VIRTUAL TIME
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Can subjective time be programmed?

The present essay pursues two goals. First, it construes a thought experiment ("Gedankenexperiment") as to what a technical simulation of time experience has to achieve minimally. Second, it tries to give a notion of what kind of reality the experience of time represents. It is still an open question whether the experienced "flow" of time corresponds to anything independent from subjective experience or not. Phenomena we call mental are of a kind of reality that is confined to being subjectively experienced. The technical simulation of time experience might well enlighten the relation between material and mental reality, beyond the relationship of subjective and objective time.

I

The sphere of subjective experience differs fundamentally from physical spacetime. It is centered in the "here" and "now". "Now" separates past and future. Only what can be experienced here and now is real in subjective perception. Therein it radically differs from physical spacetime. In the latter, all temporal states are equally real. Time as the fourth dimension neither comprises any "now" nor any distinction between past and future. Sure, in physical spacetime there is the observer's point of view, but there is no center. It is unique and universal. On the other hand, being centered in the "here" results in a multiplication of the subjectively experienced world as many times as there are cognitive organisms. Being centered in the "now" means that everything not present exists only in imagination. It is this basic difference that makes it interesting that with computers physical structures came along allowing to simulate subjective experience to a yet undetermined degree of approximation. Information processing machines are physical structures as any parts of inorganic nature are. This structure is theoretically fairly well understood; it can be technically manipulated to the limits of physical feasability. Here lies one of the basic differences from organic nervous systems which we are still far from understanding. A striking expression of our ignorance is the mystery of their double aspect being observable from the outside and constituting a sphere of experience being accessible only from inside.

Spheres of experience are totalities of states of awareness, polarized in themselves between source and goal of attentive awareness. Their center is the origin, their extension depends on the goals of attentive awareness. The activity extending the sphere of experience is both focussing and selective attention. It is — as visual perception — selecting features in the two-dimensional visual field and leaping into the spatial depth. As acoustic perception, it is extracting continuous cues from white noise and again spatially localizing the source. What seeing and hearing have in common with other forms of perception is that they store the sequence of perceptive states beyond the actual moment. Attention goes beyond the Here in space as it goes beyond the Now in time. In this leap into the dimension of world, attentive activity sets out the spatio-temporal sphere of experience.

The origin of attentive awareness has a spatio-temporally continuous trace which is interrupted only by phases of dreamless sleep and states of unconsciousness. The other side of attentive awareness does not display such continuity. Our attention is free to leap in space and time. Only part of what we experience stems from immediate perception. Only those states of the world are accessible for perception that are directly causally connected with the perceiving organism. Temporally, only (relativistically) simultaneous states are perceivable. States not simultaneous with the act of perceiving exist only in imagination, i. e. are virtual. This applies to all contents dreamt of, phantasized, or solely imagined. It applies further to all anticipated

and remembered perceptions. Because the part of the world synchronous with the act of perceiving is very small compared to our view of the world at whole, the major part of the sphere of subjective experience is virtual.

Physics abhor the idea that everything non-present should be virtual. For physics, time is only a parameter[1]. Physics could conceive of the "Now" only as of a punctual event or as a point in the temporal axis. If the present were itself lasting, there would be distinguishable earlier and later parts within itself. One and the same moment would then include moments just-still-future and just-now-passed. Such a simultaneity of temporally different parts is strictly impossible in time as a one dimensional continuum. A punctual present, however, would have no duration and hence no measurable extension. The reduction of reality to a punctual present would yield as real only a temporally extensionless cross-section of the universe. From a physical point of view, something without temporal extension cannot be called real at all. Thus, physics are only consequent in treating the very division of time into past, present, and future as unreal. Since without the change of future into present moments and then into the past there is no "flow" or "passage" of time, physics is to negate the flow of time as such[2].

Even in subjective experience the virtual character of the non-present requires qualification. "Remembered" and "expected" is not synonymous with "just imagined". Recollection and expectation differ from mere imagination in that they are connected with a compelling and subjectively not disposable impression of factualness. Our past is no dream, our future death no fancy. Finally, the present as reduced to a mere point in time cannot be experienced any more. In order to be perceiveable, the present itself must be lasting, must have its own duration. It must include parts that are just passed and right now to come, i.e. no more or not yet present as compared to the instantaneous now. But these parts are not simply virtual in the sense of not existing. Rather, the just-still-future and the right-now-passed are co-present in the presence of awareness.

The duration of the experienced present has been measured experimentally. With normal test persons, it lasts up to three seconds[3]. Events of this duration are experienced as one whole. But this one whole is not a simple one. It is an integration over a sequence of perceivable atomic parts. The smallest unit of time perception is about 30 milliseconds. Below 30 msec, no difference between nor sequence of stimuli is perceived. But only one of these atomic parts is exactly now. This part is the one the test person concentrates on in the click experiments in which the dissolution capacities of time perception are measured. If the other parts co-present with it are still future or already past, then their virtual character is different from that of the expectations and recollections that happen in attentive presence, too.

