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CHAPTER NINE

The Specious Present: A Neurophenomenology of Time Consciousness

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1. SETTING THE STAGE

My purpose in this essay is to propose an explicitly naturalized account of the experience of present nowness based on two complementary approaches: phenomenological analysis and cognitive neuroscience. What I mean by naturalization, and the role cognitive neuroscience plays, will become clear as this essay unfolds.[1]

It would be foolish to claim that one can tackle this topic and expect to be satisfied. The experience of temporality addresses head-on the fundamental fact that we exist within a transparent web of time. The elucidation of the experience of temporality occupies a central place in the history of thought altogether, and most certainly in the phenomenological tradition. Many have referred to St. Augustine's *Confessions* (specifically book 11) on the paradoxes of a past-containing nowness (*distentio animi*), or more recently to the pragmatic psychology of William James as found in the famous *Principles of Psychology*, where the apt expression "specious present," which gives this article its title, first appeared in print.[2]

Edmund Husserl considered temporality a foundational axis of his phenomenological research: all other forms of mental activity depend on temporality, but it depends on none of them. He worked on these questions until his death (see Appendix A). Unlike his illustrious predecessors, who never pursued their descriptions far enough, Husserl *did* manage to make real progress in the formulation of the basic structures of intimate time.

I will start by drawing from the phenomenological account developed by Husserl, fully aware that I am stepping right into a complex debate within phenomenological research. My decision to start with his texts on time has nothing to do with proving or disproving a point about Husserl's thought. I prefer to take my cues from Husserl's *style* as an eternal beginner, always willing to start anew; this is the hallmark of phenomenology itself (but it has not always been the case in practice). What interests me most are the unrealized implications of his writings: only in their turns and jumps do we get a glimpse of how his descriptions contains a dynamical bent, which is key, I will argue, for a naturalization project. This dynamical bent will provide the bridge from pure phenomenological inquiry to recent results in neural dynamics, to include the discovery of large-scale neural assemblies.

I take quite literally the importance of seeing experience as a *firsthand* description. As Bernard Besnier has recently remarked, we should not "neglect this essential guiding principle of phenomenology, namely, that it advances by description . . . of an experience that one must therefore *re-do*."[3] It is on the basis of such active involvement in the phenomenology of time that I introduce some plausible *additions* and interpretations to the current discussion.

In brief, I approach temporality by following a general research direction I have called *neurophenomenology*, in which lived experience and its natural biological basis are linked by mutual constraints provided by their respective descriptions (Varela 1996). This also means that I will not hesitate when necessary to mix both modes of discourse as if they were partner in a dance, as if they were one, for that is what a naturalized account of phenomena means, and only in action can we see it happening. Given the importance of the topic of the experience of temporality, let it be clear that I consider this an acid test of the entire neurophenomenological enterprise.

2. LIVED TIME IS NOT PHYSICAL-COMPUTATIONAL

Like any other true phenomenological study, the exploration of time entails the gesture of reduction and the identification of descriptive invariants. Phenomenological reduction is a topic that I cannot expand upon here, for justifying reduction philosophically does not serve my purpose. The actual practice of phenomenological reduction does.[4] For the reader unfamiliar with this terminology let us at least say that reduction starts by a disciplined suspension of one's habitual attitudes, a bracketing of what we seem to know. This bracketing provides the opportunity for a fresh look at phenomena, in this case temporality as it appears directly to our flesh-and-bone selves.

As soon as we enter a study with this kind of authentic philosophical attitude, it becomes apparent that the familiar account of time inherited from our modern Western cultural background is inadequate. In fact, we have inherited from classical physics a notion of time as an arrow, as a constant stream based on sequences of finite or infinitesimal elements, which are even reversible for a large part of physics. This view of time is entirely homologous to that developed by the modern theory of computation. As a refined expression of general computation, the writing head of a Turing machine inscribes symbols one by one in an infinite string, giving rise to time as a sequence-stream, exactly as in classical mechanics.

As computational views entered into cognitive science in the form of the computationalist (or cognitivist) viewpoint, computational time was unquestioningly used in the cognitive study of time. Some research continues to base experimental studies on an "internal timer" that gives rise to duration at various scales. A (hypothetical) clock emits pulses that translate into behavior; judgments on duration depend on pulse counting and are reflected on memory and decision (Church and Broadbent 1990). This strict adherence to a computational scheme will be, in fact, one of the research frameworks that will be *abandoned* as a result of the neurophenomenological examination proposed here. But I will return to this conclusion later, after presenting my main argument.

Even under a cursory reduction, already provided by the reflections of Augustine and James, time in *experience* is quite different from time as measured by a clock. To start with, time in experience presents itself not only as linear but also as having a complex *texture* (evidence that we are not dealing with a "knife-edge" present),[5] a texture that dominates our existence to an important degree. In a first approximation this texture can be described as follows: There is always a center, the now moment with a focused intentional content (say, this room with my computer in front of me on which the letters I am typing are highlighted). This center is bounded by a horizon or fringe that is already past (I still hold the beginning of the sentence I just wrote), and it projects toward an intended next moment (this writing session is still unfinished). These horizons are mobile: this very moment which was present (and hence was not merely described, but lived as such) slips toward an immediately past present. Then it plunges further out of view: I do not hold it just as immediately, and I need an added depth to keep it at hand. This texture is the raw basis of what I will be discussing in extenso below. In its basic outline, we shall refer to it as the *three-part structure of temporality*. It represents one of the most remarkable results of Husserl's research using the technique of phenomenological reduction.

Another important complementary aspect of temporality as it appears under reduction is that consciousness does not contain time as a constituted psychological category. Instead, temporal consciousness *itself* constitutes an ultimate substrate of consciousness where no further reduction can be accomplished, a "universal medium of access to whatever exists. . . . Constitutive phenomenology can well be characterized as the consistent and radical development of this privilege of consciousness into its last ramifications and consequences" (Gurwitsch 1966: xix). We find a converging conclusion in

James concerning the apparent paradox of human temporal experience: on the one hand, there is the present as a unity, an aggregate, our abode in basic consciousness, and on the other hand, this moment of consciousness is inseparable from a *flow*, a stream (chapter 9 of *Principles*). These two complementary aspects of temporal consciousness are the main axes of my presentation.

This rough preliminary analysis of time consciousness leads us, then, to distinguish three levels of temporality:

1. A first level proper to *temporal objects and events* in the world. This level is close to the ordinary notions of temporality in human experience, which grounds the notion of temporality currently used in physics and computation.
2. A second level, which is quickly derived from the first by reduction, the level of *acts of consciousness* that constitute object-events.[6] This is the "immanent" level, the level based on the "internal time" of acts of consciousness. Their structure forms the main body of the phenomenological analysis in Husserl's *Lectures*.
3. Finally (and this is the most subtle level of analysis), these first two levels are constituted from another level where no internal-external distinction is possible, and which Husserl calls the "absolute time constituting *flow of consciousness*" (p. 73).[7]

3. THE DURATION OF OBJECT-EVENTS

3.1. DURATION: THE EXPERIENCE OF VISUAL MULTISTABILITY

The correlate or intentional focus of temporal consciousness is the temporal object-event. Time never appears detached from temporal object-events; indeed, temporal object-events are what these acts of consciousness are *about*. Unlike the psychologist or the neuroscientist, the phenomenologist finds the content of the object less important than the manner of its appearance.

At various points in his research Husserl returns to the basic observation that what is proper to temporal objects is their double aspect of *duration* and *unity* (*PZB*, pp. 23, 113–14). Duration is correlative to the intentional direction: I am walking by *this* house, *that* bird flew from here to there. These are actual durations and refer to the object having a location in time. Unity is correlative to the individuality of the object-events in question, to the extent that they stand out as distinct wholes against the background of other events. Thus a temporal object-event is a complete act that covers a certain span *T*. However, the entire act is a continuous process in the course of which *moments of nowness are articulated*, not as a finished unity but in a succession. It is this mode of constitution of object-events, whatever their duration T and their content, that interests me here. It must be the case that consciousness of succession is derived from the structural features of the acts of consciousness. Our problem is how to characterize these structures.

In his writings Husserl is characteristically sparse with examples. In *PZB* he uses one recurrent illustration: listening to a melody (a choice most later commentators have followed as well). I think it is important to examine this issue more carefully for various reasons. First, because Husserl introduces his example, strangely enough, as an un-situated subject, in an abstract mode: he does not give us the circumstances under which the music is being listened to (alone, in a concert hall?), or the quality of the listening experience (is it a moving piece, is he familiar with it?). These circumstances are not incidental details; without these particularities the mode of access to the experience itself is lost.

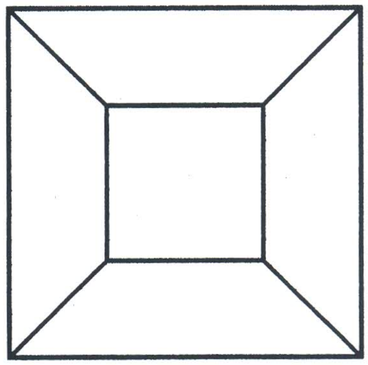
We still lack a phenomenology of internal time consciousness where the reductive gestures and the textural base of the experience figure explicitly and fully. The entire phenomenology of internal time consciousness must be rewritten with the precision of a mode of access to experience that serves as support for reduction; what transpires in Husserl's writing often falls far short of such a standard.[8] In what follows I depart from custom by inviting the reader to perform specific tasks of multistable visual perception that will provide the reader and the author with explicit common ground for discussion. Multistable perceptions make good case studies: they are precise and complex enough for analysis while still providing corresponding neurocognitive correlates. Indeed, multistable visual perception phenomena are deceptively clear. See, therefore, the experiment outlined on page 271.

The instructions for this experiment turn the subject into an active agent in the constitution of meaning, as it is illustrated here in a minimal case. There is a lot more to explore in this experiment concerning the perceptual horizon used for changing perception, as well as the strategy of language (the naming of the alternative, the "aiming" at the other possibilities).[9] But let me stay with the temporal aspects of this perception. We notice, as it has been known since the gestaltists, that as we acquire proficiency in this maneuver, reversing the image can be accomplished with little effort and upon request. It is also clear that the reversal has in itself a very complex dynamic that takes on a "life" of its own (more on this later). We also notice that the gesture of reversal is accompanied by a "depth" in time, an *incompressible* duration that makes the transition perceptible as a sudden shift from one aspect to the other, and not as a progressive sequence of incremental changes.

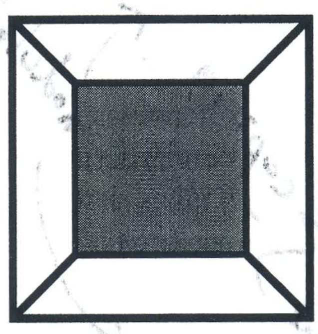
Granted, such "Necker" phenomena are not common in ordinary life. Consider the following, more realistic example: I open a door, and as I move

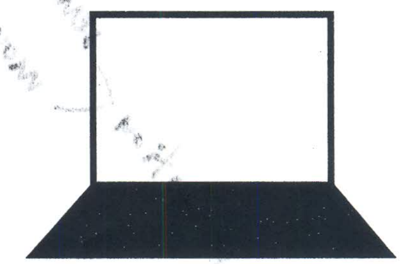
A Task in Visual Perception

Consider the following image:



Out of context, most Western subjects naturally see either a "pyramid" or a "hallway":





Suspend habitual interpretations and consider multiple variations together. We may infer that since the upper image depicts neither pyramid nor hallway, it is an ambiguous or multistable perception.

These variations can be *practiced* by the following strategy:

1. Fix on the center of the figure.
2. Blink your eyes.
3. "Aim" at its alternative.

across the threshold I run into somebody who is standing directly in front of me. Through both body motion and visual orientation the person's face comes spontaneously into focus. I recognize a colleague and thrust out my hand for a greeting. Both examples, the multistable visual perception and the vignette just presented, are very different from physically passive object-events such as listening to music.

