Chapter 6

Time and The Second Law of Thermodynamics and Its Application to the Mind-Body Problem

Time and the Second Law of Thermodynamics become relevant to the problem of mind-body interaction in the context of what has been described as the irreversibility paradox.[1] (Some choose to call it the reversibility paradox but the content is the same regardless of the terminology.) This paradox involves the fact that macroscopic systems are irreversible but macroscopic systems are reversible. To be more precise, irreversibility paradox underlines the common-phenomena suggestive of the directionality of time in which events occur in a certain configuration or sequence and not the other. For example, we can tell that the film is being run backwards if it show pieces of broken glass collecting into the shape of a vase. Intuitively, we know if a given sequence of events conflict with the directionality of time. In the case of the above example, we would say that for this particular vase, time runs backwards, allowing its shattered bits and pieces to reunite. We would also say that such an event is miraculous since it goes against the "nature of things". For

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[1]Peter Coveney & Roger Highfield, The Arrow of Time (Flamigo, London, 1991), p. 148.

macroscopic objects, time has a direction, without precluding the possibility that the direction it has for us or for our universe as a whole may be reversed or in some manners altered in some other universes, assuming, of course, that there may be universe other than the one we have perceived. This directionality of time makes sure that events follow one another in just one direction. Hence, the irreversibility of events happening in this directional time.

For human beings, time also seems to flow. This claim about the flow of time is made only in regards to how we, humans, both conceptually and experientially come into contact with time. Whether other life forms share similar temporal notion is an open question. In our own case, however, we experience time's flow in the way we anticipate events that are still yet to come, in the way we remember events that are past, and more enigmatic still in the way we live each ephemeral instant called "now". Our action is constrained by the very irreversibility of time in the sense that there is nothing we can undo about past events and nothing that we can do to hasten the oncoming future events. We can, of course, prepare for what we believe is forthcoming, but such preparations can never perfectly match what will really come simply because of the temporal distance. In between the future and the past, we find ourselves living through the swift and imperceptible transitoriness of the present.

Conceptually, time is modal.[2] "Time is a passage from possibility through actuality to necessity."[3] Such a modality influences the way we conceive of the present, the future and the past:

> Our different attitudes towards the future and the past are due, in part, to our being able, as we suppose, to make a difference to what happens in the future , but not to what has happened in the past...as agents we are committed to viewing the future quite differently from the past. The future is open, alterable, to some extent malleable by us. The past is closed, unalterable, part of the irrevocable record of history. And the present is the link between the two, the time of decision, when we have to come down on the one side or the other...[4]

The irreversible flow of time is inextricably woven into the very fabric of our human existence, so much so that to speak of a non-temporal existence for human beings is incomprehensible.

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[2]J.R. Lucas, "The Open Future" in The Nature of time, ed. by Raynoud Flood & Michacl Lockwood (Basil Blackwell, 1986) p. 126.

[3]Ibid., p. 126.

[4]Ibid., p. 126.

Against this lived experience of time and our intuitive acquaintance with its directionality, physics offers a different view of time. In the Newtonian framework, for instance, time and space are absolute, an arena in which events take place and objects have their places, an existential container, so to speak, which is independent of the objects of its containment. The image of a transcendent absolute time shadowing the march of events upon a cosmic billiard table of unending and unchanging space was the foundation of Newton's monumental description of the word. Once the equations governing the change of the world in space and in time are given, then the whole future course of events is determined by the starting conditions. Time appears superfluous. Everything that is going to happend is programmed into the starting statc. Moreover, the Newtonian laws of motion could be applied to the description of the world and followed backwards in time. What this means is that, according to Newtonian mechanics, events are time-reversible. Newtonian equations do not decide for us which direction of time constitutes the actual past and future:

