Commentary on Benjamin Libet's

Mind Time.
The Temporal Factor in Consciousness

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That we are beings who do not passively perceive the world as it is, as it presents itself to us, so to say, but who, on the contrary, actively take part in the construction of their own world (even though we are not always conscious of our active involvement), has been theorized and proved for a long time. The world does not enter our body directly as it is, without any elaboration of our own: the world is continuously elaborated and constructed by us. We see and know only some parts of the world, and of those parts we see and know only some characteristics. Moreover we see and know only some of the relationships that exist between those parts, and relate only some parts to each other and only in some specific ways. The world appears to us as it is because *we* perceive and experience it in that way, and could not perceive and experience it in a different way.

The fact that we perceive and experience it in that way is due not only to the specificity and limitedness of our sense-organs, that is, to the fact that we are provided with only some sense-organs that allow us to directly perceive only some levels of reality. Neither is it due only to the fact that we live in a society of people, having its own customs and culture that unavoidably bias our way of perceiving and conceiving of the world. It is due also to the specificity of our nervous system and our brain: they elaborate every sensory experience in a specific way.

A thorn pricks our thumb. We immediately feel a slight pain in that part of the body. Or at least we *believe* that we feel it *immediately* and in that *specific part* of the body. However, our belief begins to waver as soon as we get to know what the neurophysiologic experiments show. For instance, if you properly stimulate the area of a subject's cerebral somatosensory cortex that usually receives the sensory input from the subject's skin, you will find that the subject does not feel the resulting sensation as located in his brain, where it was originally produced, but as located in his

skin. Moreover, and more surprisingly, if you stimulate at the same time both the subject's skin and the area of the subject's cerebral somatosensory cortex that receives the sensory input from the skin, the subject will report that the sensations generated at the skin appear before the cortically induced sensations! And this happens even if the skin pulse is delayed by some hundred milliseconds after the start of the cortical stimulus (Libet et al. 1979). We feel a physical sensation in a place of the body where it actually did not occur, and we feel it occurring with a sensible delay compared to a stimulus that was applied to the skin at the same time or even later!

These phenomena, which are due to the mechanism of the subjective spatial and temporal referrals of a sensory experience, as well as other phenomena like blindsight testify to the characteristic way we human beings have of building our own experiential world. Our subjective experience of the world results from a series of operations performed by our brain and neural circuitry: it is not simply a mirror of the "outer" world, but a construction of it that takes place in accordance with the times and modalities afforded by our neural circuitry. Some of the intermediate steps our brain takes to achieve this construction can be clearly seen when some abnormal conditions occur, such as in patients affected by cerebral strokes, or in specific experiments devised by neurophysiologists.

Benjamin Libet is known worldwide for the experiments he has conducted over a long career (his first experiences date back to 1957-1958) on how the human brain produces conscious awareness. Having the possibility of carrying out research that could be done with awake patients while their brain underwent surgical treatment, and with no risk to them, Libet designed a series of experiments intended to investigate what the brain must do in order to produce a conscious experience. These experiments led him to a series of important findings that are described in this recent book and can be so summarized:

1. The brain needs a relatively long period of appropriate activations, up to about half a second, to elicit awareness of a sensation. A subject, whose primary somatosensory cortex is being stimulated with a train of electrical pulses at the minimally effective intensity, will report having a sensation coming from the skin or some other body structure only if the stimulus continues for at least 500 msec: shorter durations do not elicit any awareness of the sensation. The same is true if the stimulus is delivered in the medial lemniscus leading into the thalamus. Changing the frequency of stimulus pulses, for example, from 30 pps to 60 pps, does not result in a change in the minimum train duration of 500 msec required to elicit a conscious sensation: that is, the minimum requirement of a 500 msec train is independent of the frequency of stimulus pulses (Libet et al. 1964, Libet, 1973).