This gradual distinction between "sensually present" and "only virtually represented" does not concern the composition of the contents presented. It concerns the relationship between the temporal position of the origin of attention and the temporal position of the event appearing on the screen of awareness. Events imminently expected or just passed are of a comparably compelling presence, as is the event immediately perceived. The degree of presence diminishes with increasing distance in both temporal directions. In any case, the gradual distinction between "sensually present" and "virtually represented" has to do with the temporal perspective in which the event in question presently appears.

The shift of the present moment and the spontaneous change of the perspective in which the flow of events presents itself are evident in themselves. It is the impression that time goes by. It is, however, just this impression that relativity theory ignores as purely subjective. In the fourth dimension, time does not pass. What appears to us subjectively as a sequence of transient states, is there accounted for as a "block" of "time slices", i.e. sections of reality taken in the fourth dimension[4]. In relativity, the presence of only transient states as well as the

manner and speed of passage are mind dependent and therefore more or less illusionary phenomena[5].

Now, it would be self-defeating to deny the reality of attentive presence, its duration, and the spontaneous change of the perspective in which the world presents itself to consciousness. It is simply beyond the powers of theoretical reason to deny these facts[6]. The strongest possible contention is that the present and the flow of time are factual only within the realm of subjective experience.

If it were possible to program subjective awareness, the technical solution would include the theoretical dissolution of the contradiction between physical spacetime and subjectively experienced time. It would be pointless to rely on the physical negation of tensed time in this project. It would be perverse to attribute consciousness to a machine that does not even control the tenses of speech, that cannot distinguish between future and past, and that does not command our devices of translating — from an itself transient position — the flood of images into a stable view of the world.

II

The optimism, that we might succeed in technically reconstructing the human mind, is based less on actual results than on two principal considerations. One being that phenomena described as mental must also be produced by the neural machinery of the organism; the other, that the description of computers must go beyond the physical aspect as well, if they are to be understood as systems capable of following rules, manipulating symbols, representing knowledge.

Biological computers are still by far superior to the artificial brand. Their functional principles, though, show no difference that would preclude the technical reproduction of the functional richness of organic computers some day. Like artificial computers, organic nervous systems are systems capable of following rules, of manipulating symbols, of representing knowledge. The "computational theory of mind" is based on these similarities. The difference between the material substrate — be it neuronal or mechanical — and mental activity is seen as one of the level of description. Rules, symbols, and representations are nonexistent in the physical description of reality. Physically, 2+3 equals neither 5, nor 3+2, but nothing. To get results, the physical structure of the signs has to be interpreted as an individual token of a symbolically general type. Mathematical, logical, or quite general — syntactical rules are applicable only to symbols and representations. Compared to physical structures, symbols are abstractions (with any number of physical realizations). Accordingly, semantic meaning is abstractive in relation to the single sign (again with manifold symbolic realizations).

It is controversial, whether these descriptive generalizations can account for the difference between the physical and the mental order, or whether they cover only one aspect of possible discrimination[7]. One of the most common criticisms is that they miss the decisive difference between semantical-referential and purely syntactical use of language: Machines do manipulate symbols in accordance with formal rules; organisms endowed with speech, when using symbols, refer to a meaningful environment[8]. If this environment is understood as a sphere of experience in the sense of exclusive subjective access, the objection holds. But if it is seen as the publicly accessible physical environment, the objection misses the point. As a symbol manipulating device, a computer can be related to the environment through sensors, it can transduce sensory input into symbolically accessible objects, it can manipulate objects according to syntactical rules and thereby produce motor output that allows the computer to respond to the environment e.g. as a robot. It would be arbitrary here to deny a connection of the symbol with the outside world[9]. Furthermore, in principle, it is irrelevant whether the machine takes up linguistic input via keyboard or via phonetic detector, and whether it

answers via screen output, or printer, or speech synthesizer. Taken together, these possibilities allow to program — in principle — a referential use of language. Combining this use of language with the use of an accordingly coded model of the environment, and enhancing this combination by further implementing objective functions, the machine becomes capable of goal-oriented — and in this sense rational — behavior.

If one is ready to reduce subjectivity to the capacity of identificative perception, of referential use of language, maintaining environmental models, and goal-oriented rational behavior, then a machine version of subjectivity does not seem entirely impossible. The difference between "physical" and "mental" then is reduced to the independence of the symbolic forms of special media of physical realization. The causal nexus between sensory input and motor output, then, would be only a primitive kind of intentionality; the environmental model a computer builds up and maintains as knowledge base would be but a still preliminary kind of sphere of experience. What seems to us introspectively as spontaneous leap of attention out into the dimensions of the perceptible world would then be nothing but an extremely fast (and therefore concealed) transformation of sensory input into patterns of behavioral control. In principle, it would then be possible to translate the intentional semantics of our oriented perception and imagination into an extensional semantics of calling and parameterizing control routines. The sphere of experience as such would then be a disguised representation of behavioral possibilities, its spatial and temporal extension only a coding of complex relations of distance. The picture changes, though, when the specific temporality of the subjective sphere is introduced. When time, as expressed in the tenses of the verbs and temporal adverbs, is a mind dependent phenomenon, then the production of this phenomenon is a subjective achievement, too. This achievement goes beyond the kind of environmental relationship mentioned above. Rather, the dualism of temporal notions might then indicate a dualism of ontological realms that cannot be reduced so easily to different levels of generalization. Once this is recognized, it is hard to understand why the ongoing discussion of the ontological status of the mental omits this temporal dualism. Contrary to the ontological dualism of mind and matter, the dualism of subjective and objective time is strongly supported from the scientific side. Like the ontological, the temporal dualism ranks among the eternal problems of philosophy[10]. But unlike the ontological, the temporal dualism has now a modem version: it was post-classical physics that has defined time in so narrow and strict a way, that the connection to subjective experience has broken definitely.