> We could highlight this symmetrical time with a film of planetary motions taken by say, the Voyager 2 space probe, which was launched to explore the outer solar system in 1977. Such motions were the first to be reduced to mathematical law by Newton. Yet the film would be consistent with his laws of celestial mechanics whether it was run forwards or backwards. This belief

in a deterministic world, where time has no direction and the past and the future are preordained, has played a pre-eminent role in the development of physics. Its power is shown in a remarkable statement made by Einstein when he learnt of the death of his lifelong friend and confidant Michelangelo Besso. In a letter written on 21 March 1955 Einstein seized upon this unshakable conviction in the 'timelessness' of the laws of physics to offer some comfort for Besso's family. Death was not so final, he suggested: 'For we convinced physicists, the distinction between past, present and future is only an illusion, however persistent...'[5]

Einstein's own relativity theories which supersede Newton's laws in areas where vast masses and speeds are concerned underscore the directionlessness of time. Relativity regards time as a part of space.

It is a concomitant of this approach that we take a block view of the universe in which the future course of events is already laid out as a path in Minkowski space-time. The future already exists: it is only that we do not yet know what is in store for us, and only discover that as we crawl along our world-line More cogently, it

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[5]Coveney & Highfield, op. cit., p. 30.

> argues that there cannot be a real, modal or ontological, difference between future and past, because the present--the instant that divides past from future--depends on our criterion of simultaneity, and our criterion of simultaneity depends on our frame of reference. If we change our velocity, we change our frame of reference and our criterion of simultaneity. We change not only what distant events we take to be simultaneous with us-i.e. what we take to be present-but concomitantly what distant evetns we take to be past or future.[6]

In short, Einstein's theories of relativity takes away the fixed point of reference from which the flow of time can be seen as a succession of future events becoming present and then passing into the reservoir of memories.

Similarly, quantum mechanics takes no notice of either the flow or the directionality of time. The mathematical formalism which underpins quantum theory obeys strict time symmetry. From the perspective of the micro-system, the flow and the directionality of time is indeed mysterious, for the collision between any two molecules is completely reversible without any preference for past-future orientation. For example,

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[6]Lucas, op, cit., p. 130.

Suppose, in a sealed room, the top is removed from a bottle of scent. After a while the scent will have evaporated and dispersed throughout the room, its perfume apparent to anyone. The transition from liquid scent to perfumy air--from order to disorder--is irreversible. We should not expect, however long we wait, for the disseminated scent molecules to find their way back spontaneously into the scent bottle and there to reconstitute the liquid. The evaporation and diffusion of the scent provides a classic example of asymmetry between past and future. If we witnessed a film showing the scent returning to the bottle we should spot immediately that the film was being run backwards in the projector. It is not reversible.

Yet there is a paradox here. The scent evaporates and disperses under the impact of billions of molecular bombardments. The molecules of air in their ceaseless thermal agitation serve to knock the scent molecules about at random, shuffling and reshuffling, until the scent is inextricably mixed with the air. However, any given individual molecular collision is perfectly reversible. Two molecules approach, bounce and retreat. Nothing time asymmetric in that. The reverse process would also be approach, bounce, and retreat.[7]

Since sub-atomic particles also move about in a completely time-reversible manner, the laws governing these bodies seem to suggest that all macro-world phenomena which reflects time's irreversibility but which are also reducible to the motions of the underlying constituents are subjective, the process involved in our perception of the passage of time being similar to the process which, for instance, gives rise to our perception of a stick half-immersed in water looking bent when in reality it is straight. In other words, the view which suggests subjectivity in our perception of the irreversibility of time is the same view which relegates the passage of time to mere illusion.

There is certainly a difference between something being subjective and something being illusory. In the case of the stick appearing bent when half-immersed in water, it is a matter of our sense data not representing the true state of affair, a condition explicable under the laws of optics. We may say that such a phenomenon is an example of a "natural" illusion, as opposed to "artificial" ones contrived by magicians, eventhough both types obey the same laws of optics. In the case of illusions, we have the power to correct conceptually our perception of such illusions. We tell

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[7]Coveney & Highfield. op. cit, p. 268-269.

ourselves that the stick is not really bent but only appears bent due to a certain incidence of light and its reflection off the water surface to our eyes. It is also true that if we are so familliar with the illusion, the conceptual corrections can be automatic; that is, we do not have to think twice about the situation before arriving at the true picture.