2. There is an actual delay of 500 msec for sensory awareness even when the sensation is generated by a single pulse applied to normal sources at the skin. Libet arrived at this conclusion on the basis of three different lines of evidence.
   a) The first deals with the electrical responses of the cerebral cortex to a single pulse stimulus to the skin. A single pulse to the skin gives rise to a sequence of cortical electrical changes, called the evoked potentials (EPs) or the event-related-potentials (ERPs), which have been shown to represent nerve cell responses in the cortex. The ERPs contain a number of significant components: the primary EP and some later evoked responses. The primary EP begins after only some tens of msec. after the skin pulse. It is neither sufficient nor necessary for eliciting a conscious sensation: in fact, on the one hand, one can elicit a conscious sensation with a weak stimulus applied directly to the surface of the sensory cortex, even though this cortical stimulus does not produce any primary EP. On the other hand, a single pulse in any part of the specific sensory pathway that is located in the brain does elicit a primary EP response of the cortex, but does not elicit any conscious subjective sensation at all. The later responses of the cerebral cortex, on the contrary, appear to be necessary for producing a conscious sensation: when a person is under general anaesthesia, the later ERP components disappear, while the primary EP may even be enlarged; similarly, if the strength of the skin pulse is lowered to a level at which an awake subject reports feeling nothing, the late ERP disappear, while the primary EP response is still present (Libet et al, 1967). The late responses go on for more than 500 msec, which seems to fit well with the period of activations needed to elicit awareness of a sensation.
   b) The second line of evidence deals with retroactive, backwards effects of a delayed second stimulus following the initial testing one. By applying a delayed conditioning stimulus directly to the somatosensory cortex with a large 1-cm disk electrode after the first test stimulus (a single pulse to the skin), Libet found that the former could mask or block awareness of the latter, even when the cortical stimulus began up to 200 to 500 msec after the skin pulse (cortical trains lasting less than 100 msec, or single pulses, are not effective for the retroactive inhibition). With a much smaller 1-mm electrode contact, Libet found also that a delayed stimulus (even up to 400 msec or more after the skin pulse) can retroactively enhance, or intensify, the initial skin sensation, instead of masking it (Libet et al., 1992). The evidence that a conscious sensation elicited by a skin pulse can be retroactively modified by a second input that is delayed by about 500 msec, clearly supports Libet's view that the brain needs 500 msec to produce awareness of the skin stimulus.

c) The third line of evidence comes from experiments on reaction times (RT) performed by Arthur Jensen (1979). Subjects who were asked to press a button as quickly as possible after the appearance of an agreed-upon signal, produced RTs in the 200-300 msec range. However, when asked to deliberately lengthen their previous RT by 100 msec or so, none of the subjects could do that: instead, they produced RTs of 600-800 msec, much longer than the requested 100 msec increase. This phenomenon can be explained by assuming that subjects could accomplish their task in the usual RT test - in which they had simply to press the button as soon as possible - before or with no awareness of the stimulus; whereas, in order to accomplish the task in which they were requested to lengthen their RT by about 100 msec, they had first to become aware of the stimulus. Since achieving awareness of a stimulus requires a delay of about 500 msec, this requirement would delay the response by the additional time, thus causing the discontinuous jump in RT by about 300-500 msec in the task with the lengthened RT.

3. We are provided with a neural mechanism that accounts for our subjective feeling that we become aware of a sensory signal virtually immediately, even though there is in fact a substantial delay of 500 msec for awareness of sensory stimuli. This mechanism allows us to antedate or automatically refer backward in time the delayed sensory experience to the initial sensory signal. This mechanism is represented by the primary evoked cortical response (EP): the primary EP provides the timing signal to which the correct subjective timing of the input skin is retroactively referred. The experience of the skin pulse is thus antedated subjectively to the timing signal provided by the primary EP response (Libet et al., 1979). The skin-induced sensation appears subjectively as if there were no delay, even though it did not actually appear until after the 500 msec required for neuronal adequacy to elicit that sensory experience.
4. An unconscious function may be transformed into a conscious one simply by increasing the duration of the appropriate brain activities to a minimum of about 500 msec. Libet verified this condition by applying stimulus trains of variable duration (from 0 to 750 msec) to a subject's ascending sensory pathway in the thalamus, and having the subject face a panel containing two buttons, each of which could be lit up briefly alternatively for 1 sec. The subject had to indicate in which of the two lit periods the stimulus was delivered: he had to make that decision even if he were not aware of any sensation produced in the test. The subject then had to report his level of awareness of the stimulus (felt; not certain that it was felt; felt nothing). By a statistical analysis, Libet determined that the difference in stimulus duration between the condition in which the subject responded correctly despite having no awareness of the stimulus, and the condition in which the subject responded correctly having awareness of the stimulus, was due to