In the example of multistable perceptions we do not need to move our entire body. However, an important layer of motion is actively present, whether in head adjustment, frowning and blinking, and surely, in eye movements of various kinds. This is important, for little can be concluded from cases where all motion is absent. As phenomenological research itself has repeatedly emphasized, perception is based in the active interdependence of sensation and movement.[10] Several traditions in cognitive research have, as well and in their own way, identified the link between perception and action as key.[11] It is this *active* side of perception that gives temporality its roots in living itself. Within this general framework, I will concentrate more precisely on the structural basis and consequences of this sensori-motor integration for our understanding of temporality.

3.2. THE NEURODYNAMICS OF TEMPORAL APPEARANCE

My overall approach to cognition is based on situated, embodied agents. I have introduced the name *enactive* to designate this approach more precisely. It comprises two complementary aspects: (1) the ongoing coupling of the cognitive agent, a permanent coping that is fundamentally mediated by sensorimotor activities; and (2) the autonomous activities of the agent whose identity is based on emerging, endogenous configurations (or self-organizing patterns) of neuronal activity. Enaction implies that sensorimotor coupling modulates, but does not determine, an ongoing endogenous activity that it configures into meaningful world items in an unceasing flow.

I cannot expand this overall framework more extensively,[12] but it is the background of my discussion of temporality as a neurocognitive process. Enaction is naturally framed in the tools derived from dynamical systems, in stark contrast to the cognitivist tradition that finds its natural expression in syntactic information-processing models. The debate pitting embodied dynamics against the abstract computational model as the basis for cognitive science is still very much alive.[13] For some time I have argued for the first and against the second, and this choice justifies the extensive use of dynamical tools in this paper (see Appendix B).

From an enactive viewpoint, any mental act is characterized by the concurrent participation of several functionally distinct and topographically distributed regions of the brain and their sensorimotor embodiment. From the point of view of the neuroscientist, it is the complex task of relating and integrating these different components that is at the root of temporality. A central idea pursued here is that these various components require *a frame or window of simultaneity that corresponds to the duration of lived present.* In this view, the constant stream of sensory activation and motor consequence is incorporated within the framework of an endogenous dynamics (not an informational-computational one), which gives it its depth or incompressibility. This idea is not merely a theoretical abstraction: it is essential for the understanding of a vast array of evidence and experimental predictions.[14] These endogenously constituted integrative frameworks account for perceived time as discrete and nonlinear, since the nature of this discreteness is a horizon of integration rather than a string of temporal "quanta."

At this point it is important to introduce *three scales of duration* to understand the temporal horizon just introduced: (1) basic or elementary events (the "1/10" scale); (2) relaxation time for large-scale integration (the "1" scale); and (3) descriptive-narrative assessments (the "10" scale). This recursive structure of temporal scales composes a unified whole, and it only makes sense in relation to object-events. It addresses the question of how something temporally extended can show up as present but also reach far into my temporal horizon. The importance of this three-tiered recursive hierarchy will be apparent all through this essay.

The first level is already evident in the so-called fusion interval of various sensory systems: the minimum distance needed for two stimuli to be perceived as nonsimultaneous, a threshold that varies with each sensory modality.[15] These thresholds can be grounded in the intrinsic cellular rhythms of neuronal discharges, and in the temporal summation capacities of synaptic integration. These events fall within a range of 10 msec (e.g., the rhythms of bursting interneurons) to 100 msec (e.g., the duration of an EPSP/IPSP sequence in a cortical pyramidal neuron). These values are the basis for the 1/10 scale. Behaviorally, these elementary events give rise to micro-cognitive phenomena variously studied as perceptual moments, central oscillations, iconic memory, excitability cycles, and subjective time quanta. For instance, under minimum stationary conditions, reaction time or oculomotor behavior displays a multimodal distribution with a 30–40 msec distance between peaks; in average daylight, apparent motion (or "psi-phenomenon") requires 100 msecs.

This leads us naturally to the second scale, that of long-range integration. Component processes already have a short duration, on the order of 30–100 msec; how can such experimental psychological and neurobiological results be understood at the level of a fully constituted, normal cognitive operation? A long-standing tradition in neuroscience looks at the neuronal bases of cognitive acts (perception-action, memory, motivation, and the like) in terms of *cell assemblies* or, synonymously, *neuronal ensembles*. A cell assembly (CA) is a distributed subset of neurons with strong reciprocal connections.[16]

CAs comprise distributed and actively connected neuronal populations (including neocortical pyramidal neurons, but not limited to them). Because of their presumably strong interconnections, a CA can be activated or ignited from any of its smaller subsets, whether sensorimotor or internal. One of the main results of modern neuroscience is to have recognized that brain regions are indeed interconnected in a reciprocal fashion (what I like to refer to as the Law of Reciprocity). Thus, whatever the neural basis for cognitive tasks turns out to be, it necessarily engages vast and geographically separated regions of the brain. These distinct regions cannot be seen as organized in some sequential arrangement: a cognitive act emerges from the gradual convergence of various sensory modalities into associational or multimodal regions and into higher frontal areas for active decision and planning of behavioral acts. The traditional sequentialistic idea is anchored in a framework in which the computer metaphor is central, with its associated idea that information flows upstream. Here, in contrast, I emphasize a strong dominance of dynamical network properties where sequentiality is replaced by reciprocal determination and relaxation time.

The genesis and determination of CAs can be seen as having three distinct causal and temporal levels of emergence: an ontogenetic level, which organizes a given brain into circuits and subcircuits; a second, developmental-learning level consisting of sets of neurons whose frequent co-activation strengthens their synaptic efficacies; and a third level of determination, that of the CAs' constitution. The third level is the faster time scale of the experience of immediate daily coping, which manifests at the *perception-action* level, having a duration on the order of seconds.

In the language of the dynamicist, the CA must have a *relaxation time* followed by a bifurcation or phase transition, that is, a period within which it arises, flourishes, and subsides, only to begin another cycle. This holding time is bound by two simultaneous constraints: (1) it must be longer than the time of elementary events (the 1/10 scale); and (2) it must be comparable to the time it takes for a cognitive act to be completed, namely, on the order of a few seconds, the 1 scale) (Varela et al. 1981; Pöppel 1988). In brief, as we said before, the relevant brain processes for ongoing cognitive activity are distributed not only in space but also over an expanse of time that cannot be compressed beyond a certain fraction of a second, the duration of integration of elementary events.

In view of the above, I will now introduce three interlinked, but logically independent, working hypotheses:

> HYPOTHESIS 1: *For every cognitive act, there is a singular, specific cell assembly that underlies its emergence and operation.*

The emergence of a cognitive act demands the coordination of many different regions allowing for different capacities: perception, memory, motivation, and so on. They must be bound together in specific groupings appropriate to the specifics of the current situation the animal is engaged in (and are thus necessarily transient), in order to constitute meaningful contents in meaningful contexts for perception and action. Notice that Hypothesis 1 is *strong* in the sense that it predicts that only *one* dominant or major CA will be present during a cognitive act.

What kind of evidence is there to postulate that every cognitive act, from perceptuo-motor behavior to human reasoning, arises from coherent activity of a subpopulation of neurons at multiple locations? And further, how are such assemblies transiently self-selected for each specific task? Since this will be a recurrent topic for the remainder of this essay, I'd like to formulate it as the second of my working hypotheses. The basic intuition that comes from this problem is that a specific CA emerges through a kind of temporal *resonance* or "glue." More specifically, the neural coherency-generating process can be understood as follows:

> HYPOTHESIS 2: *A specific CA is selected through the fast, transient phase-locking of activated neurons belonging to sub-threshold, competing CAs.*

The key idea here is that ensembles arise because neural activity forms transient aggregates of *phase-locked* signals coming from multiple regions. Synchrony (via phase-locking) must *perforce* occur at a rate sufficiently high to permit the ensemble to "hold" together within the constraints of transmission times and cognitive frames of a fraction of a second. However, if at a given moment, several competing CAs are ignited, different spatiotemporal patterns will become manifest, and hence the dynamics of synchrony may be reflected in several frequency bands. The neuronal synchronization hypothesis postulates that it is the precise coincidence of the firing of the cells that brings about unity in mental-cognitive experience. If oscillatory activity promotes this conjunction mechanism, it has to be relatively fast to allow at least a few cycles before a perceptual process is completed (e.g., recognition of a face and head orientation).

Recently this view has been supported by widespread findings of oscillations and synchronies in the gamma range (30–80 Hz) in neuronal groups during perceptual tasks. The experimental evidence now includes recordings made during behavioral tasks at various levels, from various brain locations both cortical and subcortical, from animals ranging from birds to humans, and from signals spanning broadband coherence from single units, local field potentials, and surface-evoked potentials (electric and magnetic) (see Singer 1993 and Varela 1995 for a history and summary of this literature). Figure 9.1 provides a sketch to help clarify these ideas.

This notion of synchronous coupling of neuronal assemblies is of great

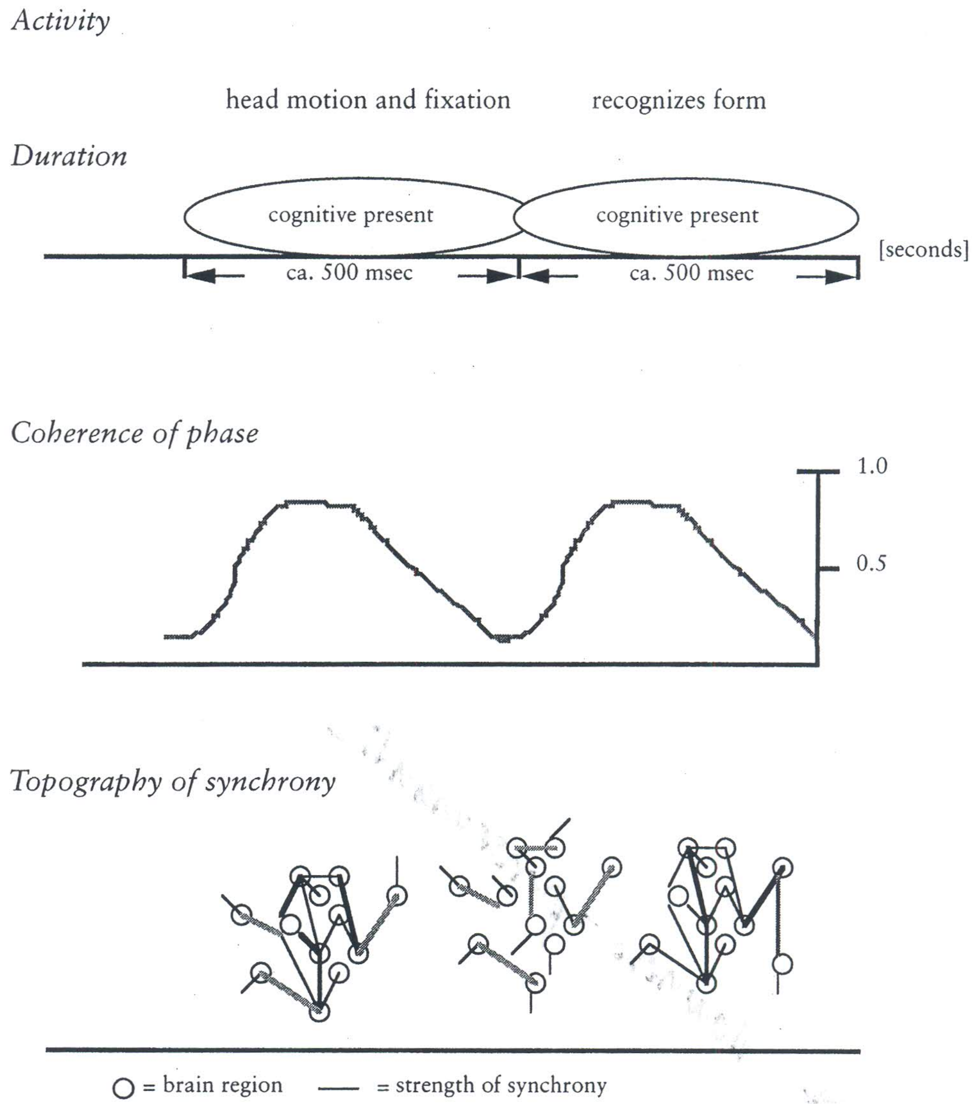


FIGURE 9.1. A diagram depicting the three main hypotheses. A cognitive activity (such as head turning) takes place within a relatively incompressible duration, a "cognitive present." The basis for this emergent behavior is the recruitment of widely distributed neuronal ensembles through increased frequently coherence in the gamma (30–80 Hz) band. Thus, the corresponding neural correlates of a cognitive act can be depicted as a synchronous neural hypergraph of brain regions undergoing bifurcations of phase transitions from one cognitive present content to another.

importance for our interpretation of temporality, and we will return to it repeatedly below (see also Appendix C). Here is the point where things get really interesting in our development of a view of cognition that is truly dynamic, one that makes use of recent advances in both nonlinear mathematics and neuroscientific observations.