On the other hand, it could be the case that no such conceptual corrections are possible when the perception is conditioned by subjectivity. A case in point is Kant's notion of our mental categories through which the world becomes intelligible for us. We cannot lay down these conceptual schemes. In this sense, the fact that, for example, we experience the world only three-dimensionally is due just as much to our subjectivity as to the world itself. In this case, there is nothing for us to correct, conceptually or otherwise. Without getting bogged down in this tangential issue about subjectivity and illusion, it will have to be said in passing that if the flow of time as we experience it is just an illusion, there should be a possibility for some correction. On the other hand, if the passage of time is subjective, at least in the Kantian sense mentioned briefly above, then it seems that there is no way to ascertain beyond the phenomena whether time is irreversible or reversible, for we can know the world only as it is received through out mental categories and not the world as it is in itself. Even without invoking Kant, to relegate the transitoriness of time to subjectivity is also to call into question the claim of time's symmetry since this is just as much a conceptual scheme.

The Second law of Thermodynamics suggests the objectivity of time. This objectivity is supported by the irreversibility of time's flow central to the Second Law. First, the content of the Second Law of Thermodynamics:

> Rudolph Gottleib proposed a version of the law and then quickly changed his name. He affected a classical disposition, and called himself Clausius, the name by which he is always known today. The Clausius statement of the Second law is as follows:
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> Heat does not pass spontaneously from cold to hot.
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> The second statement of the Second Law is due to William Thompson, who also quickly changed his name, and we now know him as Lord Kelvin. Kelvin's statement of the law is:
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> Heat cannot be converted completely to work without another change elsewhere.
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> Both clausius and Kelvin focussed their attention on the heat engine, that extraordinary device which, despite our picture of it as a lumbering, steaming hulk, is in fact an elegant epitome of change and summarizes the essence of irreversible change.
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> That the heat engine captures the essence of the

> Clausius and Kelvin statements of the Secind Law can be seen as follows. First,a heat engine needs a hot source and a cold sink, which is effectively Kelvin's statement. Moreover, in order to achieve the reverse flow of energy, from the cold sink to the hot sousce, the engine must be driven by an external motor, as in a refrigerator. The fact that work must be done in order to achieve this unnatural reverse flow is equivalent to Clausius' statement of the Second Law.[a]

The singnificance of the Second Law to the problem of the objectivity of time derives from the fact that, according to this law, events unfold toward randomness and disorder. The measure of this randomness and disorder is called "entropy". The Second Law of Thermodynamics says that entropy always increases.

> The most primitive example of a natural tendency for things todisperse is the dispersal of the molecules of a gas. Everyone knows that molecules of gas accumulated in one region of a container will quickly spread throughout it. The reverse of this process, in which

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[a]P.W. Atkins, "Time and Dispersal: The Second Law" in the Nature ofTime, ed. by Raymond Flood and Michael Lockwood (Basil Blackwell, Oxford, 1986), p. 82-83.

> molecules regroup and collect in one small region, is unnatural, and has never been observed.[o]

The situation is generalized to the level of the macro-world, we then have the very familiar situation in which our rooms always get more untidy without our interference. In other words, entropy or disorder always increases.

