possible middle ground viewpoints and the extremes they straddle.

First Person Perspective	Middle Ground	Third Person Perspective
I Am (Everything is Determined by God)	"To be or not to be" (Practical Reasoning Free Will)	It Is (Everything Is Determined by Nature)
Be	Do	Have
Spirit	Mind (spirit and body)	Body
Presence	Thinking	Non-Presence
Observer	Knowledge (Measurement)	Object
Zeroes Only (00000…)	Information (ones and zeroes)	Ones Only (11111…)
No Cause/Effect	Sometimes it is predictable sometimes not.	Complete Cause/Effect
Wave	Wave Particle Duality	Solid Object
Mysticism	Quantum Mechanics	Classical Science
Motion Impossible (Zeno Paradoxes)	Schrodinger's Wave Equation (Something is wiggling)	Motion Completely Determined (Newton's Laws)
Space and Space Alone	The Universe of Stars On a Background of Space	Stars and Stars Alone
Durations Between Clock Tics Alone	The Universe of Clocks and Time	Clock Tics Alone

Note that the middle ground positions generally are not static viewpoints, but instead oscillate (shift back and forth) between the two extremes, which are for the most part static. For example Hamlet's quandary is a formulation for how we generally

face the world. We do not want to be slammed against the extremes that God or Nature predetermines everything and all our doing is illusory. So, to various degrees we do what Hamlet did and find a place in-between "to be" and "not to be" and try to make a good play out of it.

To move back to the subject of time, note that the middle ground position concerning time (The Universe of Clocks and Time) is the only place where time actually exists. The two extremes are impossible to attain. Clock "tics" can only exist with the existence of spaces between the tics (the durations). You cannot have a background without a foreground. Tics alone are an impossibility and durations alone are an impossibility.

2. Background Illusions

We can look at the night sky and just see a vast array of stars. But what is that stuff between the stars? Can all that space be nothing? If it were nothing there would be no separation between the stars, so it must be something. If it is something it must be an object. In general we call this background space and we give it the properties of dimension and think of it as an object.

So, can we isolate space from objects? Of course not, they both spring into being simultaneously, one does not exist without the other. Something and nothing are forever intertwined. This strangeness is familiar to us when we think of the space between the stars and the stars themselves as two separate entities, and at the same time we know they are inseparable. We live with this and have a mental handle on it.

In a similar fashion we think of the tics of a clock and the duration between the tics as separate objects, even though they are inseparable. We know about this duality but usually do not have as good a feel for it as the duality between stars and space. This distinction between tics (events) and the duration between them (time) is worth looking at closer because it reveals the nature of time and I believe the nature of all existence.

3. Time Is Measured With Clocks

Einstein gave us the rule: Time is measured with clocks. This statement assumes that a universe of objects exists and that some of them are clocks. It is also assumes that observers exist to make measurements.

Here is how we make measurements with a clock:

a. An observer makes a measurement by taking a sensory picture of objects in space on the tic of a clock. Included in the picture is some form of a time tag (a number) that was derived from a clock. This time tag can be generated internally (within the body mind complex of the individual) or externally via an external clock (like Big Ben).
b. The picture is stored as the latest entry in memory storage (internal or external). This memory contains other pictures (past measurements) with their time stamps.

c. The pictures in memory are analyzed for changes that are of interest to the observer. One of the more basic things the observer is interested in is how much time is there between two images in storage. To do this the observer performs a subtraction on the two time tags and Δt is the result, a number that represents the time between the events.

4. Two basic types of clocks are used to measure time:
   a. Internal clocks

Einstein describes this aspect of clocks in his statement: "When a man sits with a pretty girl for an hour, it seems like a minute. But let him sit on a hot stove for a minute and it's longer than any hour."

I am going to develop this connection between how rapidly we make measurements (observe our environment and process the data) and our sense of time. When on the hot stove we are constantly monitoring the situation and making lots of measurements (via our internal clock) because our survival is at stake.