Thus, we have neuronal-level constitutive events that have a duration on the 1/10 scale, forming aggregates that manifest as incompressible but complete cognitive acts on the 1 scale. This completion time is dynamically dependent on a number of dispersed assemblies and not on a fixed integration period; in other words it is the basis of the origin of duration without an external or internally ticking clock.[17] These new views about cognitive-mental functions based on a large-scale integrating brain mechanisms have been emerging slowly but with increasing plausibility.

Nowness, in this perspective, is therefore presemantic in that it does not require a rememoration (or as Husserl says, a presentification) in order to emerge. The evidence for this important conclusion comes, again, from many sources. For instance, subjects can estimate durations of up to 2–3 seconds quite precisely, but their performance decreases considerably for longer times; spontaneous speech in many languages is organized such that utterances last 2–3 seconds; short intentional movements (such as self-initiated arm motions) are embedded within windows of this same duration.

This brings to the fore the third duration, the 10 scale, proper to descriptive-narrative assessments. In fact, it is quite evident that these endogenous, dynamic horizons can be, in turn, linked together to form a broader temporal horizon. This temporal scale is inseparable from our descriptive-narrative assessments and linked to our linguistic capacities. It constitutes the "narrative center of gravity" in Dennett's metaphor (Dennett 1991), the flow of time related to personal identity (Kirby 1991). It is the continuity of the self that breaks down under intoxication or in pathologies such as schizophrenia or Korsakoff's syndrome.

I am now ready to advance the last step I need to complete this part of my analysis:

> HYPOTHESIS 3: *The integration-relaxation processes at the 1 scale are strict correlates of present-time consciousness.*

We are thus referred back to the experiential domain, and the nature of the link asserted in Hypothesis 3 is what we need to explore carefully. Distinctions between ongoing integration in moments of nowness, and how their integration gives rise to broader temporal horizons in remembrance and imagination, are at the core of the Husserlian analysis of intimate time, to which we now return.

4. THE JUST-PAST IS NOT MEMORY

Temporal objects appear to us as such only because of the correlative *acts* of consciousness that have specific modes of appearance that are at the very heart of the issue of immediate temporality. Normally we designate these modes by the terms "present," "now," "past," and "future." Beyond this cursory designation, however, reduction clearly points to the mode of "now" as having a unique or *privileged status* (*PZB*, p. 35). Two lines of analysis lead to this. First, the texture of now, which James calls specious. In effect, now is not just a mere temporal location, it has a lived quality as well: it is a space we dwell in rather than a point that an object passes by or through. Second, it is in relation to the rich structure of present nowness that all other modes of temporality take form. Both of these lines of analysis will be explored here.

To start, in spite of Husserl's own descriptions and geometric depictions, "nowness" is not a point or an object but a location, a field with a structure analogous to the *center and periphery* structuring of the visual field. Husserl himself speaks of nowness as a "temporal fringe" (*PZB*, p. 35). In other words, the very mode of appearance of nowness is in the form of extension, and to speak of a now-point obscures this fact: "Present here signifies no mere now-point but an extended objectivity which modified phenomenally has its now, its before and after" (*PZB*, p. 201). Husserl is grappling here with one of the antinomies of time: it is always changing and yet in some sense it is always the same. A temporal object-event such as my identifying the figure as a pyramid has a unity that first appears as present nowness. It then slips away when it appears anew as a hallway. The previous recognition (and its givenness) has now sunk into the past, as when an object moves from center to periphery in space. This marks the beginning of the resolution of the apparent contradiction between sameness and difference, constancy and flow, which we will elaborate more below. To do so, I must now move to another level of detail in the study of the structure of consciousness, one which is constitutional (in Husserlian jargon), insofar as it provides the temporal features of mental acts that unify them into a single *flow* of consciousness.

The key issue in this stage of my examination of temporality is the contrast between the mode of appearance of now and that of the just-passed, the act which reaches beyond the now. As Husserl points out, commenting on similar reasoning in Brentano: "We could not speak of a temporal succession of tones if . . . what is earlier would have vanished without a trace and only what is momentarily sensed would be given to our apprehension" (*PZB*, p. 397, my translation).

But how can this structure of the time perception be constituted? What is preserved is also modified. If when I see a pyramid, I could still hold unchanged the nowness of when I saw the hallway, all temporal structure would disappear. The relation of the now to the just-past is one of slippage organized by very strict principles: "New presentations each of which reproduces the contents of those preceding attach themselves to the perceptual presentation, *appending* the continuous moment of the past as it does so" (*PZB*, p. 171; my emphasis).

This phrase expresses the intuitions behind the analysis of *dynamics intrinsic to these slippages of appearance*, as developed in the following section. It is key for my search for bridges between naturalization and the texture of temporal experience.

What form does this slippage from nowness to immediate past take? Is it another emergent aggregate of the temporal horizon, similar to the one we assume (Hypothesis 3) underlies the experience of nowness? This was Brentano's postulate: the constitution of the past is re-presentation or memory presentification of what preceded. In several remarks dispersed over the years, Husserl actually gets close to a demonstration that the slippage from the now to the just-past is not the same as immediate memory retrieval or *presentification*.[18] To the appearance of the just-now one correlates two modes of understanding and examination (in other words, valid forms of donation in the phenomenological sense): (1) remembrance or evocative memory and (2) mental imagery and fantasy.

There are at least two main arguments for Husserl's observation. First, memory retrieval happens in the present, in the "now," and there is surely a nowness to the act of remembering. Thus we cannot account for the past with an act that is supposedly happening in the now. Second, when I remember having seen the hallway (as opposed to being in the embodied situation of seeing it now) the past and the successive past that receded into oblivion have an immediacy, an "evident-ness" to them. In the present I "see" what just passed; in memory I can only hold it in a representation as if through a veil. Thus memory and evocation have a mode of appearance that is qualitatively different from nowness.[19]

Let us return to the visual task and resume our examination. As I look at the pyramid at that moment of now, I experience both its near side and the entire pyramid as a durable unity (the pyramid is namable). This reveals the play between the primal impression of the near side of visual perception-action and the constituting unity that make an identifiable object-event appear. It is the manifold of retentions, as illustrated by the exercise, that makes sense of the entire event: the now is experienced in an "original" way.

> For only in primary remembrance do we see what is past; only in it is the past constituted, i.e. not in a representative but in a presentative way. . . . It is the essence of primary remembrance to bring this new and unique moment to primary, direct intuition, just as it is the essence of the perception of the now to bring the now directly to intuition. (*PZB*, p. 41)

Accordingly, Husserl makes a disciplined distinction between impressional as opposed to representational consciousness. In impression an object is originally constituted and is thus given as present (I am now looking into the page and I see the pyramid). Representation represents an object-event already given to impression (I evoke seeing the pyramid a little while ago for the first time). The Ur-impression is the proper mode of the now, or in other words, it is where the new appears; impression intends the new (I was not counting on seeing the pyramid as I looked). Briefly: impression is always presentational, while memory or evocation is re-presentational. Besnier remarks: "This is what is usually expressed by saying that retention belongs to a 'living present' (*lebenhaftig* or *lebendig*). But there is something that retention de-presents [*démomentanéise*], which one could translate by *Ent-gegenwärtigung*, but this choice might create confusions."[20]

Similar conclusions can be drawn from neurocognitive evidence. For a long time cognitive psychology has distinguished between evocative memory as implied above and other forms of immediate retention, such as short-term, working, or iconic memory. I am taking these as correlates of the just-past. Interestingly, the chronometric studies of brain correlates of memory draw a clear distinction between impressional perceptual events and perceptual events requiring the mobilization of memory capacities. For instance, comparing rote versus elaborate mnemonic recollection of items yields a substantial (200–400 msec) shift in the corresponding ERPs (event-related potentials; see, e.g., Rugg 1995). More recently, brain imaging methods have begun to establish that quite different structures are mobilized during active presentational tasks according to whether these presentations are memories (episodic, operational) or products of the imagination. All these presentational tasks mobilize a whole new set of capacities that add to the flow of time but are obviously not required for it.

5. THE DYNAMICS OF RETENTION

5.1. THE FIGURES OF TIME: RETENTION AS PRESENT

Husserl introduces the terms *retention* and *protention* to designate the dynamics of impression. Retention is the attribute of a mental act which retains phases of the same perceptual act in a way that is distinguishable from the experience of the present (but which is not a re-presentation, as we just saw). The key feature of retention that is its direct contact with earlier impressions making perception at any given instant contain aspects that show up as temporally extended. As we discussed, under reduction, duration has a speciousness, it creates the space within which mental acts display their

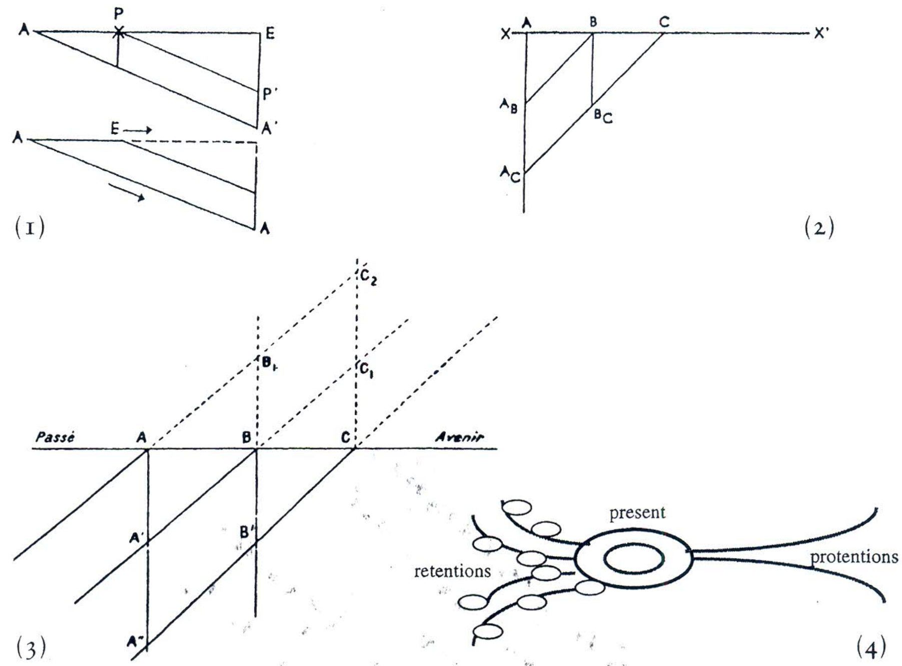


FIGURE 9.2. The "figures of time," as introduced by Husserl. (1) The diagram chosen by Stein and published in *Lessons* (*PZB*, p. 28); (2) one of several variants kept by Husserl after 1905 (*PZB*, p. 230); (3) the rendition by Merleau-Ponty (in Merleau-Ponty 1945: 477), which prolongs the lines into retentional time, as Husserl himself suggested (cf. *PZB*, p. 331); and (4) my own rendering of Merleau-Ponty's later critique of this diagram (Merleau-Ponty 1945: 479).

temporality. Similarly (but not symmetrically) another aspect contains future threads or *pro*tentions. This is the three-part structure that transforms an intentional content into a temporal extension. Figure 9.2 reproduces a sketch, one of the "figures of time" taken from the 1905 lectures, a geometrical depiction of the three-part structure of temporality. The now and the degrees of pastness are what Husserl refers to as *Ablaufsmodi*, slippages or elapsing modes, and which are depicted in reference to a source-point, whence the discreteness in this diagram. The use of lines and points is unfortunate, since it distracts from Husserl's remarkable insight; one might guess this is an echo of his training as a mathematician. The fate of these figures of time has been curious. Since they are easily grasped, they have been used extensively as summaries of Husserl's position. Yet these "figures of time" hardly do justice to the scope of his explorations; at best they illustrate an earlier and static view.[21] The appeal of the diagrams came through in Maurice Merleau-Ponty's *Phenomenology of Perception* (1945: 477) where the author comments approvingly on these depictions. However, Merleau-Ponty was well aware of the shortcoming as he added next to the diagram: "Time is not a line but a network of intentionalities." Further on, he wrote:

"The emergence of a present now does not *provoke* a piling behind of a past, and a pulling of the future. Present now *is* the slippage of a future to the present, and the just-past to the past: it is in one single movement that time sets in motion in its entirety" (p. 479). However, many writers have referred to this and several other diagrams in Husserl's writings uncritically.