an increase in stimulus duration of about 400 msec (Libet et al., 1991). This duration would be then the "neuronal code" for the emergence of awareness. The results of the experiment also provide direct evidence for a form of "subliminal perception": when subjects were not aware of any sensation and were guessing, they could nevertheless detect the stimulus and respond to it with a significant level of correctness (with trains of pulses lasting 150 to 260 msec, subjects were 75% correct). These results provide then direct evidence of the difference between unconscious detection of a signal and conscious awareness of a signal.

5. Typically subjects report having awareness of their conscious will to perform a freely voluntary act 150-200 msec before the act: however, the subjects' brain exhibits an initiating process, called "readiness potential" (RP), leading to the voluntary act that begins about 550 msec before the freely voluntary act, that is, well before (some 400 msec) the conscious will to act has been adequately developed. Libet arrived at this finding by devising an experiment in which a subject, who was fixing his gaze on the centre of an oscilloscope's face arranged like a usual clock (its spot of light revolved near the outer edge of its face, which was marked in clock seconds), was asked to perform a freely voluntary act, a simple but sudden flexion of the wrist, at any time he felt like doing so. The subject was asked not to preplan when to act: rather, he should let the act appear "on its own". The time of the act was measured by means of electrodes placed on the muscle to be activated (electromyogram). The subject was also asked to associate his first awareness of his intention to act with the clock position of the revolving light spot: this reported clock time was labelled "W". The RPs produced in each voluntary act were recorded by means of electrodes placed on the subject's head. The time of onset of the RPs could then be compared to the reported clock times W and to the actual times of the act (Libet et al. 1982, 1983). In some trials, the subjects reported having preplanned a range of clock time in which they would act, despite being asked not to do that. In such cases, the Rps averaged about -800 to -1000 msec before the motor act, but the reported clock times W resulted to be the same as those reported in the trials were subjects experienced no preplanning of when to act, that is, about -200 msec before the act. From this set of data, Libet inferred that the process leading to a voluntary act is initiated by the brain unconsciously, well before (some 350-400 msec) the conscious will to act appears. This would imply that free will *would not* initiate a voluntary act.
6. A subject who has planned to perform an act can veto it during the last 100-200 msec before the expected time of the action. This was showed experimentally by Libet by asking a subject to prepare to act at a preset time of the clock, but to veto that expected act when the clock reached 100-200 msec before the preset time. A substantial RP developed during 1-2 seconds before the veto, but this RP flattened at about 100 to 200 msec before the preset time, as the subject vetoed

the act (Libet et al., 1983). These results, together with those reported at point 5., led Libet to consider conscious will not as the mechanism that initiates our freely voluntary acts, but as the mechanism that can control the outcome of the unconsciously initiated processes, by actively vetoing them and aborting the acts themselves, or permitting them to proceed. The role of conscious free will would be, then, not to initiate a voluntary act, but to control whether the act can take place.

From a strictly neurophysiological point of view, I think that most of Libet's findings cannot be seriously refuted, at least until new and more sophisticated tools and techniques will be developed. Some specific remarks can obviously be made with regard to the technical issues implied by Libet's experiments, and actually they have been made. Wood, for instance, observes that RPs "are aggregate, incomplete measures of the neural events occurring at a particular time", and that "even earlier activity could be present and not evident in scalp recordings" (Wood, 1985, p. 558), thus suggesting that RPs may not be the proper, reliable measure of the brain activity leading to the voluntary act. On the whole, however, Libet's findings seem to me irrefutable, and have to be seriously taken into account by whoever is interested in building a theory of consciousness.

