Mental modeling helps us create mental representations of reality to better understand the underlying principles in which it operates. In fact, this mental modeling has helped us solve multiple problems in engineering, art and the likes and has popped up again in our analysis on the direction of time. It can be argued that modeling and in what context that modeling is occurring has influenced our understanding of the direction of time. Significant research has been undertaken to assist the academic community to come to a conclusion on the arrow of time. This research spans various disciplines including physics, linguistics and, of course, philosophy. Thermodynamics determines the direction of time flow with respect to the second law of thermodynamics which states that the total entropy of a system cannot decrease over time unless the system is reversible. The reversibility of thermodynamic processes, or lack thereof in the real, physical world, gives time its singular forward direction; in one way. Entropy is the variable in focus here as it statistically defines the possible microstates of a given system or “randomness”. With defining our direction of time with respect to entropy, we use the axiom that the universe has a low entropy in the past thus creating the distinction between the past and the future. In fact, this model and its interconnectedness with the second law of thermodynamics remains a big area of research in physics. However, special attention should be given to the axiom in which we declared which was the observation we made in regards to the beginning of time. In analyzing the direction of time, we define the beginning of time as the beginning of the universe or the Big Bang as it is known in modern physics. From this, we drew our inference that
entropy was low at the time of the Big Bang and since it is increasing, we draw the conclusion that time operates in a forward direction. This method of inference is one of the many ways in which we humans create conceptual models of the world.

Take for example our notion of the “modern clock”. The modern clock is a staple in industrialized Western societies where mechanization and efficiency are the hallmarks of progress. The modern clock acts as the division of time separating free and work time. As a result, the typical 24-hour day has a start and end signified by the ending of free time and the beginning of work time or vice-versa. This linear time scale was strongly influenced by societal pressures as mentioned by McLuhan in his *Understanding Media: The Extensions of Man*:

The mechanical clock, in short, helps to create the image of a numerically quantified and mechanically powered universe. It was in the world of the medieval monasteries, with their need for a rule and for synchronized order to guide communal life, that the clock got started on its own modern developments. Time measured not by the uniqueness of private experience but by abstract uniform units gradually pervades all sense of life, much as does technology of writing and printing. Not only work, but also eating and sleeping, came to accommodate themselves to the clock rather than to organic needs (McLuhan 146).

He proposes this concept of the medium affecting the society in which it plays a role in, through the characteristics of the medium rather than the actual content. Other examples include the light bulb which had a dramatic effect on people’s ability to create spaces during the nighttime. In the case of the modern clock, it changed people’s relationship with time. Conversely, take for instance, the Hopi Indians whose sense of time is defined by “corn maturing or sheep growing up” (McLuhan 147). For them, time is this process existent in natural substances that is carried out in “life dramas”. Although a necessary invention for providing order to labor in the industrial age, the modern clock ultimately changed our relationship with time. We view time cyclical, divided up based on the errands people run on a given day or the number of hours spent working
in the factory. This division lends itself to trying to evermore increase one’s productivity optimizing their tasks and to-dos based on a 24-hour time constraint. Greater output per hour results in a higher efficiency which, when viewed from the perspective of a factory manager means higher productivity and more profits. However, this is not new to the likes of Lewis Mumford who understood the prevailing effect of technology on our organic processes. Regardless, it is important to note the ability for technology, once amplified by cultural and economic objectives, to influence our relationship with natural phenomena such as time.