What does this have to do with the objectivity of time? The inexorable increase of entropy gives a direction to time; time flow toward disperal states. Putting milk into black coffee always results in brownish liquid due to the fact that the milk molecules and the coffee molecules become dispersed to the point of equilibrium. The situation in which a brownish liquid starts separating into different portion of coffee and milk never happens. However, if one pausee to ask how the purposelessness of atoms and molecules can be accomodated to the uni-directional flow toward dispersion, one begins to see the plausibility of the objectivity of time. Mathematical formalism in both classical and quantum mechanics produces complete reversibility for microscopic events. But the objects of our everyday world obeys time's irreversibility as defined by the Second law of Thermodynamics. How are we to account for such a discrepancy? One asnwer to this puzzle

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[o]Ibid., p. 83.

to post time as an objective entity. The worn-out metaphor of time as a river visualizes the situation well, for the objectivity of time has to be conceived as actually carrying along objects and events towards increasing entropy as dictated by the Second Law. The reason why ice cubes always melt to form a puddle of water and why a puddle of water never shape itself into ice cubes is because the objectivity of time and its flow towards higer entropy actualize the first event while dictating the impossibility of the latter.

In philosophical analyses of time, various opinions are offered to explain or describe the phenomena we know as "time". Regardless of the differences of opinion, however, it is usually acknowledged that among the things that exist, space and time must be also included among the existents. Even when "time" is considered to be "unreal", it is not altogether "nothing". We simply cannot eliminate our conception of time or completely reduce it without remainder. Our objective view of time is not at all far-fetched when we consider it in the light of Einsteinian space-time. The metaphor most apt in describing space-time is a sheet of rubber that can be stretched and bent. According to this picture, time is as concrete as anything can be. Yet, it reguires some conceptual flexibility to understand both space and time this way without also imposing on it the concreteness of everyday objects. In other words, time, and space, is objective but its manifestations do not resemble the appearance of things considered paradigmatic of concrete objects, a table, for instance. Quantum mechanics has already taught us to become familliar with such a unique objectivity, for example, in David Bohm's notion of the very real but undetectable pilot wave. In the same way that matter can be said to have created space-time and is at the same time embedded in it, we can view time as something analogous to a flowing river in which the drama of dispersal encoded in the Second Law unfolds.

The problem remains concerning how to reconcile the directionality of time to the complete reversibility of micro-systems. Again, we go back to quantum mechanics. It will be noted that prior to the act of measurement, sub-atomic particles cannot be said to have either positions or velocities. This lack implies that quantum entities do not have the status of "real" objects in the sense of having definite attributes regardless of observation. The quantum nature of the underlying reality, if we can call it "reality", could explain why micro-systems are completely reversible, for at this level the Second Law does not apply. The non-application of the Second Law at the quantum level, however, should not be seen as detracting from its efficacy. Neither does it result in what has been termed the reversibility paradox if we understand that the quantum realm qualifies only as a realm of possibilities or potentialities. The integrity of the Second Law remains intact since it describes the natural tendency of things to become more and more disorganized. More importantly, the crucial implication of the Second Law seems to be that the reversibility of time applies only to "real" objects, that is, objects of the macro-world. The reversibility paradox seems to evaporate when we conconsider the fact that without the act of measurement, which is the instrusion of consciousness into the quantum phenomena, there cannot be any contact between the micro and the macro worlds. It is only when the wave function collapses that a quantum entity instantaneously becomes "real" and becomes subject to the objective flow of time.

We can say that the collapse of the wave function is the beginning of entropy.[10] The monent a quantum entity is registered as a macro-world event, for example, a dark spot on a phosphor screen, that event becomes a part of the common-sense reality and is governed by the Second Law of irreversibility . According to this picture, time becomes the nexus between quantum potentialities and the everyday world of ordinary objectes and events. Since consciousness is in time, experiencing its dynamical structure in terms of the passage of time from the future to the present to the past, the mystery of the collapse of the wave function can be accounted for in the context of the irreversible change dictated by the Second Law of Thermodynamics.

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[10]Paul Davies, "Time Asymmetry and Quantum Mechanics" in The Nature of Time, ed. by Raymond Flood and Michael Lockwood (Basil Blackwell, 1986), p. 107.