Nonetheless, there are some aspects of his work that do not convince me. First, the conclusions he draws from the experiments reported at points 5 and 6. From the fact that a subject's brain exhibits a RP well before (350-400 msec) the subject has any awareness of his conscious will to perform a freely voluntary act, Libet concludes that it is not the subject's conscious free will that initiates his freely voluntary act: the latter would be initiated instead by his brain's unconscious processes. The subject's conscious free will can only control the outcome or actual performance of the act: it could only permit the action to proceed, or it can veto it. This conclusion seems to me unjustified, or at least leading astray. In fact, in Libet's experiments, subjects were asked to perform a freely voluntary act, a simple but sudden flexion of the wrist, at any time they felt like doing so. They were aware of the task they had to accomplish *well before* the time in which the freely voluntary act would occur. Certainly, the act had to appear "on its own", and the subjects were asked not to preplan *when* to voluntarily act. But, anyway, they were asked to preplan *to voluntarily act*! Therefore, in the causal chain of the events, a conscious decision to perform a freely voluntary act precedes indisputably the act itself. In this sense, it seems wrong to me to say, as Libet does, that it is not the subject's free will that initiates his freely voluntary act. In this case, it would be more appropriate to say that while the subject's conscious free will does not specify *when* to initiate the freely voluntary act, nonetheless it specifies that, at any time he feels like doing so, he has *to initiate* a freely voluntary act. I do not argue against the evidence that, when a subject plans to perform a

given act – whether voluntarily, intentionally, necessarily, casually or in any other way -, both the subject's awareness of performing the act and the subject's act itself are preceded and occasioned by the subject's unconscious brain processes. After all, it is quite a common experience for us to be able to recollect the name of a given person or place only after minutes or hours that we were asked or wanted to report it: without any prior warning, we suddenly become aware of it, after having lost any hope of being able to remember it. Our brain is always working unconsciously to satisfy our conscious needs, wills and whims: it is thanks to the unconscious processes that what we have consciously planned to do can satisfactorily be carried out. We have plenty of evidence showing how the unconscious operations of our brain allow us to solve problems, find ideas, remember things, carry out plans and perform conscious acts after we have decided or planned to do so. What I argue against is Libet's view that consciousness does not play any causal role in our life, and that it can only act as an agent who vetoes or approves something that was unilaterally decided by some unconscious processes. If there is an indubitable and definite thing Libet's experiments show, on the contrary, it is precisely the fact that consciousness *does* play a causal role in our life. I think that this fact would be more clearly seen and understood if we modified Libet's diagram of sequence of events that precede a self-initiated voluntary act (Libet, 2004, p. 137), which I here reproduce in Fig. 1 in a slightly adapted way:

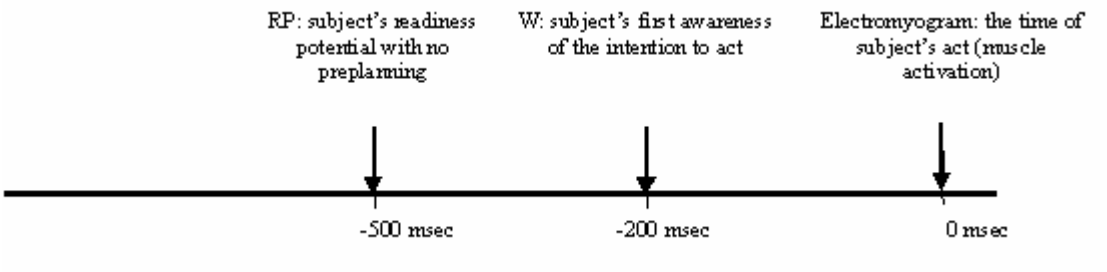

Fig. 1: Libet's diagram of sequence of events that precede a self-initiated voluntary act

by adding the indication that, at a certain initial time (let's call it, IT: instruction time), well ahead of all the recorded times (the cerebral RP time, the subjective W time and the time of the muscle activation), the subject was instructed to perform a freely voluntary act, and that he was well *aware* that later he had to perform a freely voluntary act. A more correct and complete representation of the events preceding a self-initiated voluntary act should therefore look like that of Fig. 2.

