The Relationship of the Human Brain and the Dimensionality of Space-Time

Barry Zeeberg
4378 N. Pershing Dr. #1
Arlington VA 22203
bzeeberg@science.gmu.edu

Abstract

The human brain and the perceived dimensionality of space-time form a self-referential system: The brain is the product of biological evolution; it is an object that survived under the prevailing conditions when the mutations occurred that caused its existence. A major component of these conditions is the environment, which includes the dimensionality of space-time. On the other hand, the ability of the brain to perceive the dimensionality of space-time may be limited by some inherent properties of the brain, and our perception of dimensionality may be inaccurate. I explore here the possibilities that this dimensionality is actually different from 4. In particular, the possibility of 2 dimensions of time and 4 dimensions of space is explored.

Keywords: human brain, spatial dimensionality, temporal dimensionality.

1 Introduction

The human brain and the perceived dimensionality of space-time form a self-referential system in the following sense: The brain is the product of biological evolution, which means that it is an object that survived under the conditions prevailing when the mutations occurred that caused its existence. Of course, it has also continued to survive since then. A major component of "the conditions prevailing when the mutations occurred" is the environment that is was embedded in, which of necessity includes the dimensionality of space-time. For example, if space were of 2 dimensions rather than (presumably) 3, material objects could not exist since nothing that had any height could exist in 2 dimensions - perhaps only something like a shadow on a surface could exist, and even that is questionable (since the electric and magnetic components of light vibrate in planes that are perpendicular to one another, and the propagation of this light wave occurs in yet a third dimension that is mutually perpendicular to these first 2 dimensions).

On the other hand, the ability of the brain to perceive the dimensionality of space-time may be limited by some inherent properties of the brain, and our perception of this dimensionality may be inaccurate. For example, perhaps space is (hypothetically) of 4 dimensions, but the brain is unable to perceive the fourth dimension either because such an ability did not confer an enhanced survival value during the course of biological evolution, because such an ability would result in a diminished survival value during the course of biological evolution, because the materials available (that is, existing biomolecules or atoms or molecules in the environment) were not adequate to form structures within the brain that could detect the fourth dimension, or, finally, because these materials were available but there was no viable pathway of evolutionary events that could incorporate these into the brain as it was already "locked into" a rather inflexible form relative to further evolutionary changes.

Dawkins (1987) discusses the limitations of the human brain in certain types of thinking in terms of biological evolution: It is almost as if the human brain were specifically designed to misunderstand Darwinism . . . our brains are built to deal with events on radically different *timescales* from those that characterize evolutionary change. We are equipped to appreciate processes that take seconds, minutes, years or, at most, decades to complete. All our intuitive judgements of what is probable turn out to be wrong by many orders of magnitude. Our well-tuned apparatus of scepticism and subjective probability-theory misfires by huge margins, because it is tuned — ironically, by evolution itself—to work within a lifetime of a few decades. It requires effort of the imagination to escape from the prison of familiar timescale . . . The key points of Dawkins exposition are the discrepancy between external reality and what the human brain perceives as reality, and the fact that this situation came about as a consequence of the constraints imposed by the mechanism of evolution. As suggested above, one consequence of the constraints imposed by the mechanism of evolution may be the inability to perceive higher dimensions of space-time.

I explore here the possibility that the dimensionality of space-time is actually different from 4. In particular, the possibility of 2 dimensions of time is presented. It is shown that this could in fact be true in that there would be no inconsistency with our common experience or with known physical laws. It is further shown how some of the consequences would impact upon both pragmatic and philosophical considerations, such as the existence of "free will." I also explore the possibility that we are embedded in a 3-dimensional subspace of a 4-dimensional reality. The approach taken here is somewhat indirect, in that what would happen in a 2-dimensional subspace of a 3-dimensional world is inferred, and it is left to the imagination as to what the consequences would be of extrapolating these results to a 3-dimensional subspace of a 4-dimensional world.

2 Spatial Dimensionality

2.1 3-Dimensional Space as a Subspace of a Larger-Dimensional Space

The possibility that 4-dimensional space-time happened by chance and what physics and existence would have been like in other numbers of dimensions have been considered in great detail in a surprisingly large number of papers (Atkins, 1992; Barrow and Tipler, 1994; Kaku, 1994; and references therein). The possibility of the existence of higher-dimensional spaces arose from superstring theory (Kaku, 1994). In this attempt to find a unified theory of matter and space-time, 10- and 26-dimensional spaces were uniquely found to allow strings to vibrate self-consistently. The very elegant mathematical work of Ramanujan coincidentally contained mathematical functions that are identical to those underlying string theory and in which the constants 10 and 26 play a key role.

