Causation, Time and the Emergence of Space

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Abstract

In this paper David Humes analysis of causation is discussed and a way of connecting cause and effect is suggested. This connection is found to be time itself and time is understood to be an active agent transforming reality from instant to instant. The notion of localities and a network of connected localities is seen to create space. Localities that do not interact with photons but with state changes in the central nervous system create the experience of mind that in turn causes changes in state of the nervous system. It is claimed that this interaction provides an understanding of mental causation.

> How can the past and future be, when the past no longer is, and the future is not yet? As for the present, if it were always present and never moved on to become the past, it would not be time, but eternity. Augustine of Hippo

1 Introduction

When a billiard ball strikes another and the second ball moves off in some direction we are tempted to say that the first ball's striking the second *causes* the second ball to move. Humes analysis argues we cannot perceive any potentiality in the first ball that could possibly cause the second ball's motion. In this famous argument how the state associated with the one ball's motion is transferred to the second ball is invisible to us. We cannot see the slender thread that binds cause to effect and so, being unperceived we cannot say that it exists and the idea of a special relation between cause and effect might be an illusion. All we can say with confidences is the two events are conjoined. Hume does allow that if, in our experience, the two events are always conjoined we may have reason to believe that one causes the other. But in no case can we say definitely that one event causes another. Is the search for this thread hopeless? Interestingly, Hume provides us with an example, that of divine intervention. He takes the time to rather thoroughly describe how this might work. He then discounts this as a possibility as it does not really explain anything. It merely assigns to the invisible connection that we seek to God. So we are substituting one unknowable agency for another. We will not attempt to establish a certain principle, or even a principle in which we have a high level of confidence. We will seek an argument to the best explanation, an hypothesis that is useful to the understanding and perhaps can be extended in unlooked for directions: something that might satisfy a more utilitarian perspective in the manner of William James.

When I began this paper I did not see clearly where it might lead. Much to my surprise, it has lead into areas of active interest by many people. I think there are parts of the paper that touch on causal set theory and loop quantum gravity. While I know very little of these subjects, from my limited understanding I am somewhat surprised that my simple musings have lead to where it has. Certainly I share an interest in ordered sets with causal set theorists. I leave to others more competent than I to judge the accuracy of these observations.

2 The Ordering of Time

Upon reflection it appears that any analysis of causation must begin with some analysis of the nature of time. After all, we say that causes precede effects and in what do they precede? They precede in time. This remarkably simple statement has within it a hidden assumption about the nature of time. The word precedes carries with it the notion of an ordering. If a set is not ordered, we can hardly speak of one element preceding another. How does time come to be ordered in this way, with one event preceding another?

The Ordering of Moments

We take as given that there are moments. In Russell [1] we see a different starting point in which Russelll starts with a primitive notion of interval and develops a notion of moments that are provably dense. In this analysis we reverse Russell's produre and We will not try to define in a formal way what is meant by a moment, but will depend on an intuitive notion.
We would like to speak of a set of moments, but to do so each moment must be distinct. This presents a difficulty as we would like to assert that each moment is exactly the same as every other moment. This is a similar situation that one might encounter when considering a set of points. If each point is exactly the same as every other point, how can there be a set of distinct points? Generally points are thought to have different positions and so the set of points is possible because each point has a different position and so is distinct. But is position a property of a point or a relational property that depends on the geometric properties of the manifold in which the point finds itself? In asserting the existence of a set of points are we not also assuming the existence of some manifold in which position can be defined? We believe this may be the case. In asserting the existence of a set of moments we encounter a similar conundrum. Each moment may be distinct in the sense that it occupies a different position in a manifold of time. But in this analysis we have not even encountered the idea of time, and so it might be instructive to attempt to deal with the problem a little differently.

