Chapter 5
Physics and Our Intuitive Outlook on Time

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Abstract This discussion is an attempt to reconcile our ideas of physical time with those of psychological time. Based on accepted arguments from relativity and on a much less accepted interpretation of quantum phenomena I am adopting a picture of physical time which accords equal and full reality status to all moments in time. This seems to be in sharp conflict with our intuitive outlook, according to which the future has no reality yet and is open to the decisions of our free will. I will show that this conflict is due to a flawed concept of free will and its relationship to determinism.

1 Our Intuitive Outlook on Time

The past, for us, is the accumulation of erstwhile present moments. It exists only in our memory in the form of immutable historical facts. The future does not exist yet. It is open to the decisions of our free will, we have a choice in sculpting it according to our intentions, making, for instance, present sacrifices for the sake of future benefits. The present moment divides time into past and future. It is a thin slice of reality between what is no longer and what is not yet. If $\Psi(t)$, $t \in (0, t_e)$, describes the history of the world, seen from a vantage point outside time, with t the time parameter, t_e the end of times and $\Psi(t)$ a full description of the world at t, the present moment at time T would correspond to something like $\Psi(t)\delta(t - T)$, where Dirac's δ-function lends reality only to an infinitely thin slice of time centered on T.

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Only this present moment is real, the past being no more, the future not yet. It is as if the machine at the foundation of the world was just sufficient to represent one moment in time and had to go through the succession $\Psi(t)$ of states, one moment T at a time, continually changing its constitution to represent those moments. The present state of the universe has been generated by a chain of states. Each of these states interacts only with itself, and neither the past, being but a memory, nor the future, not existing yet, take part in the dynamic game. Reality—present reality—is a dynamic, ever changing entity which takes us along in its flow.

There is no doubt that this outlook on the nature of time is dominating our thinking and speaking about the reality of this world. And yet this perspective on things engenders enormous difficulties on all ends. I will summarize some arguments that have been raised by physicists over the course of almost a century, adding up to a radically different view, according to which the full entity $\Psi(t)$, $t \in (0, t_e)$, has "simultaneous" reality, if the word "simultaneous" is not taken to refer to "same t" but meaning that physical processes at any moment $\Psi(t)$ of the universe can be influenced directly by physical processes at any other moment, present, past or future: simultaneity *sub specie aeternitatis*, to borrow a phrase from another realm. This view of a universe with eternal reality makes it look like a fixed recording and seems to clash sharply with our outlook on time and life. Although there are important physical arguments in favor of the eternal universe, physicists are essentially ignoring it. Even the original advocates have found their proposal to be starkly counter-intuitive. This paper examines this perceived clash in the light of our concepts of mind processes.

1.1 Physics

A direct reflection of intuitive time in physical theory is field physics. In this version, the description $\Psi(t)$ of the state of the universe at time t includes fields that summarize all retarded signals from past events. The full entity $\Psi(t)$, with time parameter t running from 0 to the end of times, is only a figment of historical nature. To speak of reality one has to pick a moment T and form a time slice $\Psi(t)\delta(t-T)$. This time slice contains all the information necessary to produce the next moment, $T+\varepsilon$, ε an arbitrarily small and positive time increment. In this way, the full history $\Psi(t)$, $t \in (0, t_e)$, of the universe is fabricated incrementally as a wave of real moments.

This is a version of physics that corresponds closely to our intuitive notion of time. But as everybody knows, there are problems with it. One is relativity, according to which the definition of the historical moment T is different for different observers. As we believe that the reality of all observers is to be given equal status, this forces on us the conclusion that more than just the one global moment defined by my own here-now must have "simultaneous" reality.

This problem of the definition of a time slice that can be called this moment is heightened to extreme acuteness in the realm of quantum phenomena, which by their very nature need non-local communication. An excited atom emits a photon that is eventually absorbed by another atom. Interference effects show that the emitted wave is extended in space and reaches many potential absorbers, which may be widely dispersed in the universe. But the photon is absorbed in only one place. This necessitates communication between the potential absorbers. It is as with airline seats, which can be assigned to only one passenger, necessitating communication between all customers potentially interested in the seat and a central computer which eventually assigns it.