This raises two questions. The first is whether our own 3-dimensional space is actually a subspace or a projection of a larger-dimensional space, and our senses are such as to only be able to perceive the 3-dimensional space. The second is whether anything material could exist within 2-dimensional space. A corollary to this question would be whether a sentient being living within 4-dimensional space would have the same questions about whether anything material could exist within 3-dimensional space.

Is our own 3-dimensional space actually a subspace or a projection of a larger-dimensional space, and our senses are such as to only be able to perceive the 3-dimensional space? This hypothetical limitation of our senses could have arisen in various ways. Two scientific explanations suggest themselves. First, the materials for perceiving the additional dimensions might just not have been available (say, in the Earth's crust or dissolved in sea water) during biological evolution. Second, they might not have conferred a selective advantage for survival at the time when they would have been incorporated, and after that time they might have been incompatible with the other parts of the organisms.

2.2 Existence of Material Objects within a 2-Dimensional Space

Can anything material exist within 2-dimensional space? Of course, mathematicians can "simulate" a 2-dimensional reality, but I tend to doubt whether this could exist materially. The basis for my doubt is that atoms and subatomic particles (at least in our 3-dimensional world) have mass, and even energy has a mass-equivalent (for example, the wave-particle duality of electromagnetic radiation). Ordinarily we think of density as the ratio of an object's mass divided by the volume it occupies. Of course, the density need not be isotropic, and in 3-dimensional reality it is easy to envision an object that is very dense vertically and of low density horizontally. However, there are limits to this. In 2-dimensional reality a material object would need to have infinite density vertically (that is, in a direction perpendicular to the surface of the 2-dimensional space), since this material object is not permitted to have any height whatsoever. So these objects could not be made up of atoms as we know them. If two objects in 2-dimensional space were moving towards each other and collided, since they have no height they would simply pass "through" each other and never know that the other one was there (for that matter, each one might not even know that itself was there).

Mathematically, we can define abstract objects that are 2-dimensional (such as is done in Euclidean geometry), but other than an abstract triangle, we would need to have a triangle at the minimum printed in ink that was one atom thick, and this would no longer be a 2-dimensional triangle, but it would be a 3-dimensional triangle. Thus, although an empty 2-dimensional space might exist, my question is whether the existence of a material object in 2-dimensional space is possible in external reality or whether it is a concept which is the abstract product of the brain. Phenomena could be defined in 2-dimensional space as a mathematical "projection" of phenomena in 3-dimensional space, but this procedure might exist only as an activity of the imagination.

2.3 Relationship of Collisions in 2- and 3-Dimensional Space

As a simple specific example of the generalization that I will make thereafter, imagine two objects in 3-dimensional space that are free to move about independently in any direction. Now imagine a fixed sheet of white paper, which can be either flat (if there is such a thing as "flat" given that space is curved) or curved (that is, it could form the surface of a sphere, or it could have hills and valleys, etc.). Finally, consider a fixed point source of light that is at a distance from the surface of the paper such that the two objects could fit between the paper and the light source (Fig. 1). There are four possible cases to consider. At a given point in time, the positional relationships of the surface of the paper, the objects, and the light source may be such that neither object casts a shadow upon the surface of the paper, only one object casts a shadow upon the surface of the paper, only the other object casts a shadow upon the surface of the paper, or both objects simultaneously cast a shadow upon the surface of the paper. The edges of the shadows may not be sharp, but at least if the darkness of the shadow falls off monotonically as a function of radial distance from the center of the shadow, then we may define the edge of the shadow as being where the darkness is equal to some predefined percentage of the maximum darkness in the center of the shadow. Then we could say that the two objects have "collided" in the 2-dimensional space of the surface of the paper if their shadows have collided.