Let us imagine that we have a collection of plain paper cups. We can easily say that these cups are distinct and form the members of a perfectly good

[1] Russell reference

set. But suppose the cups are very identical. Are they still distinct? We could always say they are merely approximately identical and so are still distinct. But, suppose they are perfectly identical. While this may be physically impossible we can certainly entertain the idea without fear of contradiction. Are they then, distinct and can they be members of a perfectly good set despite their identical properties? One could say that they each have unique *instantiations*. Each cup has a separate reality, a separate identity, independent of its properties. We propose that moments, while identical and interchangeable have independent instantiations, quite independent of their properties. In this sense, We have introduced the notion of existence quite independent of geometry or location, as we have yet to even mention the possibility of the idea of a location. It appears that for items to be elements of a set, they must be admitted to have an existence and that exisitence must be disticnt! We might suppose one could consider the set of non-existent things. One is tempted to inquire if this set is empty. If it is not the there exists an element such that the element is in the set. But if it is in the set, then it exists and so can not be an element of the set and so the set is empty. But does set membership require instantiation when the elements in question have no unique characteristics? I do not believe the argument supports the use of the word require, but it meets the needs of the argument. And so if we are prepared to allow the existence of moments, it seems we can argue that they are distinct entities and can be members of a set. And this can be safely asserted without knowing any of the properties of moments.

Many ontological questions are raised in the above argument. In this argument we would like to assert that an entity exists if it makes a difference to other existent entities. There is a circularity in this definition of existence, for where does the first existent object come from? We take the Cartesian argument that the self exists and this starts the whole chain of inter related being. We have argued for the instantiated existence of moments that do not seem to have any other properties beyind existence. They have no location, mass, volume or shape. It is often asserted that things that lack these properties can not be said to exist. We argue that even lacking these properties, they do exist because their existence makes a difference to things that clearly do exist.

At this point we will make a few somewhat unfounded common sense observations that will motivate some more formal statements. We will consider sets of moments and how these sets lead us to the ordering of time. Let us observe that the collection of previous moments (previous moments taking the common sense meaning) from the perspective of 1 PM is smaller than the collection of previous moments when viewed from a later moment, say 2 PM. That is the past becomes larger as time goes by. Furthermore the set associated with 1 PM is a subset of the 2 PM version. With this we are making the somewhat interesting assumption that the past does not change with the passage of time. The past is the same when viewed from ether 1 PM or 2 PM We often wish that we could travel back in time and change something that we did. But we cannot. The past is what it is. To reiterate, from the perspective of 1 PM, the collection of past moments is a subset of the collection from 2 PM. This simple observation motivates the following assertions about the set of moments.

1. Let M be a set of Moments.
2. Let $\wp M$ be the power set of M
3. Let $\Upsilon \subset \wp M$ such that for each $m \in M$ there exists $\upsilon \in \Upsilon$ such that $m \in \upsilon$ and if $\upsilon_1, \upsilon_2 \in \Upsilon$ then either $\upsilon_1 \subset \upsilon_2$ or $\upsilon_2 \subset \upsilon_1$

From statement 3 it is clear that Υ is ordered under the subset operator. That is $\upsilon_1 \prec \upsilon_2$ if and only if $\upsilon_1 \subset \upsilon_2$. Furthermore the entire set Υ is ordered in this way. It is interesting to note that we have not specified the number of moments separating the sets in Υ it will turn out that this is not relevant at this stage. Υ is an ordered set of sets which we shall call sets of previous moments. We view the moments as interchangeable, but under the subset operator the sets of previous moments are not interchangeable and differ from one another in their cardinality. A set of previous moments can be said to precede another set, but moments, by themselves, can not be ordered in this way.In fact, from the point of view of an ordering all moments are interchangeable. From this point on, sets of previous moments will be the focus of our attention. Any set of sets of previous moments would contain a smallest element that would precede all other sets of previous moments. This might indicate that there was a beginning of time. While we are aware that these sorts of beginnings are fraught with all manner of difficulties, having no beginning has its own set of difficulties. So we will precede despite the problems inherent in beginnings. We have not, at this point, introduced the notion of successor or generator that when added to a given set generates the next set. These ideas will be developed later.