In brief then: "Primal impression intends the new and actual phase of the temporal objects-events, and presents it as the privileged now. Retention presents just elapsed phases and presents them as just past in various degrees" (Brough 1989: 274).

Retention is then a specific intentional act intending the slipping object constituting it as just past. Retention is not a kind of holding on to the now by its edge; it is an active presentation of an absence that arises from the modifications and dynamic apprehension of the now. Metaphorically it is more like moving from center to periphery than the aftereffect of an image, which is like the present modified only in intensity. But in the temporal realm, it is a curious structure indeed: it is present-living past. Or, as Husserl quipped in a handwritten marginal scribbling on his working notes: "But 'perceived past' doesn't that sound like a 'wooden iron'? [*hölzernes Eisen*]" (*PZB*, p. 415).[22]

5.2. RETENTION AS DYNAMICAL TRAJECTORIES

It is indeed a wooden iron, unless we take a dynamical view of how the origin of the now can be formulated on the basis of our three working hypotheses. The use of "append" and "slippage" in the phenomenological description already evokes this view, but it needs to be developed fully. Besides the fact that there is substantial experimental support for these hypotheses, it is essential to recognize that we are dealing with a bona fide candidate for the synthesis of a temporal space where cognitive events unfold. The discussion that follows requires at least some understanding of the dynamics of nonlinear phenomena as applied to cognitive events. The reader not familiar with basic notions can turn to Appendix B for a sketch.

Let us be more specific. Large-scale phenomena seen in the nervous system as long-range integration via synchronization of ensembles cannot be dissociated from intrinsic cellular properties of constituent neurons. Intracellular recordings studied in in vivo and in vitro slices of various brain regions, of both vertebrates and invertebrates, have shown the pervasive presence of intrinsic, slow rhythms mediated by specific ionic gating mechanisms (Llinás 1988; Nuñez, Amzica, and Steriade 1993). In other words, what we have are large arrays of neural groups that because of their intrinsic cellular properties, qualify as complex nonlinear oscillators (see Appendix C for an explicit account of fast-slow nonlinear oscillators).

Why is this of importance here? Because it leads us directly to an explicit view of the particular *kinds* of self-organization underlying the emergence of neural assemblies. These arise from collections of a particular class of coupled nonlinear oscillators, a very active field of research (see, for example, Mirollo and Strogartz 1990, Winfree 1980, Glass and Mackey 1988, and Kelso 1995). These dynamical processes, in turn, illuminate the mechanisms whereby neuronal assemblies "now" possess a three-part structure.

The key points to keep in mind for our discussion are the following. First, self-organization arises from a *component* level, which in our case has already been identified as the 1/10 scale of duration, and reappears here as single or groups of nonlinear oscillators. Second, we need to consider how these oscillators enter into synchrony (see Hypothesis 2) as detected by a *collective* indicator or variable, in our case relative phase. Third, we need to explain how such a collective variable manifests itself at a global level as a cognitive *act*, which in our case corresponds to the emergence of a percept in multistability. This global level is not an abstract computation, but an embodied behavior subject to initial conditions (e.g., what I "aimed" at, the preceding percept, etc.) and nonspecific parameters (such as changes in viewing conditions and attentional modulation). The local-global interdependence is therefore quite explicit: the emerging behavior cannot be understood independently of the elementary components; the components attain relevance through their relation with their global correlate.

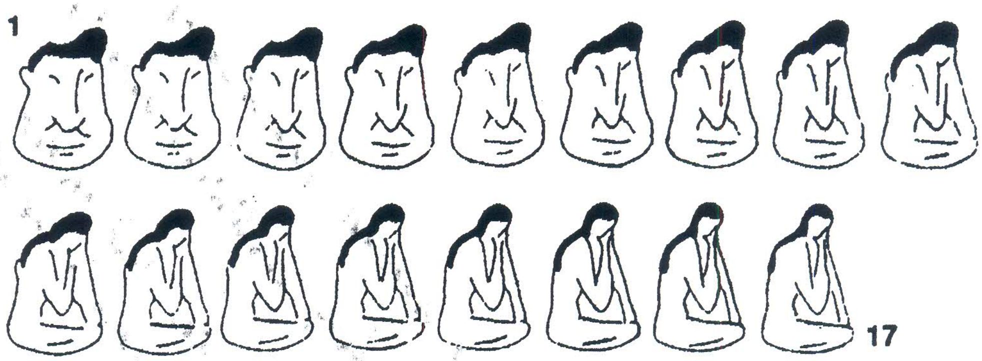
What have we gained? Very simply that in these kinds of emergent processes there can be a natural account for the apparent discrepancy between what emerges and the presence of the past. In effect, the fact that an assembly of coupled oscillators attains a transient synchrony and that it takes a certain time to do so is the explicit correlate of the origin of nowness (Hypothesis 3). As the model (and the data) shows, the synchronization is dynamically *unstable* and will constantly and successively give rise to new assemblies. We may refer to these continuous jumps as the *trajectories* of the system. Each emergence bifurcates from the previous ones given its initial and boundary conditions. Thus each emergence is still present in its successor.

To bring this idea closer to firsthand experience let us perform a second task in visual perception (p. 284). After following the instructions, observers have reported that the positions at which the perceptual switches occur do not coincide but are lengthened in either direction of the image sequence.

When this is analyzed from a dynamical point of view, the following account is plausible: The extremes of the series ("female," "male") are closer

A Second Task in Visual Perception

Consider the series of images below (Fisher 1967):



Practice the following task:

1. Starting with the male image on the upper left, slide your eyes sequentially over the figures until you reach the female image at the bottom right.
2. At some point, the perception of a male face will have switched to one of a female body. Mark the point at which this has happened.
3. Starting at the opposite end, repeat the process in reverse. Mark the point at which your perception switches.

to a stable attractor basin corresponding to a single percept. When the ambiguity has increased sufficiently (when the observer has moved to a position sufficiently advanced in the series), we pass through a bifurcation or phase transition and the emergence of a new percept becomes possible. Note, however, the system tends to stay close to the fixed point of origin, as if this point had an active residue (hysteresis, in technical jargon) for the trajectory, an appended remnant (to use Husserl's term). The order parameters constrain the trajectories, the initial percepts hover around the stable percepts, but these trajectories may wander to different positions in phase space.

This behavior embodies the important role of order parameters in dynamical accounts. Order parameters can be described under two main aspects:

1. The current state of the oscillators and their coupling, or initial conditions; and
2. The boundary conditions that shape the action at the global level: the contextual setting of the task performed, and the independent modula-

tions arising from the contextual setting where the action occurs (namely, new stimuli or endogenous changes in motivation).

This second visual task makes it is clear that we are not dealing with an abstract or purely syntactic description. Order parameters are defined by their embodiment and are unique to each case. The trajectories of this dynamic, then, enfold both the current arising and its sources of origin in one synthetic whole as they appear phenomenally. A wooden iron indeed.

5.3. THE DYNAMICS OF MULTISTABILITY

The kinds of specific dynamics we have brought to bear on the understanding of retention and the just-past are not simple. Arrays of coupled oscillators are particularly interesting because they do not in general behave according to the classical notion of stability derived from a mechanical picture of the world. Stability here means that initial and boundary conditions lead to trajectories concentrated in a small region of phase space wherein the system remains, a point attractor or a limit cycle. In contrast, biological systems demonstrate *in*stability as the basis of *normal* functioning rather than a disturbance than needs to be compensated for, as would be the case in a mechanical system.

Let us return once again to our experiential ground of visual multistability. As we saw in the example of Fisher's figures, multistability is the result of properties that are *generic* to coupled oscillators and their phase relations. In other words, their mode of appearance is an invariant under certain conditions with reporting subjects. This is further clarified by recent experiments performed to study the dynamics of multistability in visual perception. As shown in Figure 9.3, J. Scott Kelso and colleagues (1994) presented observers with *variant perspectives* of the classical Necker cube, a close relative of our first visual task. By asking the observer to push a button when the perceptual reversal occurs, one obtains a time series of reversal which obeys a stochastic distribution (a gamma function with a mean at around one second). Kelso and colleagues, however, requested observers to perform the same task of time measurement while noting separately the time series as a function of perspective, which is thus used as an order parameter.

The interesting observation is that, again, at the extremes of the images (the "hexagon" mode, and the "square" mode), the distribution of reversal intervals is considerably flattened. The subject is more likely to have sporadic figure reversal, or to be "fixed" on one mode for a longer duration. At these extremes subjects report getting "blocked" by an interpretation. As before, one can think of these results as the way the coordination of a wide ar-