It is just speculation but our internal clock may be related to brainwaves since they are clock like and when they are missing (flat line) we are not functioning in time. I mention this in case a reader may wish to pursue it. Currently it is thought that brain waves are the result of the averaging of the electrical fields involved when many neurons are firing. It may be just the opposite and neurons synchronize themselves to the brainwave clock. Just a thought.

The processing overload of clocking lots of pictures into memory and analyzing them makes us feel that a lot of time is involved. Note that children are processing more information than adults and that time for children seems to move more slowly.

Putting our sensory images into memory and processing them is what we usually call thinking. And thus the more thinking we do as individuals the more our sense of the passage of time.

Many of us have experienced the effect of anesthetics during medical operations. The anesthetics stop our mental processing (thinking) and when we become conscious again in the recovery room it feels as if no time has lapsed. However the doctors and nurses and everyone else in the hospital agree with the clock on the wall that one hour has passed. For the most part we override our internal feeling and agree that one-hour has passed even though it is in direct conflict with our personal sense of time.

On the personal level, the application of "time is measured with clocks" is equivalent to the statement "thinking produces our internal sense of time". This analysis is unscientific and heuristic, but since we have a sense of time independent of external clocks I feel justified in saying that

there is an internal clock (somewhere in body/mind) operating in all observers.

The process of thinking (making and analyzing measurements on internal clock cycles) is primary when considering time because without this internal clock phenomena there are no other clocks to consider (the external ones). When the internal clock stops no mind processing can be done and there is no external world to experience (including clocks). Note that I am considering sensory inputs as physical things that must be converted to thoughts (mind stuff) for us to make sense of them. From this internal clock viewpoint everything is all mind stuff.

In the table showing middle positions there is one called "Thinking". It is flanked by "Presence" and "Non-Presence". Here thinking indicates sensing the external world, processing these inputs internally, and acting on the external world. All these actions rely on an internal clock. Presence also relies on an internal clock for sensory inputs and action outputs, however there is no mental processing going on. Non-presence as used here indicates no external activity. All sensory inputs and outputs are illusions within the individual via internal clocks operating only on memory.

Thinking is associated with waking consciousness. Presence is associated with immediate "now" experience. Non-presence is associated with the dream state. All these states work with an internal clock. When the internal clock is missing it is called dreamless sleep.

Now the fun begins. Once we start thinking we can have an external world that can be experienced and understood. At last we can consider the aspects of clocks and time that science usually investigates.

b. External clocks

External clocks are complex objects that people can read at a distance. They can be synchronized locally but do not represent a universal absolute time as investigated by Einstein. The way measurements are made is the same as described in section 3 above. Events are recorded on the "tic" of the clock and not in-between. If we want to know what happens between tics we need to get a faster clock so that we can make more measurements. This digital nature of clocks and the fact that "time is measured by clocks" gets around one of the persistent trouble spots in science/philosophy "the continuum barrier".

5. The Continuum Barrier

The following quote is by Matteo Viale (Kurt Gödel Research Center for Mathematical Logic at the University of Vienna)

The continuum is arguably the most fundamental object in all of mathematics. It is the concept behind virtually all measurements. But how many real numbers are there? How many points are on a line in Euclidean space? This is one of the great mysteries of mathematics, and it can be proven to be a mystery: by the work of Cohen in 1963, the methods sufficient for 'everyday mathematics' are inadequate for solving this problem.

Draw a line on something and then put a grain of sand on that line. Can that grain of sand be moved? The answer is "of course it can be moved" because from a practical standpoint we all know we can move things like a grain of sand, but from a theoretical standpoint the answer is not clear.

If we chose a point next to the grain of sand we find that it is not next to the grain because there are still an infinity of points that are closer. A case can be made that there is no closest point to the grain of sand because there will always be points in-between. This is basically the core of Zeno's paradoxes on motion. Achilles arrow cannot be in motion because at any instant the arrow is on a point of the continuum. Once you agree that it has a position you are "in the soup" logically and there is no place for the arrow to go. And yet we know it goes, so what is going on? The answer as developed below is found in the nature of clocks and thus the nature of time.