III

To be sure, post-classical physics is no monolithic block. Until present, no unification of macroscopic theory of relativity and microscopic quantum theory succeeded. One — if not the major — reason of incompatibility lies in the notion of what is a "fact". The theory of relativity accepts the macroscopic facts as given. For quantum theory, factualty becomes problematical. According to the quantum theory, facts are "produced" through irreversible macroscopic processes — like measuring procedures — out of what otherwise are just possibility fields. This transition draws a line between phenomena already determined and others, still undetermined. This distinction might be another expression for the subjectively experienced difference between past and future. It is just this difference that relativity denies. Relativity neither recognizes time-dependent difference in determination nor temporally changing borderlines between temporal regions. For quantum theory, determination itself is a physical process. It takes place e.g. in experiments in which indetermined quantum fluctuations are "forced" to change into measured i.e. macroscopic facts. Living organisms, too, are capable of transforming singular quantum events into macroscopic facts. Single photons, for instance, may be critical for (of course macroscopic) visual perceptions. There is evidence, moreover, that quantum effects play a role in the synaptic circuits of the nervous system[11]. Though there are immanent physical reasons for accepting elements of tense in the notion of time, physical orthodoxy stays abstinent[12]. The reason for this is neither ignorance

nor stubbornness, it lies in the inconsistency of the notion of tense itself. The division of time into future, present, and past implies the qualification of everything non-present as not yet or no more existing, i.e. as not really existing. The modalities of "not *yet*" and "no *more*" do not cancel the negation of existence. They only allow for the possibility of the future preexisting in a special mode, and the past post-existing in another special mode.These special modes are expressing that the future is not distant in every respect, and that the past is not bygone in every respect, but that both are already viz. still present in a re-present-ing sense.

The reduction of reality to what is strictly present would make reality disappear into that extensionless cross-section through world's states. The presence of not-yet — and no-more-being-actual, on the other hand, is incompatible with the chronometrical definition of time and its representation in the continuum of real numbers. But that is not all. The tensed forms of speech suffer from internal inconsistence. It the temporal position of the present moment changes with time, the temporal properties not only of the moments immediately neighboring are changing. All moments that lie in the future become less future, all past moments become more past[13]. Every discernible "Now" has its own corresponding order of time, enclosing the whole future and all of the past ordered accordingly. This pro- or retrospective change is problematic enough as such. The instability of temporal properties, however, also includes that the truth-value of tensed propositions changes spontaneously and without any change in the sequential order of time positions. One and the same temporal position, as identified by chronometrical date, first acquires the predicate of "being future", then of "being present", and from then on of "being past". This change is none in the order of events. Events with positions before others will always be earlier, events with positions behind will always be later. On the other hand, the identical time position may be future as well as present as well as past[14]. This incompatibility has led to the deduction of the unreality of temporal "Becoming" itself. According to the principle that contradictory notions cannot denote anything real, the scientistic critique of language has banned the use of tenses into everyday's mythology[15]. This ban has not been relieved up to this day by any counter-proof of compatibility.

IV

It is one of the omissions in departmentalized intellectual history that the analytic criticism of the use of the grammatical tenses and the phenomenology of temporal awareness never dealt with each other[16]. The phenomenological description remained historical and qualitative[17], the criticism of language formal and logical. As the paradox of tense resists both physical and language-critical dissolution, it would be up to a detailed phenomenological description to bring the temporal dualism into fruitful contact with the ontological dualism. Granted that inconsistent concepts cannot denote real things, but the change of the present, the duration of presence, and the difference between future and past are subjectively inescapable (and intersubjectively transferable) facts, nevertheless. That they appear only in subjective experience, is no argument against their realness. Mental realities are always and only of this kind of factualness. The mind-body-problem is about the ontological status of this matter-of-factness.

We cannot deliver a phenomenological description of temporal paradoxes here. Such a description cannot be replaced either by investigating means of reproducing time perception technically. This essay can only attempt to localize the source of the paradox. In order to see more clearly where this source is *not* to be found, let us inquire first the possibility of programming the linguistically correct use of tenses in speech, and secondly that of technically reproducing the duration of attentive presence. To put it in other words: Does the manipulation of encoded dates suffice to implement the use of tensed verbs and temporal adverbs? Are mechanisms projectable that present the moments immediately impending and those just passed in a sense comparable to the experienced duration?