As I am aware that this view of the matter is not shared by the majority of physicists, in fact is shared by hardly anyone, a paragraph or two of justification may be in order before progressing with the main argument. The standard battleground of the argument is the EPR experiment [4]. The formalism correctly describing the experiments makes use of a projection operator, which is applied to a description immediately before the absorption event, $|\psi\rangle = \sum_i a_i|\psi_i\rangle$, and which projects out from it one of the possible outcomes $|\psi_i\rangle$, realized with probability $|a_i|^2$. (In my simple one-photon exchange example, $|\psi\rangle$ would correspond to the electromagnetic wave before the absorption event, whereas the $|\psi_i\rangle$ would describe photon states localized at potential absorbers, coefficients a_i corresponding to their amplitudes.)

The problem with this picture is that a projection operator is not of this world. It does not correspond to any physical force or entity we know of, and, worse, it is applied non-locally at a moment in time, which, as remarked above, is a problematic notion in a relativistic universe. In addition, it is not clear when the projection operator is to be applied. A suggestion would be to apply it at the first potential absorption event (the first absorber atom encountered by the wave in our canonical example) and see it realized as a collapse of the wave function, but in view of relativism there is no unique first absorber. This difficulty precludes an interpretation in which quantum theory's projection operator is seen physically realized by a system of instant (that is, non-retarded) communication. Attempts to interpret the projection operator as acting only on our state of knowledge are untenable, as is the assumption that the actual decision in the EPR experiment has taken place already before the quanta parted as this would lead to signal correlations [1] which contradict experiment (for a review see, e.g., [14]).

John Cramer [2], see also [11], has proposed a system of communication between potential absorbers that is overcoming these difficulties. According to it, the transmission of a photon from an emitter to an absorber is organized by a handshake involving in addition to the usual retarded wave an advanced wave that is following the space-time trajectory of the retarded wave backwards in time. All potential absorbers send back these "confirmation waves" to the one emitter, participating there in a tug-of-war. As result, only one absorber receives all the energy of the emitter, all other potential absorbers having to give up any share of it they already had received, the whole process happening in the typical 10^{-15} sec of a photon emission event. There is no conflict with relativity, as all communication takes place along the light cone (or, in the case of transmission of massive particles, along time-like trajectories) and no concept of simultaneity is ever invoked. As Cramer's extensive discussion makes clear, all the philosophical fog surrounding quantum experiments, real and in Gedanken, clears away if this picture is adopted.

Cramer or Lewis are not the first to invoke advanced signals. These are perfectly consistent solutions to the underlying wave equations (if they are of second order in time, as, for instance, Maxwell's equations—for first-order equations like Dirac's a complementary equation has to be invoked to lead to advanced solutions), and there is a long history of discussions taking them seriously [3, 5, 11, 16, 19, 20]. Dirac [3], for instance, invoked them to derive the formula of radiative damping, for which there is no other explanation.

It is true that Cramer's picture (which he himself designates as a mere interpretation, but which is to be taken seriously as a physical theory to make sense at all) raises a number of issues, some of physical, some of psychological nature (the latter being the point of this communication), none of which, however, seems impossible to solve. The first is the necessity to create a full dynamical formulation, complete with the non-linearities involved in the decision process and the influence of all the virtual interactions and failed absorption events that shape the electromagnetic wave (turning, in the example of the double-slit experiment, the original spherical wave into the two focused beams emanating from the slits). As a very encouraging start, Carver Mead in a deceptively modest booklet [13] gives a deterministic dynamic description of the exchange of a photon between emitter and absorber atoms.