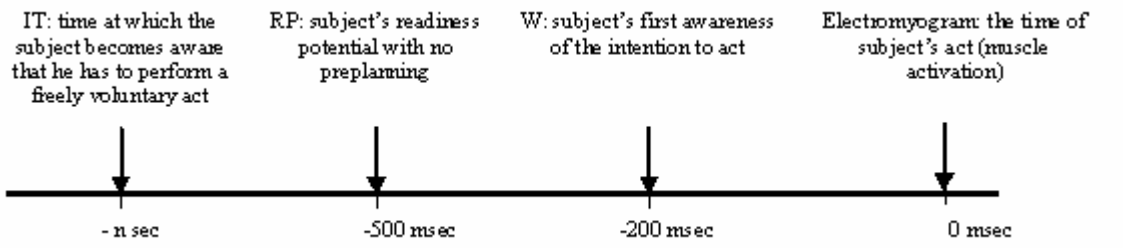

Fig. 2: My proposal of how to represent the sequence of events that precede a self-initiated voluntary act

Compared to Libet's representation, this modified version does not give cause for misinterpretations or oversights: indicating the time at which the subject becomes aware that at a later time he has to perform a self-initiated voluntary act, it correctly takes into consideration the whole chain of causal events. It thus clearly and unambiguously shows that the sequence of events ending with a specific muscular act (the flexion of the wrist) is originated by the subject's awareness at time IT.

I do not intend at all here to maintain that our acts and thoughts are occasioned only by previously taken conscious decisions, and to deny that there cannot be acts and thoughts that appear, so to say, "on their own". A lot of acts and thoughts appear spontaneously, independently of any conscious decision of ours: ideas, wills, intentions, and so on come suddenly to our minds, even if we have never thought about or looked for them before; likewise, some of our acts arise without any previous conscious intention or preplanning of ours to perform them. Undoubtedly, our unconscious brain processes occasion many of our physical and mental acts, and we become aware of them only after we have done it. All of us know very well how much effort we have to make to control and veto all those urges to act that arise spontaneously, independently of our will, and that are socially unacceptable. Indeed, in this view, Libet's conclusion that our consciousness allows us to control the outcome of the unconsciously initiated processes, by actively vetoing them and aborting the acts themselves, or permitting them to proceed, is correct. But this is just *one* of the important functions of consciousness, the other being that of being able to cause or occasion the performance of voluntary acts.

I believe that most of the problems with Libet's erroneous conclusion that conscious will does not initiate a voluntary act, originates from his misuse or misconception of the word "voluntary". Although Libet gives a clear and almost comprehensive definition of "voluntary", he seems to overlook it. He defines an act as voluntary when:

a) it arises endogenously, not in direct response to an external stimulus or cue; b) there are no externally imposed restrictions or compulsions that directly or immediately control subjects' initiation and performance of the act; and c)

most important, subjects *feel* introspectively that they are performing the act on their own initiative and that they are free to start or not to start the act as they wish (Libet, 1985, pp. 529-530).

No doubt, this definition catches almost all the components of the meaning of "voluntary", even if the most important one is only partially alluded to by point c), that is, the fact that any voluntary act is such because it is occasioned or triggered by a conscious decision taken before the act is performed. One can see that this is the most important aspect of the volitional sphere by comparing, for instance, the use of the verb "to want" with other modal auxiliary verbs. Let's start with a "neutral" situation, where no modal auxiliary verb is used, for instance: "I open my hand". Now compare this situation with one where our action is described by means of a modal auxiliary verb, such as: "I can open my hand". We immediately feel a difference. Let's try to describe this difference in attentional terms: where does our attention go? What does our attention do? The use of "can" underlines the fact that we have no problem in opening our hand, if only we desire to do that. Now let's try with a different kind of intentional state: "I want to open my hand". The attention is brought here not so much on the action itself (opening the hand), as on the conscious mental state occasioning or prompting it: the verb "want" specifies that we have no problem in triggering or activating our conscious mental state because the act of triggering or activating it depends completely on us (but it does not specify whether the action can be as easily prompted: indeed, one thing is to want to do something, quite another to be able to do what one wants to). The sentence: "I must open my hand" also focuses our attention primarily on the conscious mental state prompting the action, and does not state anything about our actual capacity to perform the action. However, unlike "to want", "must" underlines that the conscious mental state prompting the action depends not so much on us as on someone or something else.