The answer to the first question is astonishingly simple. For a semantically and pragmatically correct use of tenses, the computer has but to record its own history and to have something like a temporal compass. It needs a clock pulse control (something corresponding to the biologial clocks of organisms) and an adequate dating system for its own system history (including the chronology of information received from outside). To distinguish between past and present, the computer compares the system date with the date of the event in question. Furthermore, the machine may account for the fact that past matters are never input from sensory but always from memory sources. Let us call the system date t_s, the date of the event in question the "object date" or t_{ob}. The semantically and pragmatically correct use of tempera maybe programmed in a way that the temporal properties of being future, present, or past are expressed through a function having t_s and t_{ob} as arguments. t_s is noted by the machine's clock (like by the biological clock of nervous systems). Its continuous update is accounting for the fact that the temporal position from which assertive statements are possible, never stands still. t_{ob} keeps record of the events in the temporally stable relation of "before" and "after".

If one does not account for that the predicates "is future", "is present", "is past" do not relate to the events as such, but to the relation between the object and the act of predication, the temporal properties seem to go astray semantically and to provoke logical confusion. It looks, then, as if we would attribute the incompatible properties of being future, present, and past to one and the same event. If the temporal properties are defined as functions of two dates (t_s, t_{ob}), then the grammar of tense resolves itself into logic and the continuous update of one of the dates (t_s) by the clock. The argument that an identical event may be future as well as present and past, then, does not mean that it has temporally instable properties, but that it has double time index, one of which is stable and one is synchronized with the biological or conventional clock time.

From this definition of the properties "future", "present" and "past" it follows that the non-present is virtual. Sensorial input and hence immediate contact with the empirical outside world can only take place when system date and object date coincide. The states of the world not synchronous with the system date are accessible only via re-presentation. The reference is virtual in case that $t_s <> t_{ob}$. The different degree of reality of present, past, future and just imagined, becomes a function of the provenance of the information out of which the representation is made. The subjectively indisposable factuality of the past must then be produced explicitly by prohibiting post-hoc change of past sensory input and recorded system history. This production applies to machine and organic realization as well. That the degree of reality decreases with the increasing distance between object date and system date is then to be attributed to the fact that no method of data storage whatsoever is free of errors and that the integrity of data will suffer automatically with temporal increasing distance.

The simple difference between system date and object date, now, is not the only way of temporal virtualization by a two-digit dating system. By two-digit dating, also the embedding of processes, as is characteristic of episodic remembrance and projection, may be handled. Episodes that cannot be imagined at one instant have to be remembered or projected in an imaginative process of its own. Thus, the capacity of episodic recollection and projection goes beyond virtualization of temporal distance. It includes the embedding and virtualization of processuality as such. It is the capacity to embed the remembered or projected process into the process of remembering viz. projecting. This embedding of processes with different dates comes in fact up to temporal parallelism. Parallelism is an irreduceably two-(or higher-)dimensional phenomenon. Its realization automatically sets out a second dimension. For handling this second dimension a two-digit dating system is required.

Processes developing in more than one dimension become cronologically ambiguous. If the sequence of acts as ordered by system date are representing processes playing in object time, then sorting the whole process by system date leads to a different chronology than sorting by

object date. Since the object date is no less constitutive for the remembered past and expected future than is the system date for the activity of recollection and expectation, the chronology of constitution has emancipated from the chronology of outer events. As a sign of emancipation, it has given up its unequivocal sortability according to "earlier" and "later".

It is this degree of freedom that is at the basis of our capacity of translating the flood of images into a stable image of the world. And it is the function of judgement to establish this order. If we consider the inescapable auto-temporality of perception, imagination, recollection and even thinking, then we see that this ordering function is based on the capability of embedding processes into the auto-temporal process of awareness, and that the constitution of our image of the world is embedded into a higher dimensional process of constitution.

V

The embedding of processes into the auto-temporal process of imaging is difficult to visualize mentally. It can be easily understood, though, that the dating system allowing for such interlocking may be programmed. The "trick" in programming simply consists of defining the necessary dimensionality. In one and the same dimension it is impossible to represent processes anticipating or reproducing processes taking place at other dates. As physical time is strictly limited to one dimension and its mapability into the continuum of real numbers, physics is ignorant of such processes. But it would be wrong to infer that the processing of temporally higher-dimensional matters was not programmable. Programs instantiating a suitable dating system are, on the contrary, excellent examples of the equivalence classes the computational theory of mind hinges on.

From a physical point-view, the question whether temporally different events are as such simultanoeusly present in a machine reproducing the process of, say, an episodic recollection must — of course — be answered with "no". Nothing in the present state of a machine is past. In one and the same temporal state, everything and anything in it carries the same date. Even the machine's date of production, stamped into the hardware, is only a pattern in the present hardware structure.

Like the date on the hardware, the dates incoded in the software are — physically — mere patterns. In order to make numbers or even representations of dates out of these patterns, they must be *interpreted* accordingly. The patterns must be understood as symbols and be subjected to rules. Symbols and rules, however, are not physical objects. Physically, it is not even defined what is an artefact and hence a machine.

Symbols, e.g. numbers, are standing for something else than the writing or the bit pattern. Artefacts are different from natural objects in being produced purposefully, i.e. according to plans and intentions. Numbers are ideal objects, rules are normative instructions, plans are anticipations of future states. Obviously, things that find themselves on the other side of the gap between matter and mind.