Another problem is the necessary explanation of the fact that, in spite of the seemingly time-symmetrical nature of the transaction, quanta always end up in the future, never in the past. Although energy is shipped forwards and backwards in time during the organization of the transaction, upon completion of it no trace of these signals is left, the only effect being the transmission of a photon to a later point in time. There have been several attempts to explain this asymmetry (e.g., [7, 8, 19]), all trying to link this electromagnetic time arrow to the cosmological one, but none of them convincing yet.

A related issue, very central to the argument here, is the question whether information can be sent over space-like distances or backwards in time. There is, of course, no evidence for this, and there is a proof [6] that, given the time-tested quantum mechanical formalism, no information can be exchanged between the local measurements involved in EPR experiments in spite of entanglement and the effectively space-like communication implicit in the Cramer picture. Consequently, there is no challenge here to the physical picture that all the information we get through direct signals comes from the past, or more precisely, the interior of the past light cone. (My wording is cautious here, because on the basis of reasonable assumptions about the stability of the world we can deduce much of what is outside this light cone, a thought not followed up here.) It seems not totally excluded, however, that some experiments can be devised to directly prove the existence of advanced signals, and it may even be possible to obtain some information about the future, as the recoil of photon emission indicates the direction in which to find the absorber, and an uneven distribution of absorbers in the distant future (analogous to the uneven distribution of emitters of the cosmological background radiation) might be revealed by an analogous telescope into the future.

1.2 The Eternal Universe

The upshot of all of these thoughts is a breathtakingly different view of the reality of this universe. Tetrode [16] and Fokker [5] formulated the exchange of electromagnetic interactions between charged particles in terms of a variational principle according to which the actual world corresponds to the stationary points of an action integral (Eq. 5 in Tetrode [16]; p. 389 of Fokker [5]; or Eq. 1 in Wheeler and Feynman [20]) that contains interaction terms for all pairs of charges and all pairs of space-time coordinates lying on the same light cone, that is, being connected by signals traveling with the speed of light. A similar picture is to be painted for gravity [21]. Fields containing energy-momentum and summing up all information of the past as far as needed to make the future, are non-existent in this picture. One speaks of "action at a distance" (distance in space and time).

According to this picture, the present moment loses all of its special reality status, and the total history $\Psi(t)$, $t \in (0, t_e)$, is simultaneously real, simultaneous from a vantage point external to the perspective of our time. From this vantage point, the universe is a totally static, eternal entity, rigid as a crystal, metaphorically speaking.

The universe as an eternal entity forces on us another, curious conclusion. The earliest moments of our universe, to the extent that radiation sent out then eventually is absorbed at the end of time, are already in direct communication with those last moments of the universe. This makes it impossible to see the creation of the universe in terms of a wave progressing from a moment of original creation to the present and on to later moments. At the birth of the universe, its end was already present. This raises the question how our universe "was" created. In a second time, different from ours, along which a baby universe progresses from imperfect consistency to full consistency in terms of all interactions, realizing the variational principle of Tetrode and Fokker in terms of actual variation?

Once fully formulated, the action-at-a-distance picture of physics, complete with unidirectional energy propagation, will have to be equivalent to familiar field physics in essential aspects. In particular, it will have the same asymmetry in time. Physics is very successful in describing events with the help of field and wave equations that express propagation and causation only forward in time. The field equations make, however, only probabilistic predictions. This residue of indeterminacy is eliminated by Cramer's advanced confirmation signals. In this sense, our familiar picture of forward causation seems to be totally untouched by the eternal universe perspective (if indeed the view holds up that no information whatsoever can be transmitted backwards in time). This coexistence of forward causation with a globally entangled description of the universe produces the eerie feeling of living on a theatrical stage. Just as all the scenes of a cinematic film have simultaneous and equal reality while the film is in the box, when viewed it gives the impression of a logical, causal flow. But as the film has been produced off-line in random sequence, this causal flow is a deliberate illusion, created by cunning direction and editing.