Strangely enough, Libet's investigation focuses primarily not so much on the more important component of a voluntary act, that is, the mechanism that allows the subject to trigger the conscious mental state (a mechanism that is set at IT) causing the whole chain of events, as on the subsequent steps of the chain, that is: RP, the subject's readiness potential preceding the act; W, the subject's awareness that he is going to perform the act; and the act itself (the flexion of the wrist). In so doing, he isolates the main components of a spontaneous act, but oversights the main component of a voluntary act. This attitude of Libet is further visible in his effort to isolate the process that leads the subject to "act now" from any deliberations and advance making of choices about performing an act: "One can, after all, deliberate all day and never act" (Libet, 2004, p. 132). In doing so, he completely misinterprets the meaning of the word "voluntary", assigning it instead a meaning that is more akin or appropriate to "accidental" or "spontaneous" than to "voluntary". This misinterpretation can also be noticed in the kind of instructions Libet gave to his subjects to

encourage the activation of self-initiated voluntary acts: subjects were instructed "to let the urge to act appear on its own at any time *without any pre-planning* or concentration on when to act, i.e., to try to be *spontaneous* in deciding when to perform each act" (Libet, 1982, p.324) (italics are mine). Here one sees well how Libet uses words that do not strictly refer only to the volitional sphere, but also to the sphere of "spontaneity", "casuality" or "accidentality". However, the latter has little to do with the former: there are spontaneous acts that are not at all willed, as when you do something impulsively (for instance, when you give someone a slap), without having any control over what you are doing; conversely, there are volitional acts that are not at all spontaneous, as when, after long deliberation, you decide to do something even if you loathe doing it. The essential condition for an act to be voluntary is not so much to be "spontaneous" or "casual", as to be "pre-planned", in the sense that the subject consciously decides or thinks to perform it well before actually performing it. A clear category mistake underlies therefore Libet's erroneous conclusions about conscious will: he investigates and explains a phenomenon belonging to the volitional sphere by using methods and logics pertaining to the "spontaneity" or "accidental" spheres.

The second aspect of Libet's work that does not convince me concerns the way in which he proposes to solve the mind-body problem.

He correctly observes that the brain is the physical organ for conscious and unconscious mental functions: indeed, "there is no objective evidence for the existence of conscious phenomena apart from the brain" (Libet, 2004, p. 7). Undoubtedly, then, brain and mind are interrelated. However, as Libet clearly recognizes, they belong to two different categories. In fact, he states that the "externally observable 'physical' events and the inner observable 'mental' events are phenomenologically independent categories" (Libet, 2004, p. 17), and that: "all the brain processes that give rise to subjective experiences (including thoughts, intentions, self-awareness, and so on) do not 'look like' the emergent experiences" (Libet, 2004, p. 86). Consequently, he admits: "even a complete knowledge of the responsible neural processes would not, *a priori*, describe the accompanying mental events" (Libet, 2004, p. 86). Therefore subjective experience is not describable by purely physical observations of nerve cell activities: to get at the subjective experience, one should ask for an introspective report of the experience by the individual, who alone has access to his conscious functions.

How does Libet solve the problem of the gap between brain and mind, that is, between two phenomenic fields that are somehow interrelated but that are nonetheless categorically different and separate? Libet claims that the relationship between them "can be discovered only by simultaneous observations of the two separate phenomena" (Libet, 2004, p. 17); "correlations between the

subjective and the physical must be discovered by simultaneous studies of both categories" (Libet, 2004, p. 183).

Libet's proposal is based then upon the possibility of correlating the inner experience reported by the subject with the physical processes occurring in the subject's brain. However, apart from the temporal criterion - the "simultaneity" of the observations -, Libet does not indicate any other useful criterion of how to correlate the two phenomenic fields, and this causes some hard and unsolvable problems. Indeed, if you use the sole temporal criterion, you cannot succeed in positively correlating the two fields: while indicating *when* to observe the physical phenomena in relation to what the subject reports, it does not tell you either *where*, *what,* or *how* to observe them. The necessity of criteria that specify where, what and how to observe becomes immediately clear if you think that the physical field can be subdivided in many levels: for instance, the micro-level of the atoms and sub-atomic particles; the medium-level of cells and neurons; and the macro-level of the assemblies and systems of cells and neurons. Where should we address our research? What should be the level of observation of the physical phenomena? Moreover, what criterion should we adopt to analyze the relationships between these different physical levels? And how could we explain, on what basis, the relationships between the various elements composing each physical level? More in general, how can we explain the transition from the physical level to the mental one?