But the gap at this point is comparatively shallow. In the case of the machine program, the levels of interpretation are ordered in a relatively continuous form. On the first level above the physical-state description, it is incorporating a formal system. A formal system is a system of meaningless symbols manipulated in accordance with formal syntactical rules. Although symbols are not physical objects, meaningless symbols differ from physical structures only in a step of descriptive generalization. The symbolical level abstracts from the pecularities of physical realization. There are countless possibilities of physical realization of the symbol "27/06/1990 13.07". But it is irrelevant for its formally correct manipulation, whether it is realized by handwriting, bitmap, print type or whatsoever.

On a second level, the machine program is instantiating a mathematical model. In the mathematical model, symbols become numbers, variables and operators. They have logical meaning, are attributed with truth-values. Only by means of interpretation, without any changes on the physical or symbolic level, operations like logical inference and semantic properties like "truth" or "falseness" enter the field. But even this level of interpretation is not sufficient to turn a program manipulating arrays of dates into an imitation of an ongoing recollection. From a mathematical pointof-view, it is irrelevant whether vectors are understood as temporal or spatial coordinates, or simply as complex numbers.

If and only if certain vectors are explicitly defined as representing positions in time, the mathematical model may become a description of a dating system. Only then it makes sense to talk about embedded processes. But once (t_{ob}, t_s) is defined as a dating vector, the sequence of their values in the protocol of the machine's run represents two parallel chronologies. The reference of t_{ob} is in object time, i.e. localizing the event represented; the reference of t_s is in performance time, i.e. dating representation as an event of its own. t_{ob} and t_s together define the event of representation. This event happens in object and performance time simultaneously.

But isn't indexing one and the same representational event by two distinct chronologies simply forbidden by rules of logic? — It is forbidden, as long as we do not draw the consequence from the irreducible duality of the places of its dating. Two-dimensional dating vectors define a second dimension of time. Anything extended — be it spatially or temporally — has as many dimensions as coordinates must have places to describe it. When single-digit coordinates do not suffice for description, this implies that the matter described extends along more than one axis. As two-digit spatial coordinates indicate that the figure in question is lying in a plane and not just in a line, two-digit temporal coordinates indicate that an event takes another temporal axis over and above the chronometrical one.

VI

The technical reconstruction of detailed, episodic recollection shows the impossibility of representing the mental act of representation in one single temporal dimension. It is not sufficient for remembrance (and expectation) to only imagine the event in question. The event also need s to be localized in time. The act of recollection must include a — although imaginary — distance between the act happening now and the event appearing in it. This imaginary distance cannot lie in the chronometrical axis, because in that case Now and Then would have to be simultaneous or rather, Now would have to extend all the way back to Then. The imaginary nature of that distance does not help here. The chronometrical axis is occupied by the process of remembering. In it, there is no room for the remembered event to happen, not even in imagination. Even as imagined, the event would have to appear simultaneously with the imagining act. Were it confined to the chronometrical axis, the act could not be a rememberance but only mere fantasy. Thus, the act of recollection implicitly sets outa dimension over and above the chronometrical.

In analyzing episodic recollection it becomes clear that imagination is itself a process requiring time. This process is dated by the values of the system date variable t_s. Its sequence of states is that of the presently focussing activity. What appears in the focus, however, does not happen in the present, but in the remembered object time t_{ob}. Nevertheless, the remembered event must also take place in the present system time, for otherwise nothing could appear presently. We are facing the arising of a contradiction here, if no allowance is made for multiple axes of ongoing events[18]. The contradiction is avoidable only by introducing another dimension allowing both processes, the process of remembering and the process remembered, to coexist in time. The autotemporal process of recollection and the

hetero-temporal process remembered mustbe allowed to run parallel, separated by, again, temporal distance.

Parallelism is an irreducibly multidimensional affair. Admittedly, it is difficult to visualize temporal parallelism. But it is easy to see that the recollection of a past event is a process taking present time. In self-aware remembrance of temporally extended episodes, the second dimension will be set out implicitly and automatically. The process of imagination runs in chronometrical realtime, while the process imagined runs in imaginary object time. On the other hand, this imaginary second dimension is all that is needed to get rid of the contradictions of temporality. Just as in a two-dimensional space two points may be distant from each other while coinciding when mapped into one dimension, so in two-dimensional time temporal positions may be separated by a difference that either disappears in one-dimensional time or leads to a contradiction. Simultaneity of temporally different events is completely harmless logically, if a dimension exists in which different events may be both separated and united by a projective mapping.

Another expression of the temporal contradiction is the duration of the present. In it, the subjective impression of the shifting present comes forth. The duration of attentive presence — as mentioned above — is up to three seconds. This duration, however, is not experienced as a sequence of phases, but as one whole.

Units, like spoken sentences or verses in poems, are perceived as undivided entities within the frame of those three seconds. This whole frame is shifting — in unnoticed discreteness — in the 30 msec pace. Thus, concealed from consciousness, time perception is integrating a multitude of unnoticeably discrete time "quanta" into a time-"window" of noticeable duration. What is puzzling about time perception is that a hundred chronometrically different particles unite into a one single noticeable moment experienced as a whole.