6. Mathematics Butts Heads With Physics
   a. Zeno the troublemaker

      Zeno of Elea (c. 495 - 430 B.C.E.) was a Greek philosopher associated with the village of Elea near present day Naples Italy. He was the author of many paradoxes concerning the impossibility of change and motion. His paradox concerning Achilles arrow is particularly clear: *Since an arrow in flight does not move during any single instant it couldn't possibly be moving at all.*

      Zeno took it for granted that a point on the continuum must be stationary. This was his starting axiom and he logically went from there to the conclusion that motion was impossible because of the nature of the continuum.

      Just about everyone concludes that Zeno must be wrong because things do move. The most relevant argument against Zeno is that the methods of calculus (invented by Newton) get around Zeno's logic. However, there are many competent mathematicians who say that the paradox stands and that Zeno's logic is impeccable.

      I think Zeno's logic is correct. However there is a problem with his assumption (axiom) that a point on the continuum has the velocity of "0". The explanation involves the nature of clocks and Einstein's remarkable instinct. But before this solution is presented let me show you how Newton tricked us.

   b. Newton the trickster

      Newton approached the continuum from the other side. He assumed an arrow with a real velocity and then took it to a point on the continuum.

      Newton created the calculus that purports to show that when the moving arrow has a velocity "v" that velocity is with the arrow when it is at an instantaneous position. Newton seemed to have overcome the challenge of the continuum, however I believe he avoided it because of ignorance about the nature of real physical arrows (and apples ☺).

Newton defined velocity as $v=\Delta x/\Delta t$ the rate of change of distance with respect to time. The calculus books I grew up with went through great pains (particularly for the student) to show that discrete steps $\Delta x/\Delta t$ can in the limit be taken to the continuous velocity $v=dx/dt$ at a point on the continuum.

I think this argument is legitimate for massless objects (the ones that mathematicians love), but for real objects with mass like arrows it is not, because they do not move smoothly when Δx and Δt goes toward zero.

Louie deBroglie developed the theory that mass has wavelength just as light has wavelength. Experiments have been made showing the validity of this theory and deBroglie was awarded a Nobel Prize for his work. If you believe this theory you cannot take a moving arrow to a point on the continuum. It turns into a wavelength before you finish the process. Thus you cannot have the velocity $v=dx/dt$ at a point of the continuum as Newton's laws would have you believe.

I do not think we should eliminate as a branch of mathematics. In some theoretical applications it is completely valid. However, when it is applied to physical systems that involve objects with mass it has its limits.

So Zeno had arrows that had position but could not move and Newton had arrows that could move but could not be at a definite position. It looks like the continuum is winning.

c. Einstein the practical scientist

And then Einstein said: *Time is measured with clocks* and the continuum ceased to be the quicksand for reality. In the world of reality we make measurements. And we measure time with clocks. On the single tic of a clock we do not get a time. Time is a duration that is calculated by subtracting numbers (time stamps) that occur on successive tics of a clock. This brings up a question. What is a clock tic? We will get back to Einstein shortly.

d. The meaning of space-time and how clocks are use there.

Most scientists instead of referring to space alone or time alone now use the concept of space-time. A way of looking a space-time that I think makes sense is via the concept of velocity. All waves (electromagnetic waves) and all physical objects have velocity. It is obvious that waves are always moving but objects are also in continuous motion. This is because at the distance of the objects matter wavelength the object is not static and has a back and forth velocity (oscillation). When everything is moving the concept of velocity is universal. Since velocity is $v=\Delta x/\Delta t$ and everything (waves and objects) has velocity, everything has simultaneous space and time properties. Space properties and time properties are always connected, looking at space alone or time alone leaves something out. So we try to be accurate and speak of space-time instead of space alone or time alone.

Space-time does not have instants (points) of "time" or instants (points) of "space". I believe these point concepts are a left over from considering space and time as independent. When we consider space-time we have a new type of

point, *the tic of the clock*. On the tic of a clock we do not quite make a measurement. I know this will sound strange because we are so used to thinking of space and time as independent. The tic of the clock is an event in space-time where an observer records numbers, space numbers and time numbers. On the next tic event another set of numbers is measured. The space and time numbers generated on sequential tics of the clock are used by the observer to calculate Δx and Δt.