3 The Definition and Agency of Time

But a set of previous moments is a static structure. Υ must contain a largest element, a largest set of previous moments. This set we will call the present moment. We are perhaps, making a problematic statement. How can we say a set of moments, is a moment. We are adopting this usage to reflect the we have found that the ordering of moments requires us to consider sets of moments. The idea of a present moment must carry with it some kind of ordering and so it is natural to think of the present moment as the last moment which it turns out is the largest set of past moments. And so we are seeing our notion of a moment changing. It is no longer a rather nebulous entity but is rather a set of such entities! But, the present moment remains, statically, the same. To conform to any intuitive notions, it must be that the set we call the present moment changes. These considerations lead us to define time the following way.

We suggest that the agency that effects this change is what we ordinarily call time. Time is the agency that acts on the set of previous moments to transform the present moment into a past moment while creating a new present.

In addition this acts to make the size of the present moment continuously increasing. The word continuously is problematic. If there are finitely many previous moments, then their domain is not continuous or dense, but is discrete. We will proceed as if the domain is discrete.

We now have a primitive and simple model of time. We have begun to develop an idea of time that sees it as an active agency and not merely a passive dimensional locality in which events occur. That is not to say that it is sometimes helpful to think of time as part of a locality and certainly the development of the idea of space/time is certainly one of the great achievements of the 20th century. But we are now getting underneath those ideas and starting to think of time as an agency the stitches together the events that surround us and even makes them possible by its action.

Thus far we have considered a universe that consists solely of time. We must now consider the ideas of locality and physical state. We have been concerned with a collection of sets called previous moments and how the agency of time continues to enlarge the set from moment to moment. In this initial rather empty universe nothing much is happening. We will now introduce the ideas of locality and state.

4 Locality and State

As with the term moment, we will not define locality but will attempt to make our use of the term clear. The term locality has two common meanings. In the first the meaning carries with it the idea of position. In the second the idea of neighborhood or an area where certain activities occur is meant. Our usage of locality is closer to the second meaning and does not include the idea of position. This meaning of locality implies that there is a stage on which a particular state of affairs exists which we will call the locality's state. To begin we will assert that there is only one locality and in such a case the idea of position is meaningless as position is a relative term referring to the relation between one locality and another.

We assert that there is a locality that has a particular state. So what might the state of this locality be? It is tempting to ascribe this state to some object residing in the locality. For how can there be a state without an object that embodies that state? But as to the nature of this object that embodies the state, we will make no ontological speculations. In fact the state may not be associated with an object at all. In this case it is suggested that the locality itself may be said to have a state.

And so at this early stage we should try to imagine something very simple. Perhaps the state indicates how full the locality might be. We could say a state of 0 indicates the locality is empty and 10 that it is full. Empty, or full of what? At this point we are careful to leave this question open. What sorts of things are contained in the universe is, even now, an open question and we should be careful not to project properties that are overly narrow to our purported locality. Now we might ask, What happens to the state of the locality when the current present changes?. There are several possibilities. It could remain the same, it could change randomly, or change in some vaguely predictable way or in some very predictable way. At this point we are open to all these possibilities. But as time is the agency driving the creation of new present states, what is driving the changes to the locality's state? We do not know the answer to this question. *It is a version of Hume's question about the connection between cause and effect.* Up to this point the only defined agency in our universe is time as it changes the set of previous moments. Unless we are willing to introduce some wholly new agency to effect this change, we might suppose that it is time's agency that changes the state of a locality when it changes the present moment.

We suggest that the invisible thread that connects cause to effect is a function that maps the current state a the locality when the agency of time updates the current moment.

We assert the following to clarify what is meant.

1. There is at least one locality
2. Associated with each locality is a function that maps the present moment into a state. The function may not be Computable

We can not seek the machinery that implements this mapping because the machinery would have parts that are changing state and it is this change that we are trying to explain and so we would be caught in an infinite regress of ever smaller machines. While the mapping occurs when the present moment changes the action of the function may be directed by finite rules based on the current state or randomly.In some cases it might be possible that the state does not change at all.