The shift and duration of the present must be described in mutual dependence. The phenomenon, that makes the interrelation obvious, is actual perception. In order to investigate the capacities of a multiple dating system in our thought experiment, imagine a high speed computer connected to optical sensors and appropriate output devices as standard in machine vision. Suppose the most advanced techniques of pattern recognition and object modelling be implemented. As a parforce-imitation of human vision, let the computer take a snapshot of sensory input every 30 msec. To simplify matters further, let the machine store the latest hundred snapshots in RAM. Three seconds are thus recorded in a phase spacing kind in memory. Of these 100 records, each one represents one determined state of the exterior world. The records as such, though, are "blind", i.e. are simply data bases for identification. In order to make the machine "see", the data must be processed by pattern recognition. Then the identified patterns have to be modelled as named objects.

The storage of each set of the latest hundred snapshots of sensory input in RAM maps the phase space of the latest three seconds recorded into a dynamically addressed stack of dated representations. To account for the shift of the time-window and the changing composition of its temporal parts, the stack of records must be dynamically relocated to the pulse rate of the input. This movement does not necessarily have to be achieved by a change in position, but must happen at least virtually in the dating system. Each pulse with a different system date corresponds to a particular composition of the whole stack: Each record in the stack must carry both the date of recording and the date of the system status to which its position in the stack corresponds.

This virtual dynamic data storage enormously increases the analytic powers of pattern recognition and object identification. If the information input is kept in RAM for three seconds it is accessible for analysis and interpretation all that

time. Identification, memory use, and model building may then take time by themselves without losing contact to direct sensory input. The two-digit dating system holds apart and combines in its turn the processes of input and identification of sensory data. The two digit dating further allows for an analytic screening of the recordings as a phasespatial "block". Characteristic changes along the chronometrical axis may be determined through this data storage like spatial contours. Hence, it could well have biological sense, too, that nervous systems make use of this (or a similar) method of data storage.

The duration of the present, however, does not mean that a hundred phase-states are presented simultaneously in a row. The duration, rather, means that a span of time remains open for the identification of the sensorially perceived impressions. The perceptive image as such is temporally unique, and always updated to the last input received. When a movement, a gesture, a musical motif, when spoken phrases and verses from poems are perceived as an entirety, this entirety is no simultaneous sequence of states. It only does not get finalized before the end of the sequence. It is not before the very end that it becomes clear what it was all about: whether the movement was a step or only a wiggle, whether the gesture was inviting or teasing, whether the motif was the one with the rising end or the falling one, and soon. Only at the end of the verse, the whole line is defined from the beginning. With every additional word — and even each phonem — the meaning of the sentence changes and with it the meaning of what had already been said. Until finished, the meaning and even identity — of the previous phases must be kept open and revisable19. It is the duration of the present which creates this openness for whatever is happening within its frame.

The ex-post insertion of identified parts into the image of perception at the level of the last input is an astonishing performance. It is neither introspectively nor extrospectively easily accessible. This may be the reason why it has been doubted for long time that it might be objectified and chronometrically explored. But indeed, neurological research succeeded in providing evidence for such an ex-post insertion of an identified event into a perceived image on the update-level of actual input. It is the so-called phenomenon of "antedating" and manifests in such a way, that a sensation (of pain) when reaching the level of consciousness is experienced as having been there for as long as the process of its identification had taken.

B. Libet was able to show in a series of ingenuous experiments[20] that up to half a second passes between the application of a first stimulus on the skin and the beginning of sensation of pain. Of this half second, the transmission to the brain takes only 0.015 seconds. The whole rest of the time is needed for identifying the sensory input as what had been perceived. It is the span of this interval by which conscious sensation is antedated *upon* completion of the identification process. Thus, the sensation actually appears after this half second; but simultaneously with its emergence the impression — and a compelling impression it is — arises, that the sensation is already lasting for the half second in question.

This post-hoc synchronization of the perception with the stimulus is an illusion in a certain sense; the most immediate sense data are already masked with respect to time. But the experience *as an experience of an object*, i.e. as perception, is not an illusion at all. The event of the perception is just synchronized exactly with the event perceived. The sensation as perception would only be illusory if it presented the event with a time-lag. If the event of perceiving pushes the perceived event along in a way that it produces the appropriate sensation only by way of cheating, the results of perception do not only include a perfect deception, but also a kind of retrograde causality.

This phenomenon of antedating is important for the thought experiment of simulated time perception for two reasons: For one, the phenomenon cannot be merely epiphenomenal in the sense that its production were meaningless for observable behavior. Secondly, none less than

the neurologist John C. Eccles sees in it a genuine mental performance that cannot be explained on a neurologic-mechanical basis[21].

As confusing and going against the rules of chronometrical real-time the phenomenon of antedating might appear, it represents an overall feature of our perception. For us, as bodies capable of independent motion and subject to injuries by fast moving objects, it would be fatal if our perception of what happens around us were always delayed. In order to cope with quickly changing situations, above all the visual and auditive image of perception must be up to date with the actual event. But the identification of what is seen and what is heard does take time. The time-lag has been explored the best in haptic perceptions only because these are most suitable for experiments in this field. But we cannot assume that the visual or auditive intepretation of unexpected stimuli is systematically faster than the identification of unexpected stimuli on the skin. In continuous seeing and hearing, the delay must be masked too. If the image of perception has to be up to date with what's going on outside, identification may be partly lagging, but the parts identified later must insert themselves flawlessly into the pre-projected image. This lag and insertion seems to be particularly well concealed in visual perception. In continuous seeing, the pre-projection may use the intermediate — more or less processed — input for updates. Secondly, an event can be identified very quickly if it had been clearly expected.