A computer program that "knew" the equations of motion of the two objects in 3-dimensional space could then determine when the two objects have "collided" in the 2-dimensional space of the surface of the paper. Some of these 2-dimensional collisions would correspond, in fact, to an actual collision in 3-dimensions, whereas others would correspond to the 3-dimensional objects passing by each other between the light source and the surface (Fig. 2). In any event, the computer would then have to simulate the result of the 2-dimensional collision (that is, invert the equations governing the projections from 3 dimensions to 2 dimensions, or, stated differently, reverse engineer these relationships), and change the trajectories of the 3-dimensional objects so that the motions of their shadows would be consistent with this result of the 2-dimensional collision (Fig. 3). It is not clear to me whether there would be a unique pair of such trajectories or whether there would be a set of pairs of trajectories such that the motion of the shadows of the 3-dimensional objects would satisfy the "physics" of the 2-dimensional collision. This is a very unusual situation,

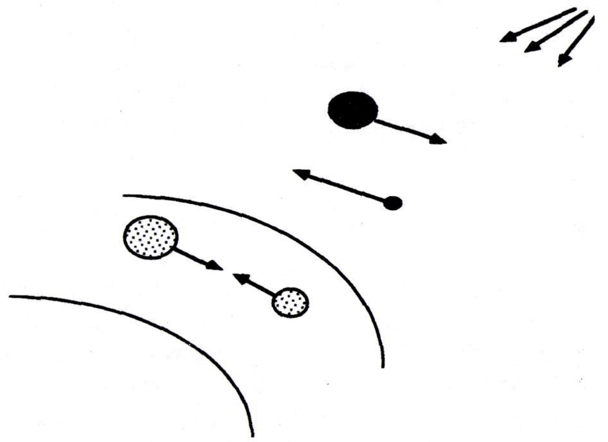

Figure 1. A Fixed Point Source of Light, Two Objects in 3-Dimensional Space, and their Shadows on a 2-Dimensional Surface.

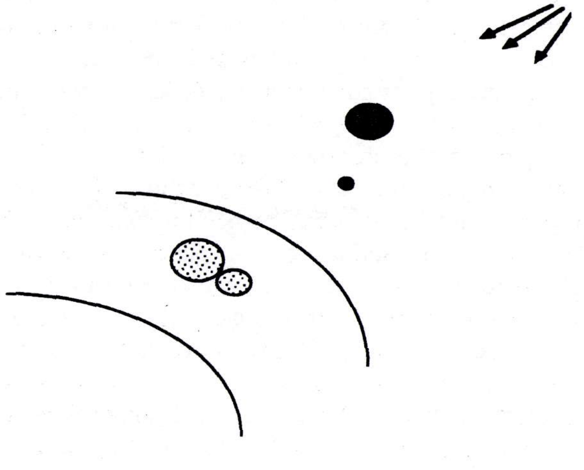

Figure 2. Collision of the Shadows on the 2-Dimensional Surface.

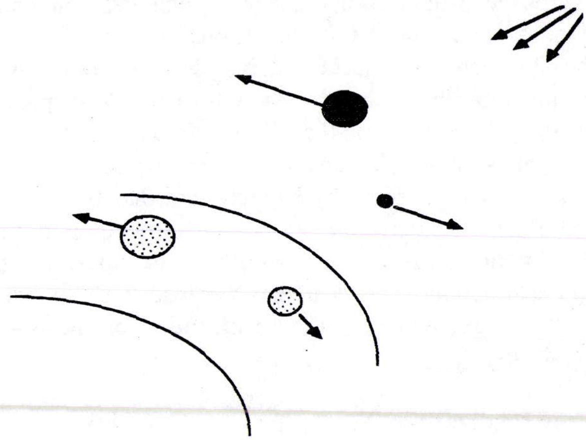

Figure 3. Consequence in 3 Dimensions of a Collision of the Shadows in 2 Dimensions.

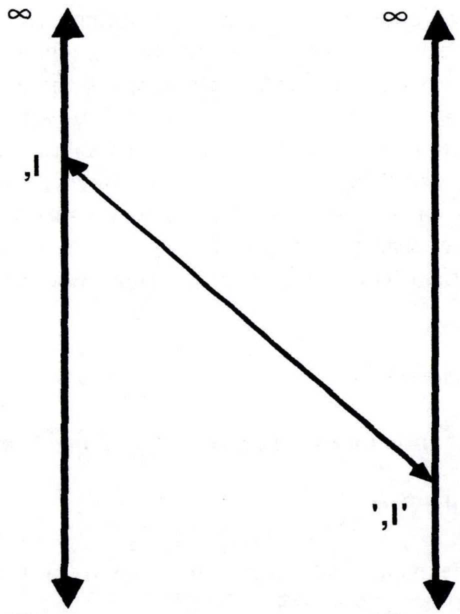

Figure 4. 2-Dimensional Temporal Space. An Example of Two Universes Offset by u'-u Selected from a Continuum (Uncountable Infinity) along the x Axis. The Diagonal Line Indicates a Possible "Isobar" along which u+l=u'+l'.

since we started with the 3-dimensional objects being the "independent" variables which determined phenomena on the 2-dimensional surface, but we end with the phenomena on the 2-dimensional surface being the "independent" variables that determine the subsequent motion of the objects in 3-dimensional space.