5 Time's Agency and a Computable Future

So, in addition to increasing the size of the collection of sets of previous moments, a new agency is given to time, the creation of a locality's state when the present moment changes. It is not necessary to change the state of a given locality. Furthermore, it could be that the changes in state form a very predictable progression, a progression that is definable by a finite process or finite string. This sort of progression is said to be computable. In our toy universe we might imagine the state might increase by one until 10 is reached and then decrease by one until 0 is reached and then repeat the process. We would watch the evolution of our universe as it fills up and empties. We might even guess at the natural law governing these changes . We might say the state of n is caused by the state of n-1 mod 10! In this simple example we begin to see how the agency of time might be the invisible thread that connects cause and effect and that manifests the action of natural law. But we are now also open to the possibility that the generation of new states might not be deterministic or computable and that the future may be inherently unknowable.

At this point one might ask, how does time know the natural law, and by what mechanism does it change the state of the locality? But if we have, indeed, reached the bottom of the reductionist ladder, this question has no answer for if there were a mechanism that creates the new state, then that mechanism would have parts that changed their states and relations to one another and so those parts would be the thing that fills our locality and occupies our attention. And then those parts would have no explanation.

6 locality

Thus far our universe has consisted of a single locality in which we have developed the ideas of previous moments and previous states. It seems reasonable to ask, what effect the existence of multiple localities might have on our deliberations. But we must not move too quickly in this regard. Is it possible that the universe in which we find ourselves is best thought to have only one locality? At first glance this proposition seems absurd. We are no longer constructing a toy universe, but are referring to a universe that consists of billions of galaxies each consisting of billions of stars operating by complex and dimly apprehended natural laws. In what way and with what conceit could such such an awesome edifice be considered a single locality? But we must not forget that in accord with our best current understanding, the whole of this gigantic edifice started as a single point or one locality some billions of years ago. It is important to note that single point and single locality are not the same. Single point implies a zero metric, single locality has not such implication.

If we have the temerity to say that that the universe has but one locality, then all that we have said to this point is applicable. Of course that kind of state that might be associated with the real universe must be very different from our toy one. This state information can be thought of as a list of numbers, an n dimensional vector. As time creates new past moments and new state vectors these vectiors begin their journey through the phase space. This picture is really quite general. Different dimensions of the phase space might be deterministic, others random, and others of other connections. But this view, as attractive as it is, is may not complete. And so we introduce the idea of many localities.

7 multiple localities

We will assert that there are multiple localities. What do we mean by this? It would be natural to quickly say that multiple localities are separated and separated by distance. But, in this, I fear we might be moving ahead too quickly.It is important to consider that we really do not know what is meant by distance in this case and as we shall see, this concept is best left to much latter in the discussion. But if we say that there are two localities, what do we mean by this and how does this differ from only one locality? Two localities are different if and only if, these two localities have different sets previous states. The sets of previous moments may or may not differ.In this analysis there could be a very large, but finite, number of localities.

8 (locality)

We are now entering an area that has much in common with physics and cosmology. It is not our intention to solve the problems that are being actively pursued by professional physicists. We will only try to establish a conceptual framework that may help to shed light on some aspects of the mind body problem. It is altogether possible at this point to imagine a universe of a large number of localities, some localities evolving independently and having no effect on other localities's evolution and others effecting the state changes in other locations. We normally ascribe distance when two localities do not seem to influence each other. But as we have stated, we will avoid appealing to distance at this time. When two locations can directly effect the evolution of each other's previous states we will say they are local to each other. Those localities that do not effect one another in this way are said to be non-local. In summary we now have expanded the agency of time to the creation of new states of many localities sometimes under the direction of Computable rules and influenced by the evolution of other local states. But also states may evolve in a manner that is not Computable.

One way of picturing this universe of localities, some connected and some not is by a network. A network of localities can be imagined in which some localities are directly connected and some not. In the figure below, nodes 1 and 2 are directly connected and changes in state at either node will effect the other node directly when the next update of the set of previous states is performed. 3 and 1 are not directly connected, but changes in state at node 3 can be propagated to node 1 by node 2. But how could multiple localities come to exist? It could be that the existence of one locality gave rise to a small directly connected network that then created more localities. This process could have proceeded exponentially in the early universe giving rise to the so called inflation.