Eccles considers this antedating as a striking example for the interaction between the self-conscious mind and the nervous substrate. The question, how far it may be programmed, thus, should yield further insights into the status of presence and raise the issue whether the nature of subjective experience demands a stricter separation between mind and matter than the computational theory of mind is willing to accept. Let us continue the thought experiment of machine vision. The machine will pick up a record of the sensory input from the video camera every 30 msec. For current identification, a stack of 100 recordings shall be kept in RAM in their original sequence. Each of these 100 recordings represents a determined state of the outside world.

If the identification as such takes time, the event to be perceived is synchronous to the event of perceiving only up to the first moment of contact. From then on, the chronology of perception differs from the chronology of the perceived. Between the first sensorial contact and the identification of what it is that was perceived, the whole duration of attentive presence (i.e. normally up to these three seconds) may pass. What cannot be identified within this period will remain unnoticed.

It is this detachment of chronologies that the two-digit dating makes manageable. Furthermore, it includes the "trick" of antedating. The differentation of t_{ob} and t_s means also a record of the distance opening up between the event to be identified and the event of identification. This distance plays a double role in identification. The identified event is reset by its span, while the image appearing is projected forward by the same span. The resetting gives the event its position within the exterior chronology, the forward projection inserts it into the image on the frontline of events. The identification may take different lengths of time for various parts of the image, depending on the degree of difficulty involved. The unified image projected to the frontline of events is achieved by assembling it synthetically from different distances.

This synthesizing from parts, the identification of which may take the whole duration of the time-window, is not completely trivial. Nevertheless, even this cognitive performance is programmable with the help of the two-digit dating system. It is programmable as an extrapolating extension of identified courses of events by the distance t_s — t_{ob}, the latter being available at any moment and in any information segment. To achieve better insertion of the extrapolated parts into the synthesized image one might also program the — at least

superficial — checking of intermediary, i.e. more or less rough, input. The applicability of this method will depend on the degree of deviation between projection and input. Smaller deviations or deviations within the limits of what can be prognosticated will be correctable, surprising changes will have to go through the identification sequence from the beginning.

Programs that achieve this synthesis to the extent that they control human-like behavior in robots even in quickly changing situations, are still a thing of the future. And it is quite improbable that they will work exactly according to the model presented here. The development of equivalent programs, though, is foreseeable and it may be predicted that their method of projecting and inserting will consist — among other things — in the modelling of knowledge bases of real type motion sequences. The modelling of such knowledge bases could be similar to children's learning. One may imagine the building up of such a base with the help of two monitors; one showing the input as the video camera records it, the other showing the image as it appears after the extrapolation of the identified course of events. The measure of perfection of this program lies in the degree of similarity achieved between the synthetic and the coarse, raw image. Independently of its degree of perfection, the synthetic image, then, will be no more blind like the raw material, but "seeing" in the sense that it allows the robot to act spatially and in accordance to changes in its environment.

In the fact that this second image is in principle possible lies an answer to the question, whether — and to which extent — the duration of presence may be reconstructed technically: It may be reconstructed to the extent to which extrospection reaches. It may be copied up to the point just before antedating changes into the compelling feeling to have perceived the matter — such as it has just been identified — already before the identification. But even here, all aspects relevant to behavior may be simulated. The behavior of a machine orienting itself in its own environment in such a way, does not need to be distinguishable externally from that of a being to whom we attribute inner experience and mental representation.

VII

Does this show that subjective experience of time is programmable? What is shown is what the problem of programming is *not*. It has become clear that from temporal paradoxes no convincing argument for the existence of a physically irreducible realm of the mental follows. Finally, it became obvious that even materially realizable production processes of the duration of presents are imaginable. What we do *not* think, however, is that the possibility of programming the algebra of higher temporal dimension confirms the claim that mind and matter are differing only in generalizing levels of description. Instead, we think that the computational theory of mind misunderstands the status of the interpretation that turns a machine program into mathematical model, and the manipulation of this model into a temporally higher dimensional event of representation. Not the machine, but *this interpretation* produces the levels. Why should a process of changing charges — as complex as it may be — in a semiconducting hardware structure be the representation of a higher dimension? Only beings, within whom this dimension is already present, may come up with such an idea. A little more self-awareness, though, will prevent the attribution of awareness to a computer. A computer does not take notice of anything in any experiencing mode. It does not feel, regardless of how well it imitates human behavior externally; there is nothing that corresponds in it to the continuum that is interrupted b% dream and unconsciousness in spheres of subjective experience. In short — there is no inner aspect of its empirical behavior. Even when it watches its own function in the sense of self-monitoring, no introspection in the phenomenological sense takes place. There is nothing but manipulation of symbols.

As our own inner view presents the world theatre to our attentive awareness, we are projecting a corresponding stage into beings to whom we attribute awareness of their own. Intuitively we know, that any aware being is a world of its own; and that this world exists as

often as there is an awareness. But as these worlds are monads inaccessible from the outside, we can transform foreign beings into subjects only by projecting a stage of their own awareness behind the facade of empirically perceivable behavior.