Are there any loopholes that could save us from the eternal universe perspective? In Wheeler and Feynman's [19, 20] classical version of absorber theory (this term referring to the idea that emission of a photon necessitates the presence of an absorber as much as absorption of a photon necessitates the presence of an emitter, a thought already clearly expressed by Lewis [11]), only rather general properties of the future absorber needed to be postulated, leaving ample space for different world histories if only they keep these general properties intact. If, however, individual quanta are involved, and if nature is accurately making sure that no single quantum was either lost or absorbed twice under violation of energy conservation, there seems little chance of avoiding the picture that the future is specified “now” down to the last quantum jump of every atom. (In the Hanbury–Brown–Twiss effect, see [10], several emitters of compatible frequency collaborate to transfer photons to several absorbers, so that a picture seems possible in which intermediate bundles of photons shield the emitters from the absorbers, but it is not clear whether detailed communication between all participants can indeed be obviated in such multiple-photon transfer events.) As no such loopholes are in sight, let us proceed with the view that the universe is “simultaneously” real in all its detail; that it has eternal reality.

2 The Eternal Universe and Our Intuitive Notion of Time

Although it is recommended to us by strong arguments, the perspective of the eternal universe is not in the textbooks. The reason for this very likely is the apparent clash with intuition, which has been remarked by almost all authors advocating and discussing this view. Just as the intuitive reality of a solid and immobile Earth at our feet undoubtedly was a factor in delaying the Copernican revolution for more than a century, strong intuitive counterarguments will first have to be put out of the way before the reality of the eternal universe has a chance of being accepted.

2.1 The Present Moment

Einstein regretted that our intuitive notion of a moment in time is not reflected in the theories of physics (see the citation in the chapter by H. Lyre). In the eternal universe the moment is bereaved of special significance altogether. Let us examine whether this creates a serious conflict with our perception of time.

We of course have no direct access to the reality of the world but see it through signals and, little appreciated outside of neuroscience, through reconstructions. It needs complex processes for the brain to make sense of the signals that reach it. What we take to be a directly perceived reality in front of us is a construction whose substance is mostly conjured up from memory. Although we subscribe to it in our everyday life, it is a naive illusion that the reality of our immediate environment should swim directly into our mind through our senses. Already from physics’ point of view there is the problem that signals arrive with delays and were it not for benign continuity on a time scale attuned to the pace of our own reactions it would be all too evident that our perception can at best be a perception of the past, not the present.

But the problem goes much deeper. Our brain process is a succession of activity states. These all have rather little content but leave behind traces that help to direct and shape further activity states. The process is structured such as to converge on globally ordered brain states in which a rich array of subsystems each reflect the same reality in their own language in mutual consistency [17, 18]. We perceive this consistency as consciousness: awareness of the reality at the focus of our attention. This coordination of sensory signals with memory items, representations and interpretations comprises predictions of possible future events, complete with potential actions to take.

The attainment of this coherent state, the reconstruction of reality, is a time-consuming process which would not make any sense were it not for structural continuity of our environment on a time scale slower than the brain process. (Indeed, the mind's reconstruction of reality has its very natural extension in the process of science, which may take centuries, and again would not make sense in the absence of structural stability in the world.) We can deal with rapid processes (our auditory system, for instance, does so routinely), but the analysis and proper representation of rapid temporal relations has, of course, to come after the event, our representation of rapid temporal sequences has to be symbolic (like the persistent oscilloscope trace of a nanosecond signal) and the laws and mechanisms involved in the translation from the actual rapid process to the off-line representation must be stable. When our arm is tapped simultaneously at two different points along its length we perceive the two taps as simultaneous although the signals arrive at our brain at different times. This would be impossible if temporal processes in our environment had to be represented in the brain literally, as exact temporal replicas. If we want to be precise about a brief moment—a set of simultaneous events—it has to be a past moment, the present time being employed to reconstruct and contemplate it.

Let it be remarked that also when dealing with very slow sequences of events we have to represent them symbolically to project them onto the time scale of our thought processes. And let it also be remarked that we can perceive and generate historical records of our own thought process, but this perception fails on a time scale faster than a fifth or a tenths of a second.