Certainly, one can resort to the concept of "emergence", as Libet does: "My view of mental subject function is that it is an emergent property of appropriate brain functions" (Libet, 2004, p. 86). But this is not an answer to the question raised by the mind-body problem. This simply shifts the problem and does not get to its root. Emergentism does not explain how one can get from the physical level to the mental one. It simply states and describes a given situation: a certain combination of elements or components gives life to a certain property that could not be predicted *a priori* from the properties of the component themselves. The way emergentism describes the transition from one phenomenic level to another one safeguards the independence of the two different levels, but does not explain or analyze how one level produces the other. The kind of description emergentism gives can be attractive for very simple and basic phenomena, such as that of benzene, which Libet quotes. However, for more complex phenomena and physical structures, it says nothing, it adds nothing to what we already know about them. As far as the brain is concerned, for example, it does not specify what kind of combination produces mental phenomena: is it the combination of groups of neurons? Is it the combination of neurons forming such groups? Or is it the combination of atoms forming neurons? Or is it some other kind of combination, such as that between atoms and groups of neurons? Moreover, it does not specify the kind of combination: is it a chemical one or an electrical one? Or both? Or some other kind of combination? Try to imagine the

following situation: you do not know anything about how car engines work, and you want to explain how they work using an emergentist description. The only reasonable thing you can say is that a combination of steel, copper, wires, pieces of iron, some fluids, and so on gives life to something that makes a certain noise, emits steam and other kinds of evil-smelling gases, and makes the car run. But you cannot say anything about, for instance, the devices that synchronize the working of the various parts of the engine, or the use of a certain cable connecting two or more different parts: you would not even know anything about their existence! To be able to explain how an engine works, you need an intermediate level between the physical one and that of the external observable properties of the car engine (noise, steam, running car). This intermediate level can only be represented by a theoretical *model* of the engine that describes precisely:

1) what the main property or function of the engine is, that is, its "essential performance" (Italian "prestazione essenziale") as Negrotti more precisely and technically has termed it within the framework of a general theory of the artificial (Negrotti, 1999): is it, for example, that of making the car run, or that of emitting steam and evil-smelling gases?;
2) how, given certain physical constraints, this function can be carried out, that is, what mechanisms can *produce* it and how they *produce* it;
3) how these mechanisms can be physically realized.

In a word, you have to conceive of the property or function of the engine as the product of the operations performed by a physical mechanism or set of mechanisms. The analysis of the mechanism can lead you from a macro-level to a micro-one, so as to subdivide the mechanism in parts that are more and more elementary. The important thing is, nonetheless, that you specify exactly how each level and the parts belonging to it contribute to the general working of the mechanism. In one word, you have to supply a model that specifies how certain operations performed by certain physical mechanisms produce the functions or properties you want to obtain.

You can easily see from the example of the car engine that Libet's proposal of the sole "simultaneous observation" of the two different kinds of phenomena (whether they are a car engine and its external observable properties, or the individual's brain processes and the subjective inner experience he reports) cannot fill the gap existing between them. To fill the gap you need an intermediate level that shows how the operations performed at one level produce the effects observable at the other level. As far as the relationship between brain and mind is concerned, this implies developing a theoretical, *operational* model of mind that specifies: what its main functions are (for instance, consciousness, thought, memory, perception, imagination, etc.); what mechanisms

- given certain constraints, that is, what is for instance physically, psychologically and neurophysiological known - can produce such functions and how they produce them; and how these mechanisms are physically realized. As Silvio Ceccato (Ceccato, 1962, 1974, 1980) argued many years ago, only such a kind of model would be able to provide a suitable and viable criterion capable of directing the physical investigation. In fact, by analyzing and representing our (conscious and unconscious) mental life as a function or set of functions performed by the working of some physical organs (the brain as a whole, or its parts), it is possible to assign every single mental property or function to some physical organ. In this way, the road is open to the systematic and detailed research of the physical bases of mental life: by subsequent and finer and finer manipulations of the physical substratum, one can empirically determine and isolate the organ that is responsible for the production of a specific mental property.

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