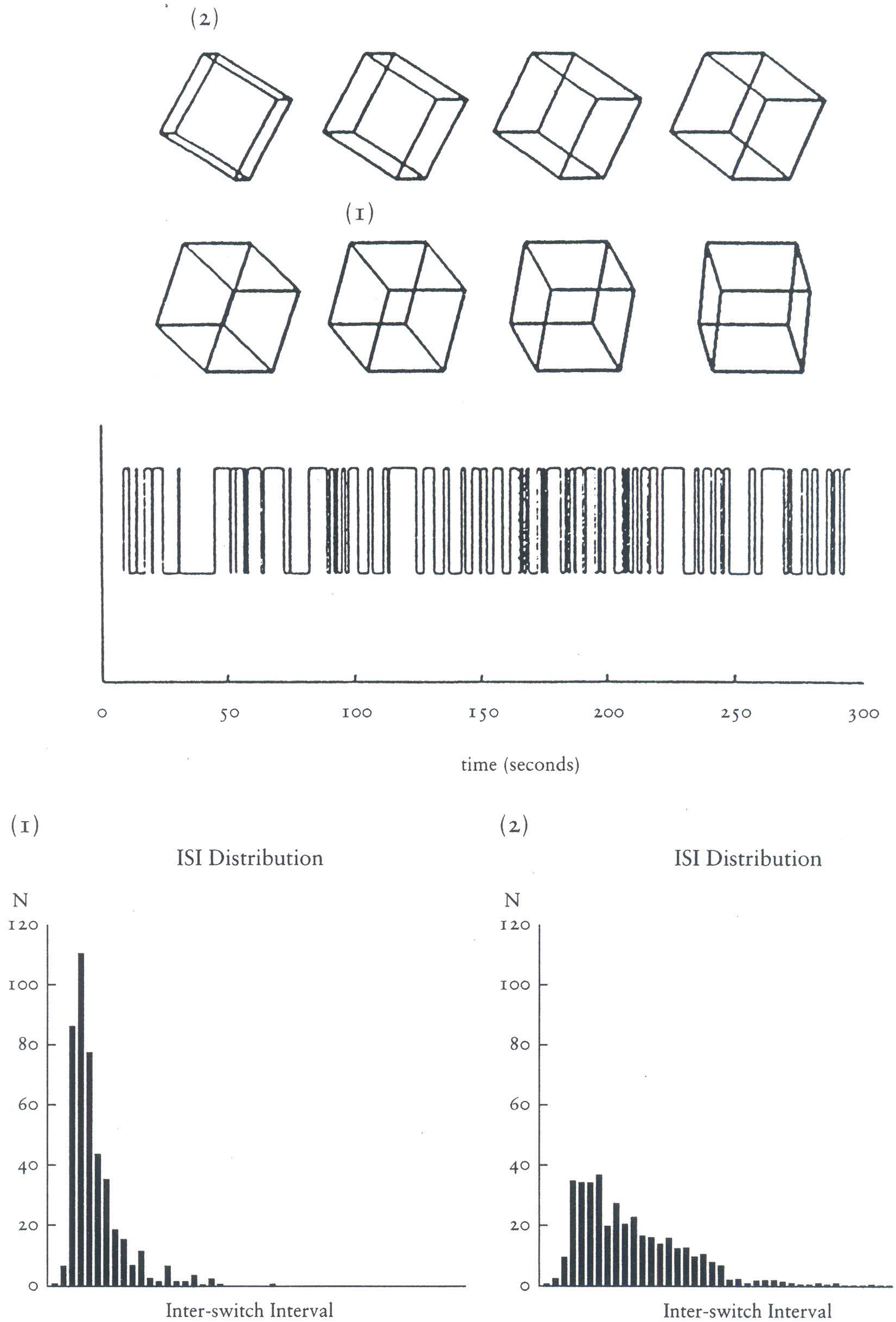


FIGURE 9.3. Multistability of perception of the Necker cube from different perspectives, used here as an order parameter. When the cube is reversed from projection (1), the time intervals between spontaneous inversion are shown in the lower diagram, with an upward trace each time a reversal is perceived. This interswitch reversal time series has a probabilistic distribution shown below, a distribution that is considerably spread when the viewing projection is changed to (2). In this latter case the switch is more difficult, and the observer is "struck" with one interpretation for longer periods of time. (Kelso et al. 1994: 219–21)

ray of oscillators appears via a common variable of phase. By introducing perspectival variants, the location in phase space is accordingly modified, and new dynamical modes appear, in this case revealing a saddle instability (Figure 9.4, p. 293).

That this dynamical interpretation is actually linked to neuronal ensembles as we have been assuming here is shown by recent experiments (Leopold and Logothetis 1996). A monkey was rigorously trained to voluntarily "aim" at reversing a set of ambiguous figures (binocular rivalry, a visual task known to be similar to Necker cube or Fisher figure reversal), and then to indicate the moment at which this reversal appeared for his perception. At the same time, the firings of individual neurons were recorded from a number of its visual cortical areas. The authors report that in motion-sensitive area MT, a percentage of neurons correlate with reversal and can be modulated by the perceptual requirements of the tasks; this percentage is diminished in primary regions V1/V2. This kind of evidence strongly supports the notion that multistability arises through the large-scale collaborations among neurons at many different places in the visual cortex and elsewhere in the brain, a concrete example of an emerging CA for a specific task which has perceptual and phenomenal correlates.

Elsewhere in this volume, Tim van Gelder also discusses the three-part structure of time from a dynamical cognitive science viewpoint. It is quite reassuring that we have independently reached converging conclusions concerning the key role of dynamical interpretation in a research program of naturalized phenomenology, and more particularly concerning the re-understanding of the three-part structure of time. However, our views differ in some significant aspects, which are worth underlining here for the reader.

In his discussion van Gelder grounds his analysis on "Lexin," a connectionist network developed by Philip Anderson and Robert Port for auditory pattern recognition. As in a large class of connectionist work, Lexin changes its connection according to a training period, following which a sound input triggers a dynamical trajectory that approaches an attractor, a unique location in state space. Lexin's architecture has its roots in work of the early 1980s, which made popular the standard view of neural networks as dissipating dynamical processes governed by point attractors and limit cycles or, as they are usually called, attractor neural networks (ANNs; Amitt 1991).

In contrast, in more recent, biologically oriented dynamical studies, the generic role of instabilities has been stressed, a needed expansion of results in neural networks and connectionism. ANNs have played a role in our understanding of biological circuits and, more important, in the development of artificial intelligence. In the hands of the engineer, motion and perceptual devices that mimic some living behavior have provided impressive performances (see Arbib 1995 for a recent overview). Lexin in particular is meant to retrieve a learned set of auditory patterns. However, only with a dynamical description that incorporates *in*stability as having a role can we satisfactorily account for enactive cognition such as the three-part structure of time. In this class of dynamical systems, the geometry of phase space needs to be characterized by an infinity of unstable regions, and the system flows between them spontaneously even in the absence of external driving forces. There are no attractor regions in phase space, but rather ongoing sequences of transient visits in a complex pattern of motion, modulated only by external coupling.

Auditory perception, particularly in mammals, is so rapid (some mammals can make individual sound discriminations in the order of 2–3 msecs on the 1/10 scale) that it is far from clear how a slowly converging ANN could be a good model. More important, any model based on point attractors will surely lack the intrinsic interest of endogenous instabilities proper to brain dynamics. This is, again, one of the reasons we stay close to biologically inspired, coupled, nonlinear oscillations and frequency binding as a source of dynamical correlates proper to complete cognitive acts.

Van Gelder's analysis and mine coincide, however, on the intuition of the pertinence of dynamical views for the illumination of retention. Unlike him I have my reasons (discussed in section 7) for seeing protention as quite asymmetrical from retention, and as not having, as retention does, a constrained path in phase space.

6. THE DYNAMICS OF FLOW

6.1 THE GENETIC ANALYSIS OF TEMPORALITY

I need to turn now to the final step in my analysis, a step that is taken on far less trodden ground than the intentionality of object-events and retentional dynamics, two "classical" topics in phenomenology since the time of Husserl. Because the discussion so far has been concentrated on a particular kind of intentional act, retentional dynamics still belongs to the type of constitutional analysis referred to as "static," the classic level at which most commentators of Husserl's time analysis remain. It is called static because it is intentionally directed to object-events and to what appears (either as being an external process or as having immanent duration, such as the completion of a movement). In other words, so far we have considered the more accessible levels of temporality, the appearance of object-events and the acts of consciousness that constitute them.

Husserl brings to the fore a third and final level of analysis that has been less explored by later work. This is "the absolute time-constituting flow of consciousness" (*PZB*, p. 73). In the context of the present use of dynamical ideas it is interesting that Husserl's choice to refer to this level of study as the "flow" is suggestive: "It is absolute subjectivity and has the absolute properties of something to be denoted metaphorically as 'flow' [*Fluß*] as a point of actuality, primal source-point, that from which springs the 'now,' and so on" (*PZB*, §36, p. 368).

The idea of flow opens up to two less "classical" issues that I will dwell on here: (1) the *genetic constitutional* analysis of time, just introduced above as the flow of absolute time, and (2) its close relative, the *affective* dimension (see section 7). Husserl established the distinction between static and constitutional analyses of time during the years 1917–23. These topics are notoriously more difficult to explore, not only because they are grounded in Husserl's later work (see Appendix A), but also because they touch on subtle areas, which is what makes them more attractive. Accordingly, the reader is asked to consider what I propose in the remainder of this text as a *sketch* of future work more than anything else.[23]

Return to the first visual task (it is important that you actually do this). Choose one of the percepts, "aim" at changing it to the other one, then return to the one you chose first. The result is clearly two distinct experiences that are similar in content. The link joining them demonstrates the basic fact that there is an underlying temporalization that is relatively independent of the particular content of the views. As Husserl concisely remarks: "Every experience is 'consciousness' [*Bewußtsein*] and consciousness is always consciousness-of. . . . Every experience is itself experienced [*selbst erlebt*] and to that extent also intended [*bewußt*]. *This* being intended [*Bewußt-sein*] is consciousness of the experience [*Erlebnis*]" (*PZB*, p. 291).

The link is a *reflection*, which is not always present but may always be put into action, for it accompanies all my acts. This reflection is temporal, since experiences *are* (immanent) object-events with duration: they appear already slipping into the past and gradually disappear into the fringes of time. It is against this background of the flow of experiencing that the duration of object-events and the experience of temporality is constituted. This underlying flow raises then a new apparent paradox: it can be detached from the temporal object-events but at the same time it appears inseparable from them, since without object-events there is no flow.

The nature of this immanence is taken up again by Husserl in the following (remarkable) passage which summarizes his previous analysis: "I may express the situation thus: What is perceived, what manifests [*selbstgegeben ist*] as an individual object, is always given in unity [*Einheit*] with an absolutely non-manifest domain [*nicht gegeben Mannigfaltigkeit*]" (*PZB*, p. 284; translation slightly modified).

Proper immanent temporality is that of lived experiences themselves.

Here we reach what might rightly be perceived as the second aporia of temporality: the coexistence of permanence and change. Consciousness is a constant background against which distinct temporal acts and events appear. Around 1911 Husserl introduced the term "double intentionality" (*PZB*, pp. 80, 379) for this articulation, since there is not only a retention (of the object event) but also a *retention of retention* (a reflective awareness of that experience). These two sides of intentionality work together and are inseparably interwoven into the unitary flow of consciousness. Consciousness could not exist apart from the acts it intends or experiences, but it remains distinct from them, a pregnant unity of appearance and nonappearance.

We may now ask what avenues of access or exploration are available to study the immanent flow? As discussed before, one main source is the *reflexive* act, the becoming-aware of experience as temporal. This is quite immediate, and the most convincing argument to establish that flow is an essential phenomenon. However, although accessible, immediate reflection is a task made difficult by the simple fact that to provide description we need to keep up with the shiftiness of changing experience. As we have said, shifts take mere fractions of a second, and even diligent observation makes it hard to provide useful distinctions.[24]

The second royal avenue of access to the flow is remembrance, if we understand that such presentification must be done in a "pure" manner, with a view to its nature and not its specific content. I can very clearly relive the last visual percept in the task. But this evocation is complete only when it pulls with it the embodied context in which that image arose (my posture, the car passing in the background, the concurrent fragments of ideation as I was doing the task). In other words, although an evocation intends an object which it brings to presence in a specific mode (see section 4), it does so as a field: the intended object is a center, but it is also a periphery full of the context of the embodied experience. This fringe, although not intended, is, nevertheless, brought to life by remembrance: "In order to examine properly (in its 'genetic' constitution) the temporality of immanent experience, it is necessary to direct one's reflexive focus during an experience of *Erinnerung* on the experiences that are re-produced by themselves. This is difficult" (Besnier 1993: 347).

Indeed it is, but at least it is feasible enough so that we can concur that there is such a thing as the bringing into life the fringes of a memory. Where one could have found an isolated item sought by remembrance, we find, without specifically looking for it, the appended relived threads of the experience itself. Or if I may speak more figuratively: in remembering an intended object, it comes out bristling with retention threads of the original experience. Stated positively: what makes remembrance have such a retentional fringe must be *the manner in which these very retentions were constituted.*

In our attempt to naturalize acts of retention, we attempted to solve the "wooden-iron" nature of the past-always-present (see section 5). Further examination of the mode of appearance of immanent temporality confronts us again with a new apparent paradox, not unlike that of the wooden iron. The process of slippage itself (that is, de-presentation, *Entgegenwärtigung, dé-momentanéisation*) has the marks of being an active or even self-generated process. Can there be a process that is a cause of itself? In this case the paradox takes the more classical form of a *regressum ad infinitum.* Is there an angle to illuminate this second apparent contradiction?

6.2. THE GEOMETRY OF NONLINEAR FLOWS

An answer to these questions has already been sketched in passing, and it now needs to be unfolded more fully. The neurodynamics of time we have been pursuing is essentially based on nonlinear coupled oscillators. As we saw, this class of dynamical systems finds its wealth of behavior in the fact that constitutional instabilities are the norm and not a nuisance to be avoided. The case of multistability makes this quite evident experientially: the percepts flip from one to another (depending on order parameters; see Figure 9.3) by the *very nature* of the geometry of the phase space and the trajectories.