It might be speculated that, in the real world as opposed to the simulation model, the laws of physics or the shape of the various spatial and temporal dimensions are such that this would really happen, and that this is not just a thought experiment. It would be an interesting challenge to develop a mathematical and physical basis under which this behavior would occur naturally, rather than as a somewhat contrived abstraction. It is clear that we lose track of which is the "real" object and "real" space, and which is the "projection" of the real object and the projection of the "real" space.

2.4 Simulation *verus* Realization: An Analogy with Genetics

At the risk of running off (momentarily) on a slight tangent, the interplay between the 2-dimensional world and its set of rules and the 3-dimensional world and its set of rules may have an analogy in the interplay between genetic encoding (the sequence of nucleotides within the DNA of living cells) and the implementation in the real (external) world of the products of the decoded DNA. Hundreds of millions of years of biological evolution have led to a brain that "functions" in the real (external) world of the products of the decoded DNA. Now that the technology is available to decode the sequence of nucleotides within DNA, one might ask the question: why bother to play it out; why not just simulate it? Presumably the answer is that the brain, being the end product of hundreds of millions of years of biological evolution, survived as a real object in the real world because of certain properties is has. One of those properties, perhaps one of overriding importance to its survival and existence, is its need to play it out rather than to simulate it. That is, a brain that would be satisfied with simulation rather than with implementation might not survive or exist for very long.

3 Temporal Dimensionality

3.1 The Logical Constraints and Consequences of Time Travel

3.1.1 Inability to Alter the Past

The following ideas were inspired by a film that I recently watched in which a person from the future (say at time t_2) was able to be transported back to a past time (say to time t_0). The rules (presumably some fundamental laws of physics) in other fictional works permitted the person from the future to alter past history, starting at time t_0 onwards. However, this is clearly unacceptable since then a person could kill his or her own biological mother before she gave birth to that person, and consequently that person would not exist in the future; clearly someone who does not exist in the future can not go back in time, leading to an impossible contradiction. Fortunately, in this particular film, the rules did not permit the person to alter past history. In addition to these rules, a peculiar coincidence occurred: the person who was transported back to a past time was eventually shot and killed in the past at a time t_1 between t_0 and t_2. Furthermore, since he was transported back in time only by about 25 or 30 years, he was alive as a young child at t_0 and at t_1. At t_1, remarkably, this child was present and witnessed the shooting of his adult self that had been transported back from the future.

Remarkably, the concept of time travel through a wormhole is represented in the published scientific literature (Morris, Thorne, and Yurtsever, 1988). These studies involved both a rigorous mathematical framework, as well as some practical engineering possibilities. As described by Kaku (1994), According to Hawking, there may be an infinite number of alternative universes coexisting with ours, all of which are connected by an infinite web of interlocking wormholes. As discussed below, a possible consequence of the (hypothetical) existence of time travel is the existence of an uncountable infinity of universes which are time-shifted replicas of one another.

Quite apart from the story itself and the unusual coincidence just mentioned, the two facts - namely that a person can be transported back to a past time and that the person is not permitted to alter past history - have some remarkable consequences. Although these consequences are the inevitable result of these two facts, it is easiest to use the story itself to illustrate these abstract consequences in a rather concrete manner. Because of the fact that the person who had been transported back in time is not permitted to alter past history, the little boy will grow up to become an adult man who will go back in time. This is easily shown using a proof by contradiction. Suppose that the little boy will *not* grow up to become an adult man who will go back in time. Then past history has been altered, which violates one of the rules.