Let’s take a look at more formal systems such as physics and mathematics which inherently decide on a direction or framework for dealing with time. The father of classical mechanics, Isaac Newton, describes time as independent of space and the universe, and concluded that time should be measured independently. However, this turned to be a false truth when Albert Einstein described in his theory of relativity the interconnectedness of time and space and its ability to exhibit dynamic behaviors. Dynamic behaviors which were assumed to be static and non-changing in the case of Newton. This paradigm shift shed light on the importance of reference points. In defining the reference point and the coordinate system for which our calculations will be conducted, you inherently define the logical foundation for which all theorems and axioms can build up from. If the reference point is restricted to a desert in the mid-West, it makes sense for Newton’s laws of physics to reign supreme and proliferate effectively. However, if the reference point changed from a macroscopic object on Earth to say a photon traveling in space, a different logical foundation is declared and hence different axioms are used. When observing static objects, their change in position is effectively zero. But observing the individual atoms of the object, the case is quite the opposite. The atoms engage in
vigorously vibration, oscillating back and forth. For static objects, their motion is typically plotted as a linear relationship with respect to time. But in the case of the atoms, we describe the motion trigonometrically in the form of sines and cosines. These, too, are plotted on a linear timescale. But the question arises, why do we utilize the same time scale for microscopic atoms as we do for macroscopic objects when we can observe that the same laws of physics that apply to macroscopic objects tend to fall apart when observing the world of the atom and individual electrons. In other words, why is the direction of time which we define when observing macroscopic objects also used when observing quantum mechanical systems? The issue we encounter occurs in defining our logical foundation for which we decide to build our axioms and theorems.

When analyzing formal systems and the axioms which are birthed, one naturally encounters the notion of binary opposition. In Immanuel Kant’s *Critique of Pure Reason: Excerpts on the Idea of a Beginning of Time*, he brings forth the question regarding the beginning of time and the end of time:

Nothing seems to be clearer than that, if one maintains: "The world has a beginning," and another: "The world has no beginning," one of the two must be right. But it is likewise clear that, if the evidence on both sides is equal, it is impossible to discover on what side the truth lies; and the controversy continues, although the parties have been recommended to peace before the tribunal of reason. There remains, then, no other means of settling the question than to convince the parties, who refute each other with such conclusiveness and ability, that they are disputing about nothing, and that a transcendental illusion has been mocking them with visions of reality where there is none (Kant 10).

He is essentially describing the inherent logical boundary that is reached when you consider the possibility of time having a beginning and it’s binary counterpart, an end. It is similar to the integer positive one and the integer negative one found in typical number systems. They are
opposites and their existence is dependent on the existence of the other. This dependence ultimately causes these two values to cancel out, resulting in something that does not exist. Shakespeare plays with this binary in his play, *Macbeth*. In Act 1, Scene 1 of the play, the witches state, “Fair is foul and fouls is fair: Hover through the fog and filthy air.”. Clearly, our cognitive abilities find it necessary to find binary opposites in thoughts or logical statements. As is the case when trying to define the direction of time, if time has a forward direction, it *must* have a backwards direction as well.

On the topic of language and discourse, it is argued that our language systems have a direct effect on our definition of time. This ties back directly to modeling and our need for it when engaging in the communication of our ideas. Our perception of the world is inherently defined by whatever mental biases are existent in our neural patterns at the time of the observation. To explain this, Alfred Korzybski coined the term, “The map is not the territory”. Say for instance that a territory was presented before you and you were tasked to draw a map of the territory for use in a travel guide. While observing the territory, you couldn’t help but notice the beauty of pine trees and how they are reminiscent of your childhood home town. You devote immense effort to depicting the pine trees in their truest form at the expense of the rest of the territory. Now when the map is viewed by viewers reading the travel guide, they can’t but help notice the beautiful pine trees! This is a classic example of the effect of perception on the depiction of an object or entity. In Ted Chiang’s *Story of My Life*, he uses this concept to describe the relationship between language (our medium for mental modeling) and time. In the short story, landings of extraterrestrial beings cause the US military to elicit the help of a professor of linguistics to understand the true intention of the aliens. In the 2016 film adaptation,
*Arrival*, a dialogue between Ian and Louise, the main character, summarizes the essence of the story:

**Ian Donnelly**: If you immerse yourself into a foreign language, then you can actually rewire your brain.
**Louise Banks**: Yeah, the Sapir-Whorf hypothesis. It's the theory that the language you speak determines how you think and...
**Ian Donnelly**: Yeah, it affects how you see everything (Villenueve).