From these considerations it can be concluded that we do not perceive time in any direct sense, our conscious representations "flowing with the time," but that we deal with time in a symbolic, indirect way, hovering back and forth around the clock's time as we represent it. Not even the timing of our mind's process is perceived and represented in any direct sense. In consequence, the physical time parameter t and the infinitely short δ-moment of the introduction are mere constructions and are not accessible directly. In the psychological literature there is something called the "psychological moment," something evolving on a time scale of a fifth or a tenth of a second, something we perceive as indivisible and elementary and which comprises the coherent perception of a chunk of reality. But there is no reason to ask for a reflection of this in relativistic physics, no reason to ask for a concept of simultaneity, at least not beyond the temporal resolution of our senses and the signal horizon of our immediate perception. The intuitive notion of a moment in time mentioned in the introduction is an idealization that does not stand up to scrutiny. A more realistic notion of time perception creates no clash whatsoever with the idea of an eternal universe.

To the contrary, in its microcosm our brain treats time in a way that has many similarities with the Tetrode–Fokker picture of the universe. Our reconstruction of a sequence of events (or indeed our perception of one) is achieved in an iterative optimization process, distantly analogous to the variation of Tetrode–Fokker's action, involving signals going forward and backward in (imagined) time, all along trying to do justice to forward causality, achieving it dynamically without being bound to it kinematically.

2.2 Asymmetry of Time and Free Will

All the signals that reach our senses come from the past light cone or its interior. To the extent that we can reconstruct certain knowledge about the external world it relates a brain state to the past. As the signals reaching us never convey any information about the future, all we know about it are predictions and imaginations. Recognizing our predictions as unreliable we see the future as uncertain. To the extent, however, that we believe to have certain knowledge and predictive power in a given situation, as is sometimes the case, we consider the future as inevitable and certain. The perceived reality status of the future is therefore merely a function of what we know, and there is no basis for the conclusion that the future is uncertain in any deeper sense. Unexpected movements, e.g., of other animate players, may necessitate quick updates of our predictions so that our imagined future is often subject to sudden changes, but this change takes place only in our head, just as an unexpected move in a film that we see changes our expectations for the rest, although, of course, that rest of the film had been set in concrete before we went to the cinema.

We would be inclined to accept this conclusion lightly, the same way we accept the reality of a far country or planet in spite of uncertain knowledge about it, if it was not for another issue of great impact on our outlook on life, an issue which I presume to be the reason the eternal universe first strikes us as a horrible vision worse than a prison life sentence: We live with the idea that by our own acts of free will we can change the future in a real sense[1] and an eternal universe would take away that freedom from us. Free will is an idea of fundamental importance to us, it establishes the sovereignty of our self and consciousness. If we could not change the future, we feel, we might as well subjugate to fatalism—do nothing and wait for what is coming anyway.

[1] This idea of changing the future by a local act of will, by a free decision, would re-introduce the concept of a distinguished moment: the branching point were the decision happened. But this version would not create a conflict with relativity and Einstein causality as my decisions are localized not only in time but also in space and all consequences are confined to the interior of the future light cone.

There is an old and very deeply ingrained sentiment that free will and determinism are not compatible with each other. For this matter, the eternal universe is just an acute version of determinism: complete and unconditional determinism that cannot even occasionally be punctuated, e.g., by superior intervention. Spinoza [15] had this view of a completely deterministic world (and of God, the two being identical with each other), and he was and is deeply hated for it.

Before we can deal with this apparent contradiction we have to briefly discuss the concept of determinism and perceptions thereof. Mechanistic determinism speaks of a system whose inner workings never leave the minutest choice in its progression through time. This was the determinism that Spinoza spoke about, and this was what Einstein meant when saying that God would not play dice. Now, in the conventional view of physics its system, described by deterministic field equations, is randomly changed by quantum chance, although under many circumstances these quantum decisions have only imperceptible effects. In Cramer's transaction version of quantum mechanics even this quantum uncertainty is eliminated with the help of advanced signals, re-establishing complete determinism (although the above wording has to be changed, as the universe is not determined in its forward progression in time but as a totally rigid array of retarded and advances signals criss-crossing the universe from one end to the other, both in space and in time). It is, metaphorically speaking, as if the universe had already run its whole course and we were dealing with a recording.