We have been lured in to projecting such a stage by the external simulation of human behavior if we attribute (its own) intelligence or even worse, consciousness (to a machine). But only because we set up this stage behind the physical description, the changing states of charge in the semi-conduction hardware structure become an imitation of a subjective sphere of experience. Only this massive presumption turns the exchange of numerical values in memory addresses into an imitation of antedating. Without this interpretative ingredient, nothing comparable would appear. As a computer does not hear nor feel, nothing like a compelling impression of "lasting already so and so long" can happen in it. The trick that makes the computer imitate the behavior of beings who experience this compelling impression of feeling and noticing, in fact consists of nothing but the exchange of numerical values. And the algorithm enabling it to imitate the behavior of actually remembering and anticipating beings, is nothing more than the implementation of an algebra necessary for the manipulation of higher-dimensional dynamic variables. As the numerical pattern of three-dimensional spatial coordinates is not three-dimensional itself, so the manipulation of dating vectors is not a temporally two-dimensional process. What is — in effect — temporally two-dimensional, is the auto-temporal process of re-presenting imagination of future and past episodes. Something of this kind we can experience in self-aware observation of our own attentive behavior. A temporal sequence including another temporal sequence in itself, though, has not yet been noticed in a computer.

If attentive presence actually is necessary to experience the passage of time, then time does not pass for a computer. It does not even pass for the machine when it imitates the motion of the time-window. The event of imitation, then, is nothing more than the section of space-time the machine states occupy. In space-time, one temporal state is as real as another. Only by conferring its own temporality to the sequence of states observed, the auto-temporal activity of perception makes the flow of events "flow".

To which extent the separation or rather bifurcation of such auto-temporality is possible, physics is investigating in the field of complex dynamic systems and of self-organization. It is — physically no longer inconceivable to formulate something like the spontaneous transition we attribute subjectively to the present[22]. But today's computers are still far away from systems in which one could assume the existence of mechanisms for breaking the symmetry of time.

In spite of this abyss separating the auto-temporality of awareness from the sequence of machine states, the machinal re-production of its temporal capacities yields important insights into awareness as such. First, it makes clear that the difference between objective and subjective time lies in the higher dimensionality of the latter. Secondly it shows that subjective experience of time effectively uses the capacities of an imaginary time axis with logically describable consequentiality. Finally, the reconstruction shows that the higher dimensional movement does not have to contradict the laws of physics. But it is also made obvious, that the methods available at present are not in any imaginable way sufficient to technically reproduce this higher dimension.

References

[1] For qualification of footnote 12 and section VII below.

[2] cf. Grünbaum 1968a, 1968b.

[3] see Pöppl 1978.

[4] cf. Smart 1963, p. 133

[5] As expressed in Einstein's assertion that the division of time into past, present and future is nothing but an illusion, though a very resisting one. Cf. his letter to son and sister Michele Bessos to 23/3/55 in: Einstein/Besso 1972, p. 537 f. The list of scientists and philosophers following Einstein in this tenseless notion of time is long and illustre, containing among others the names of Russell, Quine, Sellars, Smart, Grünbaum Davidson.

[6] And furthermore, the world as a four-dimensional "Block Universe" may be theoretically conceived of but not actually experienced. If we want to experience the world in move than one single state and more than a small fraction, we must experience it from the position of a changing present. At least this experience, then, will be historical. It passes through various states that are not all equally real. Instead, it experiences either itself or its objects — in an involuntary and spontaneous change of what is real.

[7] For an open and therefore interesting discussion of this topic between philosophers, psychologists and computer scientists cf. Pylyshyn/Demopoulos 1986.

[8] This objection is closely connected with the name of John R. Searle. Cf. Searle 1983, Chapter 10 and Searle 1984.

[9] Cf. Beckermann 1988

[10] Cf. Franck 1989

[11] Cf. Eccles 1985

[12] As some kind of exception, the thermodynamics of imbalance, the theory of complex dynamic systems and of self-organization distinguish between parameter and operator time. But that does not mean acceptance of temporality in the sense expressed by the use of tense in speech. But there are some similarities, though. Cf. Prigogine 1979.

[13] Cf. Zeilicovici 1986, p. 175 ff.

[14] This contradiction is known as McTaggart's Paradoxon. Cf. McTaggart 1908 and 1927, chapter 33. For discussion and further literature, cf. Franck 1989.

[15] This criticism is originally formulated in Russel 1903, section 442. For a contemporary reference, see Mellor 1981.

[16] In Husserl's sense; cf. Husserl 1905.

[17] Even where phenomenology and formal logic met — see Miller 1984 — the description never got to the core of the temporal paradoxa.

[18] This observation has — as far as I know — been described first by Rachel Salamander. Cf. Salamander 1982, p. 313 ff.

[19] Cf. Franck/Franck 1986, p. 70 ff.

[20] Cf. Libet 1973

[21] Cf. Popper/Eccles 1977, p. 315 passim

[22] Cf. Prigogine 1979, especially the chapter X added in the extended edition 1984.

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