Besides the man who was sent back in time, there were other people alive at time t_2. The fact that the man was sent back in time did not stop the lives of these other people from continuing forward from time t_2. On the other hand, the life of the little boy at time t_1 continued onwards too. In particular, his life continued onwards until he became the man who was sent back in time. There is thus an infinite cycle of events, given in what we would think of as "chronological" order: (1) A man appears at time t_0. (2) A little boy sees that man killed at time t_1. (3) The little boy grows up to become a man. (4) At time t_2, this man is sent back to the past. (5) The man appears at time t_0. (6) A little boy sees that man killed at time t_1. (7) The little boy grows up to become a man. (8) At time t_2, this man is sent back to the past. (9) The man appears at time t_0. (10) A little boy sees that man killed at time t_1. (11) The little boy grows up to become a man. (12) At time t_2, this man is sent back to the past. It is obvious that events (1) through (4) occur repeatedly, without end (this occurs a countably infinite number of times).

3.1.2 Existence of a Countably Infinite Number of Universes

Now, there must be at least two separate universes that co-exist simultaneously. It is obvious that the little boy is growing older in one universe, starting at time t_0. At the same time, the people who were alive at time t_2 are growing older. They must be doing so in another universe than that of the little boy, since in this other universe the little boy is now a grown man. That is, in the first universe the little boy and an adult version of himself co-exist; in the second universe a younger manifestation of the adult exists. But it then follows that there must be a countably infinite number of universes, since each time the cycle of events (1) through (4) occurs, an additional universe is required in order for time t_0 to have a place to occur. Eventually this additional universe reaches times t_1 and t_2, and when it reaches t_2 there needs to be yet another universe at local time t_0, *ad infinitum*.

Assume that there is another person who is also a time traveller sent back in time. Each time a person is sent back in time, we require an additional countably infinite set of universes to co-exist, unless the time difference for the additional people is in a kind of synchrony with that for the first time traveller (then their cycles could share a common countably infinite set of universes). Now, we can ask whether the co-existence of the countably infinite set of universes is the *result* of the time traveller, or whether this set would have existed anyway. This is like saying that I took a trip to another country, but the country didn't exist until I arrived there. That is, the sole purpose of that country's existence was to give me a place to arrive at; it wouldn'thave been there if I hadn't gone to it. Clearly (or rather, *almost* clearly) this is not how countries work.

3.1.3 Existence of an Uncountably Infinite Number of Universes

But if we take the more reasonable approach that the countably infinite set of universes exists independently of the activities of the time traveller, then there is no reason for nature to have favored the differential between the particular times t_0 and t_2 as being the basis for a countably infinite set of universes. Then there will be a countably infinite set of universes for each pair of times. Since there is an uncountably infinite number of pairs of times, we then have an uncountably infinite number of sets of countably infinite sets of universes, or, more simply, an uncountably infinite set of universes forming a continuum in a one-to-one correspondence with the real numbers.

The most parsimonious treatment of this situation is to think of time as we think of space. That is, all the times that ever did, do, or will exist actually do exist simultaneously. We have no problem thinking of two different places existing at the same time, and we must now think of two different times existing at the same time. More specifically, it is really different universes co-existing, each of which is aging at the same rate, and each of which is offset from some other one by any specified time interval that one cares to choose. Each universe is an exact replica (*modulo* the offset) of the others, and events happen absolutely identically in each one. That is, each one represents an "instant playback" or "instant playforward" of the others.

3.1.4 The Human Brain: Relationship of External Reality and Perception

If all of this is actually true, then it is interesting to note that Darwinian evolution resulted in our having the ability to perceive two different spatial locations simultaneously (not counting the effects of special relativity) and to move from one location to another. In stark contrast, Darwinian evolution did *not* result in our having the ability to perceive two different temporal universes simultaneously nor to move between them. Apparently this did not represent a selective advantage as far as survival or existence is concerned. But then, we might have to redefine what is meant by "survival or existence." Since all of time always exists simultaneously, anything that ever was for one fleeting moment always was and always will be (in one of the universes or another), that conclusion alters the notion of survival.