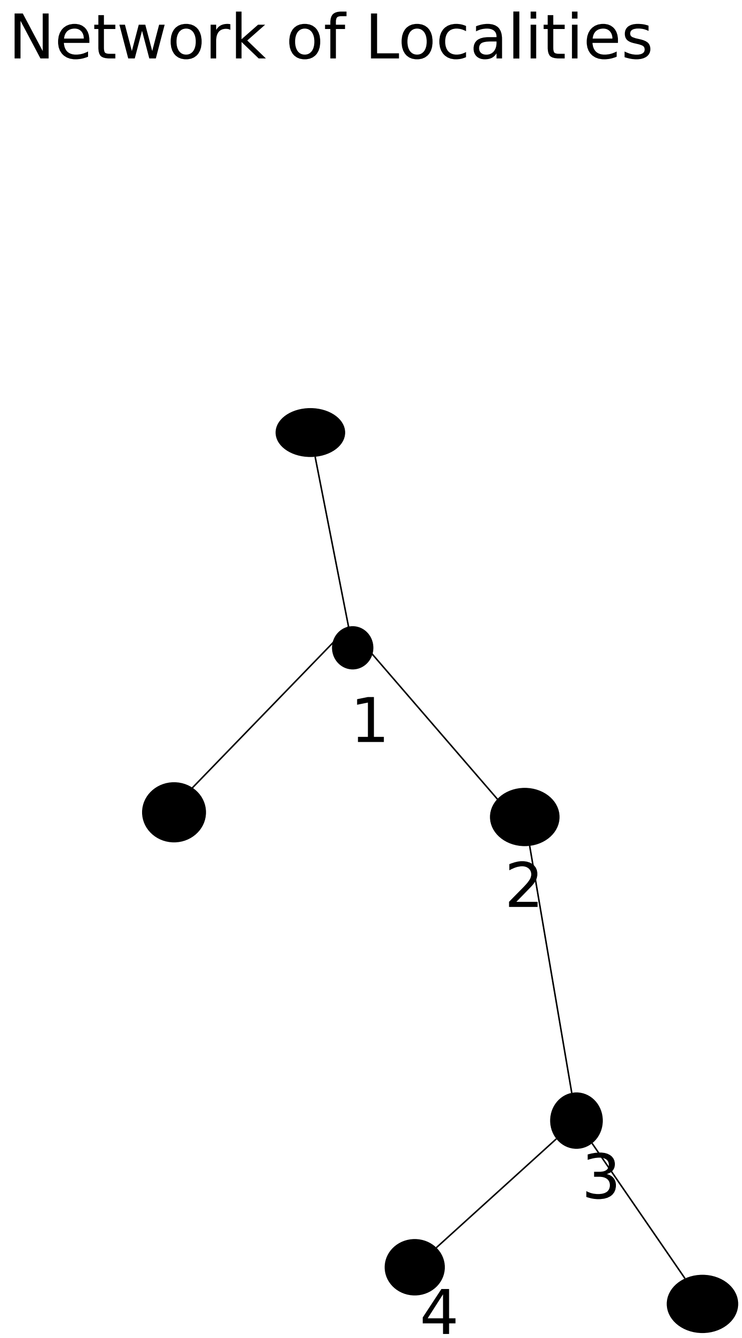

Figure 1:

9 (non computable states)

In the creation of the set of previous states the changes in state(state transitions) might be computable. That is there is some finite string that defines the rule for creating the next state. But what do we mean to say that some state transitions are not comuptalbe? There is no finite string that defines a rule governing the state transition. This is very different from saying that the rule is very complicated or difficult to understand. Here there is nothing to understand.If the state transition is not computable then there can be no mechanism hidden behind the curtain that is the true reality. For any hidden mechanism would be describable by a finite string. Perceiving these mechanisms and describing them mathematically and with precision is what is meant by scientific understanding. But realizing the non existence of a mechanism is also an understanding, an understanding that there is nothing behind the curtain and we have come to the bottom of the ladder. In the case where state transitions are not not computable and are independent of previous states, we say these transitions are random. It is not completely clear that these random transitions actually occur in our universe. If they do, then the creations of finite random strings would be possible based on these state transitions.(get quote from von Neumann)