Through the process of learning the language of the aliens (which embody circular properties), Louise experiences a change in her perception of reality so much so that it influences her perception of time. Her reality begins to embody the characteristics of circular time such as the ability to access points along a timeline which would be deemed as occurring in the future, if observed from a linear perspective. This example gives us insight into how discourse structures our perception of reality. In Terry Eagleton’s *Literary Theory: An Introduction*, he states:

Truth is the product of interpretation, facts are constructs of discourse, objectivity is just whatever questionable interpretation of things has currently seized power and the human subject is as much a fiction as the reality he or she contemplates, a diffuse self divided entity without any fixed nature or essence (Eagleton 201).

Our discourse is our human cell, limiting and constraining our understanding of reality! It is important to be cognizant of language, not just those such as English or German but also mathematical languages, when designing formal systems for understanding time.

Human thought and intelligence is ultimately at the root of these formal systems. But after a deeper analysis, we begin to see the emergence of logical contradictions and limits to our modes of thinking. An interesting example from number theory is Godel’s Incompleteness Theorems. These two theorems help demonstrate the limitations of any formal axiomatic system, our focus, however, is on the first theorem. The first incompleteness theorem states that the
consistency of any formal system cannot be proved in that system but only in a larger system (which cannot again prove its own consistency). In other words, a formal system cannot prove itself! Douglas Hofstader explores the notion of self-reference and “strange loops” in his 1979 treatise on mathematics, computer science and consciousness *Godel, Escher, Bach: An Eternal Golden Braid*. Taking these two example statements from the book:

> The following sentence is false.  
> The preceding sentence is true (Hofstadter 21).

We immediately encounter a paradox! The notion of self-reference is important when understanding human intelligence and consciousness but also plays a role in our declaration of a direction of time. By deciding that time has a linear, forward direction, for instance, our reality also takes on a linear, forward direction. This has recursive effects on formal systems such as mathematics and physics as well as language. Hofstader enhances his discussion on strange loops with an allegory titled “Contracrostipunctus”. The main character Crab has purchased a new hi-fidelity record player, of which he is relatively joyous about. This record player has the ability to play back any record with perfection. His friend, Tortoise also a trickster, brings a record to Crab’s house and plays the record “I Cannot Be Played on Record Player X”. Interestingly enough, the song is designed to produce the precise vibrations needed to destroy the record player. As Hofstader remarks, “The paraphrase of Godel’s Theorem says that for any record player, there are records which it cannot play because they will cause its indirect self-destruction”. This sort of paradox has far reaching effects on formal systems and we can conclude that it is indeed emergent.

Say for instance, that a human was birthed in an environment that was rid of all human culture, understanding of mathematics, physics and the likes. The human was suspended in space
and was deprived of sensory input. After some time, the humans of Earth venture into space only to encounter this outsider human drifting. They immediately bring him into the spaceship, providing him warm towels and some water. One of the crew members thinks that the human is an extraterrestrial being that is not human, however, they conclude he is human given his physical features. After bringing the human back to Earth, the crew members try to understand how this outsider human communicates. Pretty soon, the crew members conclude that the outsider human has no formal systems for communicating and experiences time quite differently. The outsider human sees time as operating with a circular and a linear time scale and has the ability to control the speed at which he observes motion! The Earth humans are startled at this and begin to perform tests to better understand this amazing new discovery. Pretty soon the Earth humans attempt to explain their understanding of time to the outsider human but they encounter an issue where in trying to explain time, they must first explain what language is, the concept of mathematics, the idea of night and day only to realize that the outsider human needs an understanding of Earth human language to even allow the Earth humans to convey the concept of language!

This example explains the impact of self-reference, mental modeling and formal systems on our discussion on time. We cannot argue the directionality of time while we are in time. In the case of the outsider human, it required a literal removal from all preconceived formal systems to adopt a different model for viewing time. In fact, it can be argued that we aren’t really in time and that time is simply a by product of whatever logical and formal systems we created to help us define some concept of time. The antithesis to this is that time is inherent in all intelligent beings or systems and, in other words, universal. We have seen, however, that mental modeling
and analogy making is at the core of human thought and it has influenced our understanding as well as our definition when discussing the directionality of time.