This is a widespread characterization applicable not only to this study case. Complex, nonlinear, and chaotic systems in general provide a self-movement that does not depend (within a range of parameters) on where the systems are. In other words, whether the content of my visual percept is a man or a woman or a pyramid or a hallway, the intrinsic or immanent motion is *generically* the same. If the specific place in phase space is a correlate of the intentional content of an object-event, the system never dwells on it, but approaches, touches, and slips away in perpetual, self-propelled motion. Cognitively, this corresponds to the observation that in brain and behavior there is never a stopping or dwelling cognitive state, but only permanent change punctuated by transient aggregates underlying a momentary act (at the 1 scale of duration; Hypotheses 1–3 above). Formally, this is expressed by the pervasive presence of stable/unstable regions, so that any slight change in initial and boundary conditions makes the system move to a nearby stable/unstable region.

This notion has been and is still explored by dynamicists under various guises. In the specific case of multistability of the Necker cube (see section 5.2), we assume the coordination of a wide array of oscillators via a common variable: phase. By introducing perspectival variants, the dynami-

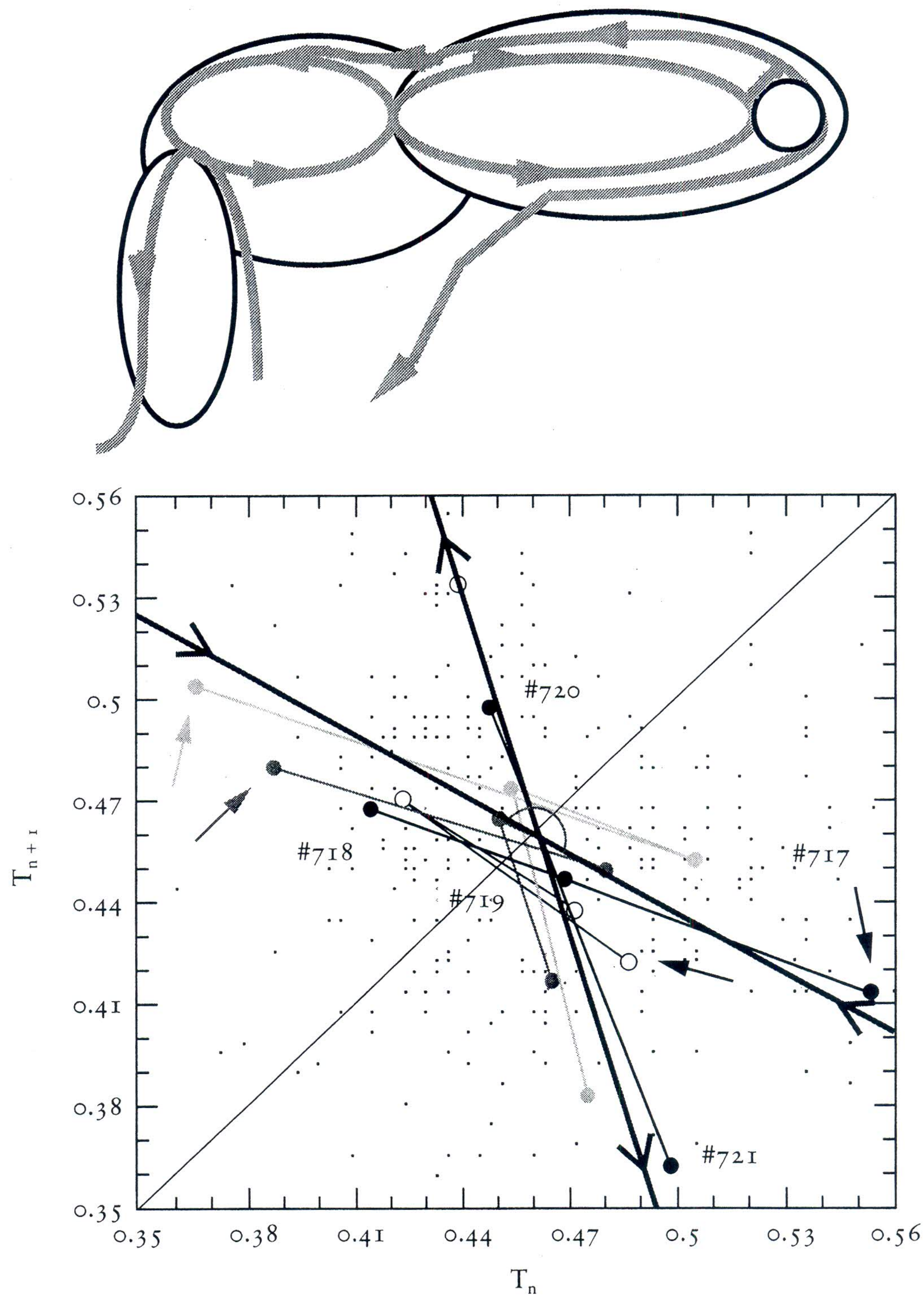


FIGURE 9.4. *Top*, a highly schematic diagram of the current view that a complex, chaotic dynamic should be regarded as having a geometry in phase space where multiple instabilities are found locally (gray lines). A system's trajectory shifts (in black lines) constantly from one local instability to another, in an unceasing flow, under the modulation of boundary conditions and initial conditions. *Bottom*, experimental evidence for local saddle instabilities in the time series from the cortex of an implanted epileptic patient. The peaks of the local discharge in the temporo-occipital cortex are followed in their return map or Poincaré section

cal landscape is accordingly shifted to new dynamical modes appearing in the phase portrait. This saddle instability implies that at that point there is mixture of tendencies to be attracted into that position or to move away from it, and the slightest perturbation will push and pull the trajectories along.

More generally, many apparently "noisy" natural events (such as the transition times between Necker cube reversals) have recently yielded unexpected deterministic patterns under nonlinear dynamical analysis beyond the reach of traditional linear analysis (see Appendix B). The main feature of these methods is to give us a view of dynamics based not only on trajectories but also in the more encompassing frame of *the geometry of the phase space landscape* (see Figure 9.4).

This is not merely a formal description. These geometrical patterns can be studied even in a highly localized grouping of neuronal activity such as that measured by an electrode on the surface of the brain (a few cubic millimeters of cortex). For instance, in a local temporal epileptic focus, which seems like a noisy oscillation, we have found evidence for such multiple determinism and instabilities (Le Van Quyen et al. 1997a, 1997b). While his brain was being recorded, a subject was asked to perform simple visual and auditory discriminations. We then studied the interval between these discharges much like the time series from Necker cube reversals. This provided consistent indications these temporal dynamics cannot be characterized as a simple "noisy" periodicity. Even a simple first-return map (the value of one time interval plotted against the value of the following one) reveals detailed changing geometrical patterns depending on experimental conditions, but shows consistent evidence of a saddle instability with stable and unstable manifolds. This observation suggests that the phase space landscape can be characterized by *departures from strict periodicity in a nonrandom manner* (Auerbach et al. 1987). In particular, the different perceptual discriminations "pull" this local dynamic toward a distinctly unstable periodicity. Although the positions of the periodic points are shifted between the behavioral conditions studied, the related slopes of approach to the instabilities appear as invariant features of the dynamics for all our experimental conditions (Figure 9.4).

T_n plotted against T_{n+1} indicated by the background points. We may investigate further the structure of the trajectories by examining individual short sequences of points around the diagonal. A typical example of recurrent observed trajectories is shown, displaying the sequence of points numbered 351–55. From points 351–54, the state of the system is drawn toward the diagonal (that is, a strictly periodic regime), but after point 354, it diverges away from the diagonal with a different linear slope. The slopes for the approach and divergence are regular and thus an invariant of the system's dynamical geometry. (Le Van Quyen et al. 1997b)

In this case study we stress the relevance of local nonlinear properties in brain events that are often lost when global, averaging methods (like spectra, or even dimension estimators) are applied. There is a surprising degree of detail displayed by the trajectories or orbits of the epileptic dynamics as modulated by perceptual tasks. A paradigmatic manifestation of this is the fact that a chaotic trajectory typically includes an *infinite* number of unstable periodic orbits. These orbits are unstable in the sense that the smallest deviation moves the state away from the periodic orbit. Thus, a nonlinear deterministic (or chaotic) system never remains long in any of these unstable motions but continually switches from one periodic motion to another, thereby giving an appearance of randomness (Artuso, Aurell, and Cvitanovic 1990).

6.3. DOUBLE INTENTIONALITY

We have gained, then, a new intuition to resolve the riddle of this second wooden iron of the mixture of passivity and activity, of invariance and change, of double intentionality. "The self-appearance [*Selbsterscheinung*] of the flow does not require a second flow, rather it constitutes itself as phenomenon itself [*in 'sich' selbst*]" (*PZB*, p. 381). Merleau-Ponty refers to this paradoxical aspect of reductive description by saying that to exist, time "must be already in me [*fuse en moi*]," and as it arises as a flow of retentions, it also self-manifests (*Selbsterscheinung*).[25] In fact: "I have not chosen to be born, but once born, time must already permeate me [*le temps fuse a travers moi*], whatever I do."[26]

Husserl develops his descriptive account of this paradoxical appearance of "double intentionality" in the notions of transverse and longitudinal intentionality (*Quer-* and *Längsintentionalität*).[27] The first is retentional dynamics—the static constitution. Longitudinal intentionality, in contrast, is the genetic constitution of the temporalization (self-manifestation) of experiences themselves. These are necessarily interdependent, but their mode of dependence and the root of their difference is what is difficult to express: "For all of that we have no names" (*PZB*, p. 371).

Longitudinal intentionality acts by an integration from within the now itself; it provides an unchanging substrate from which the flow emerges. As Besnier remarks (1993: 350), there is a great temptation to transpose the analysis of perceptual intentionality by envisaging this as a "pure" substrate or *Ur-hyle*. I do not have to enter into the thorny technical debate this mode of analysis has produced since Husserl (Depraz 1996b). My contribution is to bring to the fore the intuition derived from the generic nonlinear flows, following our hypotheses. Self-manifestation appears in our analysis as self-motion or generic instability, which is not a mere artifact of description, but an invariant formal description for self-organization. Thus its relevance to temporality is appropriate. The flow, in the neurodynamical sense, is precisely a wooden iron that exists as flow only to the extent that it is constituted in individual trajectories (not an inert geometrical magma), which, as ongoing, self-propelled, and transient, visit various regions in phase space (corresponding to an intended object-event, an appearance).

The inseparability of these two intentionalities here is not only descriptively accurate but part of the intrinsic logic of complex nonlinear dynamics. It would be inconsistent to qualify the self-motion as a "deeper layer" of the dynamical process and to describe these trajectories as mere appearance (Gallagher 1979). Mutatis mutandis, it seems illusory to isolate a "deeper" layer of genetic constitution where experience would be constituted from an absolute time, and only then made manifest in conscious intentionality. What is deep is the *link* between self-motion (immanence) and trajectories (appearance).

Enough has been said about the immanent or absolute flow to suggest its importance and perspicacity. It is surely a topic that needs exploration, and it is the natural ground for bridges to other varieties of experience and to other traditions concerned with human consciousness.[28] Indeed, this level of analysis touches more than any other on the ground of self, pure ego, or basic consciousness. Brough (1989: 288) summarizes:

> And thanks to the infinite horizon opened up by the absolute flow, we can be sure that we can go right on changing and accumulating a past, while still remaining the same. There is a fissure, then, in consciousness. Thanks to this fissure, any one of my acts, asserting itself and holding sway for a more or less brief time . . . is able to "slide off" without taking my whole self with it. If my internal awareness were glued without gap to my fleeting experiences, the passage of time would rip my ego to shreds.

But we must now leave these considerations and turn to our last topic, which is the closely related issue of the appearance of this self-motion from the perspective of affect.