There is little disagreement about what (mechanistic) determinism is, but what about its meaning for our life? Laplacian predictability has it that if the inner workings of a system as well as the initial state were known, all future states could be predicted with certainty and precision. Laplacian predictability is, however, a mere figment, for a number of reasons of a principled nature. There is, on the other hand, practical predictability, the concrete possibility to know enough about initial states and inner workings and have enough reasoning power to be able to make useful predictions with some certainty and accuracy. This is what our brain does all day and is the basis for our survival. Of course, (practical) predictability is only possible on the basis of at least some degree of determinism.

Modern digital computers have become a powerful metaphor in reasoning about determinism (and free will). They are specifically built to be deterministic by their inner workings, that is, to be totally insensitive to uncontrolled random influences, so that in their isolated domain Laplacian predictability can be realized. They can be put repeatedly into a defined initial state to always run through the same sequence of states, and a second machine can be set up to predict this sequence in full detail. Computers display also two other properties that are often associated with determinism. Clockwork regularity (displayed, for instance, by running the same program with the same initial state repeatedly) and hetero-determination. The latter is the phenomenon, possible only within very specific organized arrangements in this world, that one system tightly controls another system—in the computer, the programmer hetero-determining the process in the machine with the help of a program that the machine follows step by step. Another example of hetero-determination is the imposition of political will.

What about my free will in the eternal universe? Should I fatalistically forsake all effort and let the inevitable future happen? Not at all. My present actions participate in the course of events: the universe is forward causal and my actions do influence the future. Without my presence and without the specific decisions that I am taking, my efforts, my caring, my sacrifices, the future would be different. The future is in complete agreement with forward causality, and so sequences of events are not observed in which I do not react to visual signals and yet my body avoids obstacles. So, can I change the future? Sure I can, but what I change is not the real future but the potential future of my imaginations and predictions. Thus, there is no contradiction between free will and determinism in the external world. To the contrary, the acting individual needs at least some degree of determinism in order to be able to predict and act accordingly.

We all recognize that our freedom to act is constrained by physical law: we cannot will to lift ourselves into the air, for instance, and we do not see this as a contradiction. Also the loose determinism of social law is obeyed by us most of the time, although we cherish the idea of being able to disobey in principle. In the political realm it is important for us to be free from hetero-determinism as much as possible. This latter feeling may be one of the psychological sources of the perceived contradiction between free will and determinism, although there is no deep conceptual link to mechanistic determinism here. An actual limitation of the freedom of my will is given in cases where my actions have no influence on some course of events. In such cases we may as well be fatalistic, but it is rather the absence of deterministic links that is to be blamed here.

As long as we take an external view—treating the acting individual as a unity without analyzing its inner workings—there is no contradiction whatsoever between free will and determinism. As soon, however, we start to enquire about the inner working of our mind, an irresolvable problem seems to arise, a problem that has been commented upon endlessly. I argue that this problem goes back to a logical self-contradiction that arises if we apply the concept of an act of free will to the thought act itself.

Here are the incompatible statements. On the one hand, the act of free will is to be illuminated by insight into possible courses of future events and an evaluation of them in the light of my preferences and values. On the other hand, as expressed, for instance, by Kant in his Critique of Practical Reason, free will should not be caused itself but should be an original cause and mover.