Now assume for a moment that a person can travel back in time and *is* permitted to alter past history. But this would have to be rejected because of paradoxes that would immediately result: For example, someone going back in time before their own birth and then killing one of their own parents. So, we seem to be left with two possibilities: either travel back in time is not possible, or else there is an uncountably infinite set of universes, where each universe is a replica (*modulo* the offset) of the others. This hypothesis might be compared with the hypothesis that God exists: Both hypotheses are then the abstract product of the brain. Quite independently of this abstraction, either God does exist or does not exist in external reality. Likewise, either there is an uncountably infinite set of universes, or there is not an uncountably infinite set of universes in external reality. Both hypotheses are similar in that, at the present time, there seems to be no way of rationally ascertaining the truth or falsehood of either hypothesis. Both hypotheses are again similar in that, regardless of the truth or falsehood of either hypothesis (in external reality), both *concepts* are the abstract product of the brain. Finally, both hypotheses are similar in that it may be the case that the truth or falsehood of either hypothesis will never be ascertainable. Thus, it is no less reasonable to believe in the truth of one rather than of the other.

3.2 2-Dimensional Time:Mathematical Development and Consequences

3.2.1 Definition and Consequences for the Existence of Free Will

For the sake of nomenclature, let us refer to the universe that we are embedded in as U_0. Let us further refer to the current moment in our own universe as $U_{0,0}$. Then the general reference to an arbitrary universe will be $U_{u,l}$, where u is the index of the universe and l is the local time within universe U_u (Fig. 4). Note that both u and l can be any real number ranging from - to +. Note also that $U_{u,l}$ could alternatively be represented as the ordered pair (u, l), a notation which, by analogy to (x, y, z) as a point in a 3-dimensional spatial space, makes it clear that we now have a point in a 2-dimensional temporal space. The symbol u is interpreted as being the offset of U_u relative to U_0, and we have the fundamental relationship

$$U_{u',l'} = U_{u,l} \text{ if and only if } u' + l' = u + l$$

Now, if it is true that time is 2-dimensional, then there would be two remarkable consequences. First, we would be embedded in ‡5-dimensional space-time. Second, there would seem to be no such thing as free will: For someone embedded within an arbitrary universe at an arbitrary local time $U_{u,l}$, anything that will happen in the future (say at time l_f) is either just now happening or has already happened in an uncountably infinite number of universes, any one of which is given by $U_{u',l'}$, where $u' + l'$ ‡ $u + l_f$. It seems that a minimal definition offree will is that (a) someone embedded within a given universe at an arbitrary local time, $U_{u,l}$, performs action A rather than action B; (b) that it wasn't known in the past (that is, at U_{u,l_p}, where $l_p <$ l) whether action A or action B would be performed; and (c) something would be different at a future time U_{u,l_f} (or, more generally, at all future times l''for l'' ‡ l_f) if action A rather than action B had happened at $U_{u,l}$.

But it seems to be impossible even for the first two, let alone all three, conditions to hold: The time in the past represented by U_{u,l_p} would correspond to an uncountably infinite number of $U_{u''',l'''}$ where $u''' + l''' = u + l_p$, or $u''' = u + l_p - l'''$. Although u and l_p are fixed, l''' and u''' can be any real number ranging from - to + . If l''' is chosen such that $l''' = 2l_p — l$, then $u''' = u + l - l_p$. In other words, $u'''_p = u + l$. That is, at local time l in U_u, $U_{u'''}$ is experiencing local time l_p. This would contradict (b), since at time l_p it would then be known whether action A or action B is performed at time l. Intuitively, this is as if a woman from the future traveled back to the past and told someone in the past what she knew was about to happen, since in the future what was about to happen was already part of known recorded history. Thus, we have a proof by contradiction that there can be no such thing as free will. Furthermore, all events are predetermined.

3.2.2 Relationship to the Evolution of the Human Brain

It is obvious that regardless of whether this hypothesis is true or false, if the brain were to *believe* that it is true, then the brain would likely cease to exist. If I were to believe that all events are predetermined, then I would conclude that whatever I do makes no difference, and any "choice" I make is really predetermined; I only have the illusion of making a choice. Thus, I am absolved of any responsibility for what I do, and I can act irresponsibly. I would only do what gave me pleasure, and if everyone did this we would cease to exist, since most (but not all) of the goods and services that are of use or are essential to our existence are performed by people, not for the pleasure that the task gives them, but rather because of economic necessity/repression.