7. PROTENTION: TRANSPARENCY AND EMOTIONAL TONE

7.1. IMMANENT TEMPORALITY AND AFFECT

Return again to the first task and reexamine more closely the nature of the switching as it happens. One essential component of the experience is that the shift is sudden and accompanied by a (more or less distinct) emotional change when the visual perception shifts abruptly. Thus the mode of slippage of the now into the just-past, the retentional trajectory, not only appears as the presence of the past in a way that is distinct from representational memory but also gives us the cue that the *emotional tone* is an integral part of the phenomenon. What is the role of emotion or affect in the self-movement of the flow? And what is its role, if any, in protention, the anticipation of what is to come?

In Husserl's published texts, protention is not extensively analyzed, and I have the impression that he implicitly assumes a certain symmetry with retention, as if the same structure of invariance for the past could be flipped toward the future. But protention intends the new prior to an impression and thus can only be a prefiguration. Husserl speaks of "empty constitution" (*PZB*, p. 52), but it is not expectation or anticipation in the sense of containing a representation of what the next now will bear. To see why this is so, one need only to apply the same arguments that were used for distinguishing retention from evocative memory. Indeed, protention has a mode of openness: "The only thing definite is that without exception something will come"; in listening to a melody (his example) there is a predictable side to protention since it intends further phrases of the music (*PZB*, pp. 84, 106). These and similar remarks from the *PZB* seem to have provided the basis for the symmetrical view of the three-part structure of time, and as indicated in the oft-used figure of time discussed earlier (see Figure 9.2).

This analysis can be substantially enriched. There are at least two main sources of evidence to conclude that protention is generically *not* symmetrical to retention. The first is, precisely, that the new is always suffused with affect and an emotional tone that accompanies the flow. In fact, protention is not a kind of expectation that we can understand as "predictable," but an openness that is capable of self-movement, indeterminate but about to manifest. In this quality it provides the natural link into affection or, more aptly, with some form of self-affectedness (see below). The second is that retention has the structure of a continuum, but protention can only be a bounded domain, since we cannot anticipate that which is yet to come. While the threads of retention set the stage for protention, protention cannot modify the retentional threads retroactively.[29]

Time and affect were never systematically treated by Husserl. A substantial part of his notes is still unpublished or is accessible only from secondary sources (see Appendix A). However, a deepening of his later analysis of time makes it possible to trace some important fragments of a view of affection as initiating the drive of the lived flow itself, as Natalie Depraz (1994) points out (linking it to the parallel question of the constitution of space, p. 70). My propositions in the remainder of this section are not entirely at variance with Husserl's later research and thus in continuity with what has been already developed here. As he says: "How is the self [*Ich*] the center of this life it experiences? How is it experienced? It is affected by that which consciousness is conscious of [*Bewußtsein bewußt ist*], it follows affect, or still it is attracted, held, taken in by that which affects it" (MS C III/1).

Husserl's notes contain recurrent references to this primordial aspect of the child's early life where one finds an "instinctive" intentionality (*Triebsintentionalität*). As Depraz remarks: "Affect is thus this non-form which makes constitution of the self by itself, that affects it in the strict sense of structure, that of constitutive temporality. . . . Affect is there before being there for me in full consciousness: I am affected before knowing that I am affected. It is in that sense that affect can be said to be primordial" (1994, pp. 73, 75).

How is this pertinent to the three-part structure of time? Husserl remarks that during a melody the sounds affect me differently as it creates its retentional threads, an attentional tendency (*eine Tendenz der Zuwendung*). Or we may say it provides a *disposition* that is marked by gradual intensities. This temporalizing effect puts protention at the center stage: "It is not only the impressions from hyle that affect, but already 'hyletical anticipations of data'" (Depraz, 1994, p. 79).

Philosophy did not abandoned time as a royal road to the study of affect after Husserl. Heidegger and Merleau-Ponty both have a great deal to say about the topic. The main innovation in their philosophies is the treatment of time as self-affectedness. As Merleau-Ponty says: "Le temps est 'affection de soi par soi,'" and notes that the expression derives from Kant as modified by Heidegger in his *Kantbuch*.[30] Self-affectedness becomes a key insight into the nature of consciousness: "Even the most precise consciousness of which we are capable is affected by itself or given to itself. The very word consciousness has no meaning apart from this duality" (Merleau-Ponty 1962: 488).

With Emmanuel Levinas (1988), a further sphere of affection, hetero-affection, is brought to the fore: alterity is the primary clue for time's constitution. We are affected not only by representations and immanent affection ("affection de soi par soi"), but by alterity as inseparable from the sphere of an ego-self. In this move the very distinction between auto- and hetero- ceases to be relevant, since in all cases it all is brought down to the same manifestation: it is a question of "something other," the experience of an alterity, a difference in the identity of the present, whether by the inevitable slippages to retention, or by the anticipations in protention.

But these philosophical discussions are not central for us here in all their detail (Depraz 1998). We are seeking to move beyond the apparent paradox between an original impression in time that would be colored by affection, or conversely, the primacy of affection that would underlie temporality. We seek a nondual synthesis whereby affect is constitutive of the self and at the same time contains a radical openness or unexpectedness concerning its occurring.

7.2. TRANSPARENCY AS DISPOSITION FOR ACTION

In order to move further we need to have a concrete base for our examination, much as the visual tasks provided the basis for the static analysis. Many alternatives exist, but I have chosen to explore the role of affection in the constitution of time in the context of active involvement in the world and through the dispositional quality of affect and its gradations. From the point of view of enactive cognitive neuroscience, coping plays a central role (see section 2.2). It should be kept in mind, however, that focusing on this region of affect is by no means exhaustive.

From the perspective of phenomenology, we are referring to the phenomenology of *immediate coping*, which finds its first expression in the study of affectedness (*Befindlichkeit*) as one of the constitutive moments of Dasein that Heidegger described in *Sein und Zeit* (division 1, especially chapter 3). As it is well known, Heidegger studied most particularly our involvement with the surrounding network of tools and equipment, in order to discover what kind of beings humans must be that such encounters are possible.

I am not going to repeat the key points of the constitution of Dasein, but examine more closely the observation that *both* equipment *and* the user show up as transparent in immediate coping. It is at this point that Heidegger's analysis is much more helpful than Husserl's. Heidegger calls this stance *Umsicht*, a kind of seeing that is not reflective or thematized in any way.[31] How is the user's transparency shifted to a conscious mode that brings nowness to the fore? As he says:

> Being in the world, according to our interpretation hitherto, amounts to a non-thematic, absorbed transparency [*unthematische, umsichtige Aufgehen*], in activities that are constitutive for the network of equipment at hand. Our concerns [*Besorgen*] appear the way they do because of the familiarity with the world. In this familiarity Dasein can lose itself in what it encounters within the world. . . . How can the worldliness of this familiarity be illuminated [*erleuchten*]? How can entities at hand be thrust to the fore by the possible breaks in the network of equipment being handled in which transparency "operates" [*die Umsicht sich "bewegt"*]?[32]

Heidegger points to how intentionality, in its traditional sense, can interrupt a flow of action. If, as I write this, I hit a control key, and I am shown a message saying "Do you really wish to erase this text?" I find myself deliberately avoiding pressing the "OK" button, in an emotional tone of hope and tension. The awareness of the possibility of making a fatal mistake breaks into the present, triggering a (more or less marked) shattering of transparency. In parallel, a new stance in ongoing coping emerges: I deliberately click on the "Cancel" button.

Thus Dasein is absorbed in the world, but malfunctions and breakdowns of various kinds can shift it back out of it. I use the word *transparency* here to indicate precisely this unreflective absorption. Transparency is but a description of that which can be broken in the flow of experience, hence its interest for our purposes here.[33]

When the carpenter hammers, the hammering action and its objects are transparent. Transparency is what it is because it is eventually broken, as when the hammer slips and lands on the finger. Such a breakdown brings the transparent equipment into view, and a new set of action-assessments begins. This standard Heideggerian vignette can be extended to all embodied actions, that is, actions in a fluid context where there is always a mixture of immediate coping and concurrent secondary activities of language and mental life. It is a disposition for involvement. Transparency is therefore always in the context of a series of ongoing action-behaviors. It is related neither to content nor to efficacy (cf. my faulty typing, or the carpenter's mistake). However, transparency is not obligatory, since an attentional tendency can produce its disappearance at various degrees of abruptness. In contrast to a breakdown in equipment, attention can also be *endogenously* motivated in a reflective gesture motivated by a critical review and design. The carpenter may stop to evaluate the quality of the wood before using it, or his relationship with his employer. Notice, in passing, that the gesture of carrying out phenomenological reduction is a loss of transparency by self-motivation. This can be seen as the form reduction takes in the Heideggerian lineage of phenomenology.

Transparency, then, is a readiness or dispositional tendency for action in a larger field of specific *ontological readiness*, that is, an expectation about the way things in general will turn out. For this very same reason transparency has everything to do with habitus, the recurrence of our lives. Learning a skill is a prototypical example of transparency acquisition. However, the temporal constitution of transparency is not limited to individual actions: it extends to the full span of human life, into history altogether. In the Heideggerian jargon, transparency and its dispositions extend into historicality.[34]

The loss of transparency is never distant from a dispositional affective tone, as we have seen. But we can now see that different degrees of breakdown in transparency and the multiple manners in which it happens opens a panoply of affective tonalities: fear, jealousy, anger, anxiety, self-assurance, and so on. Accordingly, the word "emotion" is used here in its specific sense: the *tonality of the affect that accompanies a shift in transparency*. Affect, on the other hand, is a broader dispositional orientation which will precondition the emotional tone that may appear. This is quite essential.

As I write now, I have a dispositional attitude that engages me in a anticipation of writing and shaping my thoughts into sentences. As I write this word now, the disposition is colored by an emotional charge, a moderate resentment for not finding the proper expression. But that emotional tone appears against a background of the exalted mood of a productive day devoted to finishing this text.

More explicitly, I want to distinguish three scales for affect, homologous (but not isomorphic) to the three scales of temporality used above. The first scale is *emotion*: the awareness of a tonal shift that is constitutive of the living present. The second is *affect*, a dispositional trend proper to a coherent sequence of embodied actions. The third is *mood*, which exists at the scale of narrative description over time.

7.3. EMOTIONAL TONE AS DYNAMICAL LANDSCAPING

Examined from this perspective, emotions cannot be separated from recurrent constitution, since the transparency of recurrent constitution is not deliberate, but part of unthematic coping. The embarrassment that accompanies a loud belch in a French restaurant is entirely transparent to a European; it seems the "natural" reaction to have. This unreflective appearance of embarrassment as affective tone is only perceived when, say, on a trip to the Middle East. The entire social phenomenon of eating and manners is cultural-historical, but this does not contradict the visible signs of bodily emotions that go with embarrassment—redness of the face, change of breathing, and tightness of facial muscles.

For the ethologist, affect and emotions are a relatively small repertoire of immediate dispositions that are physiologically inscribed in a species inheritance, although in most mammals, habit and sustained learning may shape this inheritance significantly.[35] Neurobiologically, affect and emotions can be associated with a relatively stable set of neural correlates (see, e.g., Damasio 1994). Studies of human emotional responses, even in relatively artificial situations, reveal the extent to which the biological endowment of "basic" emotional patterns is enfolded in the historical individual. Individual habits, historicity and language, constitute the palette of human emotional life incorporating the biological makeup to an end that is individually unique.[36]

Homologously, we can say that the experience of time has a biological base in elementary events (1/10 scale), but this basis is enfolded with other structures of temporalization into the specious present that is our theme. To deny that such a deeply rooted biological basis plays a role in the appearance of temporality is fruitless. Similarly, I am not reducing emotions to their empirical correlate in a reductionistic move. As considered here, emotions are an integral part of an ontological readiness. However, this should not obscure the fact that such an ontological constitution has roots in basic emotional dispositions inseparable from our history as living beings and from minute events in brain physiology.

When I induce a break in transparency following reduction when looking at the visual image of our task, I bring to it an emotional disposition which prefigures the change in my perception. In saying "I expect to see," I also provide exogenous, additional order parameters that alter the geometry of the phase space. This process of "sculpting" a dynamical landscape is intrinsically distinct from the trajectories that move within it, but form an inseparable unity.