If the act of free will preceded the willed thought altogether, that thought could not be pre-meditated in the light of alternatives and goals because this premeditation would need thought itself. Our feeling of committing a defined act of will cannot precede the thought that formulates its substance, can only arise rather late along with that formulation (this is a logical conclusion, but see also the experiments by Libet et al. [12], that show that the subjectively perceived moment of free decision comes significantly after brain signals on the basis of which the eventual action can be predicted reliably). A tenable account of the situation is that the judgment that a particular thought corresponds to an act of free will arises along with that thought as integral part of the same creative process. This judgment is a deduction, not a cause, and is based on such signs as the absence of external stimuli and the existence of habitual patterns or related preceding thoughts. If someone wants to commit, for the sake of argument, a totally deliberate thought act, this act of will may be first and the substance of the resulting thought second, but this substance will not be the consequence of the original deliberate act but will have its origin in processes going on accidentally at the time in the brain.

The fixation on an ultimate-cause aspect of free will is a cultural tradition without any fundamental necessity. Julian Jaynes [9] argues that in early historic times humans did not see the origin of their decisions in their own minds but rather in voices, experienced literally or in a metaphorical sense. In our cultural circle and time we feel accountable for our decisions and are ready to explain the reasoning behind them (although, as evident in certain neurological conditions, these explanations may sometimes be pure confabulations, having little to do with real mental causes). We see our mind as an indivisible unity and not as a complex process of collaborating subsystems (which it, of course, really is). It is the high efficiency of the brain processes in constructing coherent mind states that creates this illusion of unity [17]. However, to the extent that we insist in the unity of the mind to be a primitive concept we cannot simultaneously reason about its inner working in terms of cause and effect, about the question whether the process of free will is prime mover or secondary attribute. Arguing about the mind process means arguing about a very complex mechanistic system composed of billions of neural elements, and any degree of order, any basis for simple statements about the whole system, must come at the end of a process of organization, not at the start.

Accepting this view of my mind as an incredibly complex array of minute elementary mechanisms I am grateful for every bit of determinism in it. I do not want my decisions to be random, but to be instructed as far as possible by judgment about desirability of outcome. The stricter the logic, that is, the inner working, of my mind the better. But, in view of this determinism, can my decisions still be called free in some sense? What about punishing a murderer if he did not have a choice anyway? There is a widespread belief that here is a deep conflict that needs to be resolved. Determinism of my brain is taken as an infringement on the sovereignty of my self, some kind of hetero-determination by my synapses and neurons. Starting with Pasqual Jordan, thinkers have grabbed an opportunity seen in quantum physics: quantum chance as a loophole out of my mind's determinism. But I do not want to throw dice to make my choices—I want them to be reasoned![2]

It is my suspicion that the generally perceived contradiction between free will and determinism has little to do with determinism as such but rather with the attributes occasionally associated but not necessarily connected with determinism, as discussed above. It would be totally unacceptable, a slap in the face of our ego's glory, if due to the inner workings of our brain we were hetero-determined by primitive instincts, were reduced to clockwork regularity, or subject to the ridicule of

[2]The neurophysiologist John Eccles saw in quantum chance the instrument through which an immaterial mind could purposefully influence the mechanistic brain, seen as "the mind's computer." However, this would not solve the dilemma but simply shift it to another domain, the mind as distinct from the brain, whatever that could be.

practical predictability, so that our every move could be foreseen! The spectre of narrowly schematic and therefore predictable behavior could come in several forms—genetically determined behavior, addiction, ingrained habits, or a view that sees our brain in close analogy to our present types of computer programs. Free will, then, means deviation from an otherwise deterministic course, deterministic in this restricted sense.