3.2.3 Relationship to the Cauchy Integral Formula for Analytic Complex Functions

The Cauchy integral formula states that, if the complex function f is analytic everywhere within and on a closed contour *C*, then if z_0 is a point interior to *C*, $f(z_0) = \frac{1}{2\pi i}\oint_C \frac{f(z)}{z - z_0} dz$ (Churchill, 1972). Thus, the property of being analytic is so strong that the values at every point inside *C* are constrained by the values along *C*. Given the determinism in 2-dimensional time implied by the absence of free will, it is natural to ask whether a similar type of constraint might exist within the 2-dimensional time plane. In fact, this is quite likely, given that time is continuous and there is therefore an uncountably infinite number of points in this plane (this is true even if time has a finite start and termination). Thus, the values at each point in the plane cannot be denoted by recursive enumeration, but must be denoted by a functional form. Given that any two universes are modular replicas of one another, there is either a copying mechanism at work, or else the progression through time in each universe is governed by a common deterministic (ie, nonrandom) rule. If the latter were true, then it might be speculated that the value at any point is given by an integral along a contour enclosing the point. This would then be an anticipatory and incursive system, since the evaluation of the enclosing contour integral of necessity utilizes an uncountably infinite number of future values.

3.2.4 The Geometry of Aging

To complete the thoughts concerning 2-dimensional time, assume for the moment that we are embedded in our own universe U_0, and we are aging along with our universe from the present $U_{0,0}$ to $U_{0,1}$, where $1 > 0$. That is, we are moving through time vertically, parallel to the y axis. Alternatively, we might be moving horizontally through the x axis. That is, we are moving from universe to universe along a horizontal line that goes through $U_{0,0}$. In this case, we appear to age by going to $U_{1,0}$, which would represent the same increment in time as would $U_{0,1}$, given $U_{0,0}$ as the starting point in both cases. Horizontal movement along the x axis may possibly not be distinguishable from vertical movement along the y axis either experimentally or in principle. Moving parallel to the isobar (Fig. 4) would correspond to remaining at a constant moment of time. Moving along any other diagonal would correspond to moving back or forward in time at a rate that is faster than the normal rate at which our universe ages.

The final comment concerning this time issue would involve the fact that when astronomers now (that is, at $U_{0,0}$) observe a spatially distant galaxy (say at a distance

D) the light that is seen actually originated a long time ago, at $U_{0,(-D/c)}$, where c is the velocity of light. According to the fundamental relationship given above, this would be equivalent to viewing $U_{(-D/c),0}$; that is, this would be equivalent to a real-time view, at our own local time, of a universe other than our own.

4 Conclusion

The possibility and the consequences of our being embedded in a subspace of a higher spatial and temporal dimensionality was explored. The relationship between a 3-dimensional subspace and the enclosing 4-dimensional space was examined indirectly by examining the more tractable relationship between a 2-dimensional subspace and a 3-dimensional space. It was found that the mathematical statement of the physical laws in the 3-dimensional space needed to be consistent with the projections into the 2-dimensional space. Specifically, if the projections of two objects collide, then the laws of physics must be such that the two objects in 3-dimensional space behave as if they have collided, even though they may in fact have passed above and below one another. Otherwise, an inhabitant of the 2-dimensional subspace would be able to accurately deduce the real situation and would not be fooled into believing that space was 2-dimensional. That is, the observable inconsistency in the consequences of apparently identical collisions would indicate the existence of a hidden variable.

The possibility of time travel led fairly naturally to the hypothesis of a 2-dimensional temporal space. Initially, the y direction could be thought of as the time axis, and the x direction could be thought of as a continuum of universes, which are time-shifted replicas of one another. The inability to differentiate movement in the x and y direction shows that this distinction is artificial, since both directions are equivalent to one another. However, it may be useful at times to retain this artificial distinction. This structuring of time would imply that everything that has happened or will happen in a given universe is happening at any desired time in some other universe. This would tend to negate the concept of free will, as everything is totally deterministic: we are just waiting in our own universe to see things that have already happened in other universes. The idea that the future already exists implies that if we had a way to access this information, this would constitute an anticipatory and incursive system.

In addition, the self-referential system human brain:dimensionality of space-time was examined. There are limitations that are imposed upon the brain as a result of biological imperatives of evolution. Some of these limitations may involve an inability to perceive external reality accurately, perhaps because the presence of that ability would have impacted negatively upon survivability. That is, evolution would tend to track pragmatic needs rather than an abstract ideal of accuracy. Of course, some degree of accuracy would be necessary; otherwise we would be constantly walking off cliffs or eaten by lions. On the other hand, it is much better that frequencies of light other than the visible are not visible; otherwise we would be overwhelmed with information that is not important for survival contaminating the smaller amount of pragmatically