With this view of space-time the continuum makes more sense. The continuum of space-time is the continuum of numbers. The numbers are not points of space or time but are used by the observer to calculate (measure) what we usually think of as space and time. The continuum has one event, the tic of the clock. Time to get back to Einstein.

c. Einstein the practical scientist continued.

The concept of a position is now forced to be a calculation that is analogous to duration. The event of the "tic" does not have a time except in relation to other tics. So the position of the arrow is a distance that is calculated by subtracting numbers (distance stamps) that occur on successive tics of a clock. As strange as it may seem the position of an arrow does not occur at a point just as the tic of a clock does not have a time. The only measured time there can be is Δt and the only measured position there can be is Δx.

There is a limit to how small we can make Δt and Δx. It is determined by the wavelength and period of the objects mass. Δx can be reduced to the wavelength of the object and Δt can be reduced to the period (1/frequency) of the object when it is considered as a matter wave.

Sorry Newton there is no way to turn Δx and Δt into dx and dt for real physical objects with mass, the nature of time as measured by clocks forbids it.

Both Zeno and Newton thought that in theory you could have a velocity at a point. In practice this turns out to be impossible.

d. The Compatibility of Mathematics and Physics

The world of natural phenomena is what we try to model with mathematics and we make the mathematics do what is necessary. The mathematical model developed by Newton had some limits. It also had some very good features in that it was simple and elegant. The new world of quantum physics has its new mathematical models not nearly as simple or elegant at least in my humble opinion. This is not at all surprising.

Some knowledgeable reader may notice that I am pushing Einstein's comment on clocks a bit. Einstein's comment was that "time is measured with clocks and space is measured with rods". The concept of space-time was just being investigated at the time of Einstein. I am just interpreting his comment in a little more up to date way. The new form is: *Space-time is measured on successive tics of the observer's clock. Space and time do not exist on a single tic of the clock, they are calculations made by the observer.*

7. How Fast Can Clocks Go

We are very concerned with the duration between the tics of the clock because that is what time is. For the duration to have meaning it needs to be measured. So we pull out another faster clock and measure it. We keep doing this until we reach a point where our technology will not allow us to build anything faster. We then as a group create a standard clock. The standard that is chosen needs to have high speed, affordability, reliability and repeatability. Once the standard for the clock is chosen it is the stopping point for discussion. What is the Δt between the tics of the present day standard clock? The answer is about 0.1 nanoseconds. This is the Δt for the natural resonance frequency of the cesium atom (9,192,631,770 Hz), or the frequency used to define the second.

NIST is very proud of its latest cesium clock and boasts that it will neither gain nor lose a second in 20 million years.

The theory goes like this. All our cesium clocks are very uniform (also very expensive). We **trust** the resonant frequency of cesium to be completely accurate. But note that we do not measure this accuracy, we assume it. And thus we conclude that the only inaccuracy in the time standard is in the actual construction of the clocks.

In practice the Δt of the cesium clock is like the time on the clock on the recovery room wall after the operation. You know there was no time that passed after the anesthetic but the clock on the wall said 0.1 nanoseconds had passed and it is the standard that the doctors (scientists) and nurses (philosophers) bow down to.

So once again we capitulate and agree to the time everybody else agrees to because after all it is the standard and external clocks do not lie.

8. The Nature of Time

Time is born when an observer makes a measurement of the duration between clock tics. With our clocks (internal and external) we bridge the continuum and experience the world.

As much as scientists want to avoid introducing "thinking" because it is so unobjective, it is unavoidable because it is what observers do. Thinking is a function of our (postulated) internal clock. An observer making a measurement with a clock is the fundamental break with pure "objectivity".

To the extent that an observer refrains from thinking time slows down and an hour seems like a minute. Time feels light and unreal. This is the very enjoyable "sitting with a pretty girl" state.

To the extent that the observer engages in thinking, a minute seems like an hour and time feels very solid and real. This is the not so enjoyable "sitting on the hot stove" state. It is here where we can write essays on the nature of time.

I hope you enjoyed the heat!