In consequence we have to subdivide our mind into two subsystems, a lower tier that is narrowly constrained in its behavior, plus an upper one that brings additional mechanisms into play that are free of the constraints of the lower subsystem and that can modify and overrule whatever that level would have done on its own.[3] Indeed this subdivision of our brain and mind into tiers has been formulated in the literature in various ways. The comparative neuroanatomist Edinger spoke, in the 19th century, of the paleoencephalon, the "fish brain", buried in ours, complete with all primitive instincts necessary for simple survival, but unable of differentiated behavior in complex situations, an ability that we owe to the neoencephalon, parts of our brain that are evolutionarily younger, especially the cerebral cortex. Freud has dissected our mind into three parts, the *id*, the *ego* and the *super-ego*. The *id* comprises primitive drives and instincts. These are dominated by the *ego* to give us consistent behavior in line with a well-reasoned set of goals. And the *ego* is modified by a *super-ego* that incorporates the societal influences of norms and ethics. Judges try to come to an assessment whether the criminal is endowed with an upper tier of moral values and of considerations of guilt and punishment. If not, the perpetrator is "deterministic" (that is, victim of the inevitability of a bare lower tier, dominated by lack of intelligence or overwhelming drives), in which case the verdict may ordain treatment and confinement rather than punishment.

The essential point here is that also the upper tier is deterministic, for the reasons given earlier, although due to its complexity it will have no clockwork regularity and easy predictability. This point is more clouded than enlightened by the analogy to the algorithmically controlled computer. There, the upper tier is not in the machine at all but resides in the mind of the programmer, who alone takes into consideration goals and judgments to adapt the machine to the intended application. At the present time we humans are very meticulous about holding the reins in our own hands instead of giving the computer the freedom to develop its own set of goals and decide accordingly. Maybe we should keep it that way, but then we should not complain about a computer incapable of flexible response to the exigencies of situations as they arise. If, on the other hand, we wanted a computer that came close to us in terms of intelligence and situation-awareness we would have to give it an upper tier in terms of motives and a repertoire of reaction patterns that freed it from the "genetic determinism" implicit in algorithmic off-line control by human programmers. To the extent that our brain is indeed deterministic it can be simulated on a computer, but the organization of its program would have to be very different from the machine-like entities we are used to now.

[3] This is just like in the external perspective, where we see a situation unfold in a predictable way and intervene with our own decisions to alter the course of action, the external situation corresponding to the lower tier, our presence and influence to the upper.

In summary, a deterministic and an eternal universe would be an unsupportable prison only if we and our mind's mechanisms were not an integral part of it. But as the universe obeys forward causality, we are very concretely participating in forming the future.

3 Conclusion

I am adopting here the view that instead of field physics a more convincing description of the dynamics of our world can be formulated by an action principle along the lines sketched by Tetrode and Fokker, admitting that much further work needs to be done to fill in important conceptual lacunas. The most convincing argument in favor of this view is that on this basis quantum phenomena can be understood in a simple and straightforward way, as worked out by Cramer [2]. According to this action principle, events at all space-time points are stitched together by a tangle of advanced and retarded signals from the beginning to the end of time. Thus, the earliest times of this universe as much as the present moment could not have a definite shape without also all later events of the universe's history being equally definite. However, for reasons that are not clear yet, the relation between past and future is not symmetric, energy and information always being transferred into the future, the effects of advanced signals being subtle and difficult to detect, making for a world that has forward causality.

Although many physical arguments speak for this perspective, it has not attracted widespread attention, let alone acceptance. The main reason for this may lie in the apparent incompatibility with our traditional intuitive outlook on time. Most outrageous seems the proposition that the future, being in instant interaction with events now, has a definite, immutable reality and form, down to the minutest atomic detail. This seems to bereave us of all freedom to act and shape the future. It is the point of this paper to show in a logical analysis of our concept of free will that there is no contradiction and that, to the contrary, free will is unthinkable without determinism, that is, a definite future, the more definite the better. Our existence, structure and behavior are factors that contribute to shaping the future (and to the extent that advanced signals have effects, also the past).

To give the status of reality only to the present moment is just another expression of the extreme egocentric perspective that our civilization has developed. There is not really any fundamental difficulty in attributing to my own youth or my own old age the same reality status as to the moment in which I am writing this, even if they are not accessible to my mind now. In fact, I experience this as a rather relaxing thought (and find it surprising that Barbour, this volume, should come to the opposite conclusion of putting even more emphasis on the here-now).

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