In fact, it has been known for some time that the intention to carry out a movement is coupled with a change in emotional tone that varies in degree. As a global variable, induced changes in the dynamical landscape can be detected. One well-known case is the readiness potential. For a finger movement, a large, slow electrical potential can be measured over the entire scalp which *precedes* by a fraction of a second the beginning of the motion, and the subject's ability to report that he has decided to initiate the movement.[37] This is not a correlate of intention (as it is sometimes described), but it does give a concrete idea of how vast a reconfiguration of a dynamical landscape is involved at the origin of a fully constituted now (moving the fingers). In the results of Leopold and Logothetis (1996) already mentioned, a similar reconfiguration of the disposition for firing of individual neuronal responses is visible some 100–200 msecs *before* the monkey indicates that it has switched to a new percept.

Why is all this relevant here? Because it is direct evidence of the manner in which emotional tonality plays into the dynamics of flow. Emotional tonality is, by its very action, a major boundary and initial condition for neurodynamics. This diffuse, constitutive effect is in accord with the mechanism of action via neurotransmitters that have been known for some time to condition the modes of response at the neuronal level, as the body of knowledge of psycho pharmacological agents attests.

This sketch of the nature of protentions via affective tonality has taken us to a third and final step of what seems to be, in formal terms, a genetic constitution of temporality. I have introduced a final dynamical principle that applies to neurocognitive dynamics as well. I refer to the mutual bootstrap between the phase space landscape and the specific trajectories that move in it, and the fact that the very same trajectories provide the very conditions for an embodied coupling, since through their coupling they shape their dynamical landscape. Metaphorically, the walker and the path are intrinsically linked.

This bootstrap principle seems to be present in a variety of natural systems and has recently been referred to as "operating at the edge of chaos," or "self-organized criticality." For example, this idea provides a renewed view of evolution, since it provides an answer to the old nature (genetic expression) versus nurture (environmental coupling conditions) dilemma. In this synthetic view (cf. Kauffman 1993) the relation between natural forms (the *Baupläne* of organisms) and the selection process in their ecological embeddedness is not one of contradiction but precisely a mutual imbrication when seen through dynamical glasses.[38] This built-in shiftiness, enfolding trajectories and geometry, gives a natural system a possibility of always staying close to regions in phase space that have multiple resources (e.g., at least two in bistable visual perception).

To conclude: The generic structure of double intentionality proposed by Husserl is, I submit, of this class of dynamical bootstrap, and the analysis of affect and emotional tonality can give the evidence for it.

8. NOWNESS: NEW FIGURES OF TIME

To gather all the threads that have been developed here, and to echo the tradition started by Husserl himself, I would like to propose a new figure of time, the *fourfold structure of nowness* (Figure 9.5).

This is not so bold or far-fetched. By now it seems clear that the point-by-point, linear time depiction at the base of the figures of time is insufficient. One major improvement is to introduce, then, not lines but flows, *dynamical* trends. A second major improvement is to take into explicit account what surfaced in the later work of Husserl himself, the central role of double intentionality, static constitution, and genetic constitution. This final ingredient gives to the homologies between the constitution of space and time the preeminence they deserve. I do this by taking the *center/fringe* structure as the very core of a new figure of time. Once these three basic aspects have been incorporated a new representation falls into place quite naturally.

1. To start, let us consider the role of dynamics that has been central in our development, and hence move away from the use of discrete points in a line as in the traditional diagram. Not only do we leave behind a line geometrical figure, but we must introduce an *asymmetry* into it. Concerning static constitution, we have discussed two different kinds of dynamical ideas:

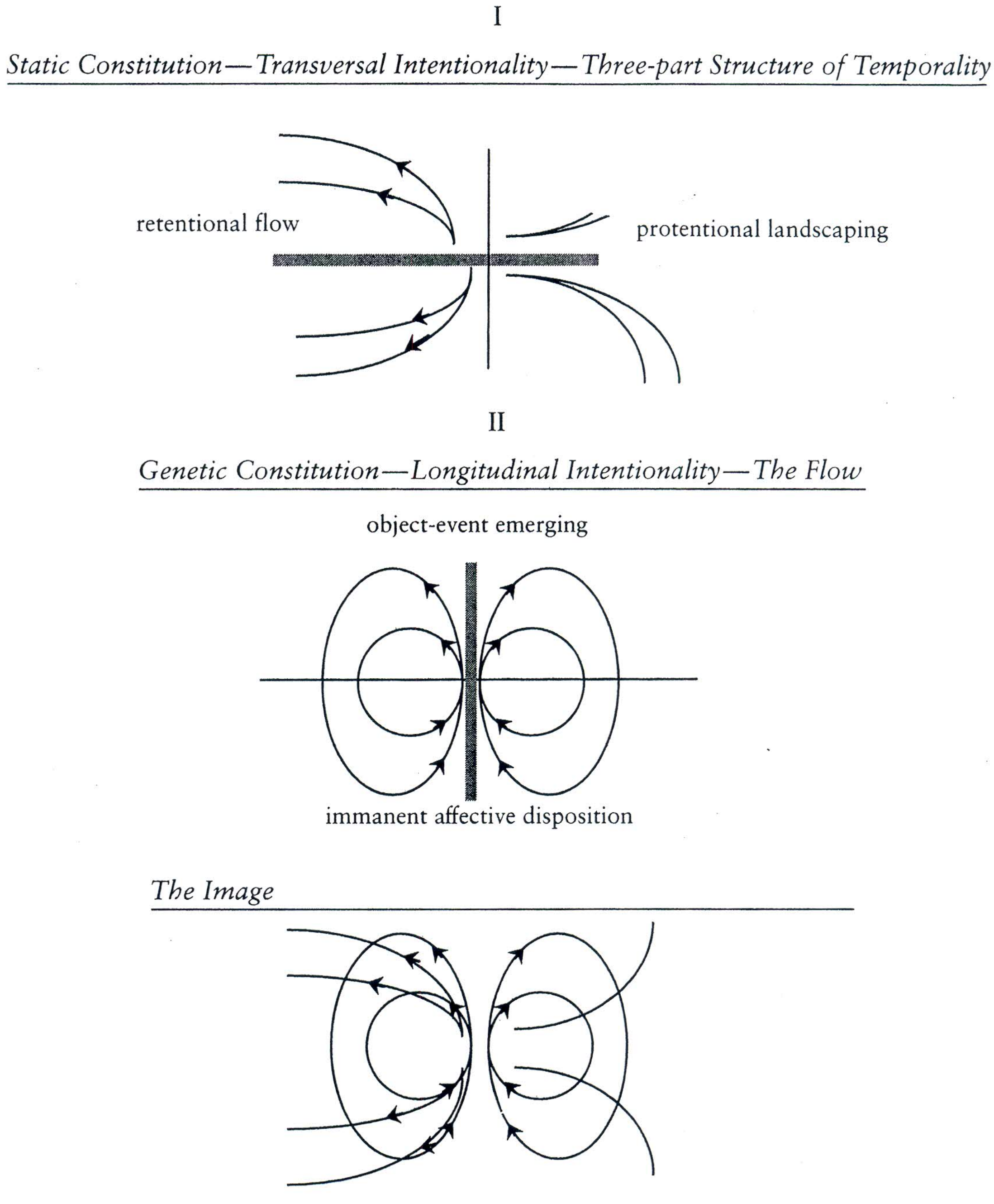


FIGURE 9.5. The fourfold structure of nowness. The new figures of time resulting from the neurophenomenological analysis presented here. For an explanation, see section 8.

retentional trajectories (the past) and order parameters for anticipation (the future). In the new diagram the dynamical quality is displayed by arrows on lines, as is traditional in mathematics, but I distinguish trajectories from anticipatory landscaping by dropping the arrowheads in Figure 9.5 (I). Concerning genetic constitution, we also have two distinct ideas: the immanent temporalization of self-motion and the directed intentionality relative to a position in phase space.

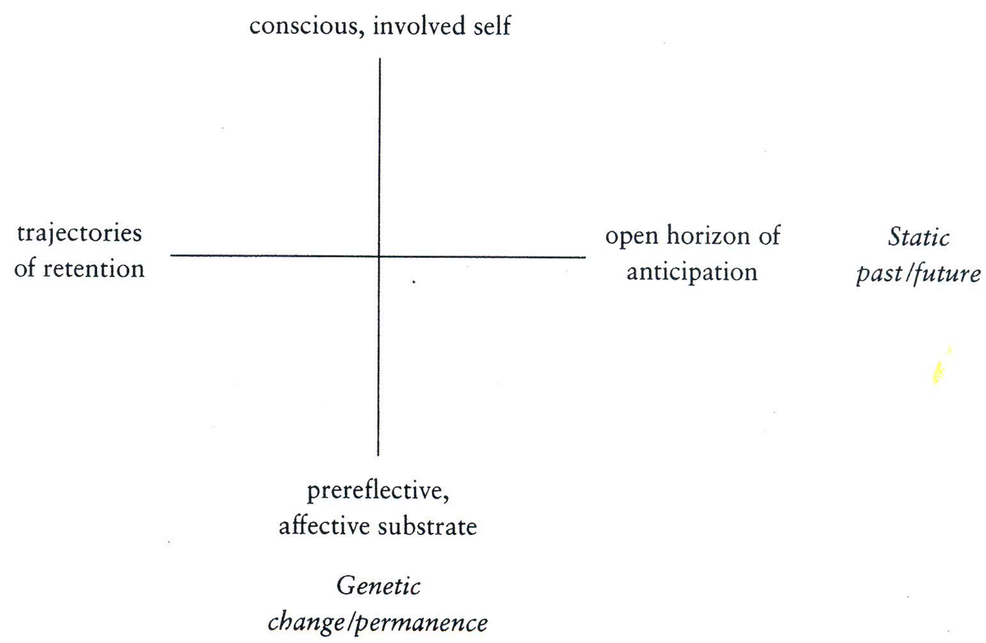
Dynamical Ingredients

trajectories of retention	order parameters of anticipation	*Static* *past/future*
transient attractors intentional content	self-motion of generic instabilities	*Genetic* *change/permanence*

2. Next we consider the spatial ingredients, that is, the role of a center-periphery configuration at the core of temporalization. Concerning static constitution, we of course recover the retention-protention axis. Again, these are asymmetrical, since retentions recede into past, but the protentional fringe is an open horizon of anticipation. Thus we find again that the center-periphery structure does not provide all the necessary distinctions, since the fringes as they move away from the center become qualitatively different. As to genetic constitution, the fringe reappears in the preconscious, affective substrate (permanence) on one direction, and in the conscious, embodied ego, aware of emotional change on the other (change).

We thus arrive at ingredients that come in *two sets of four*. The center/periphery configurations are analogous in the spatial and dynamical schemes, since they underscore the paradoxical nature of past in the present, and of change within permanence that puzzled Husserl (and many others) throughout his work. These pairs are, then, the wooden irons of the figure of time. I

Spatial Ingredients



do not presume to have resolved these paradoxes, only to have given new insights into them.

Fundamentally, there is an added insight that comes from the fact that the component ingredients have a *generic* link between them, an internal interdependence that has been explored throughout this essay. In other words, not only are the new figures of time graphical combinations of items, but they display links that are not only descriptive but effective. Phenomenologically, I have stressed the full *interdependence* of both intentionalities, the inseparability of the static and genetic analyses, and the mutual determination of instinctive and cognitive constitution of self. In parallel, the trajectories and the landscape of their phase space are a unity in a complex nonlinear system. Correspondingly, we have examined the many aspects under which determinism, the trajectories, regions in phase space, and adaptive geometrical landscapes are complementary. I consider these mutual interdependencies and their role in the constitution of temporality the most immediate insight that naturalization can provide.

With these elements in position, time, as I said, falls naturally into place. Figure 9.5 places these ingredients in relation to one another, both in terms of the role of dynamics and space, and with regard to the circular causality for the longitudinal but not for the transversal intentionality. Since the order parameters for protention do not influence retroactively the system's history, we arrive at an asymmetrical fourfold figure of time.[39]

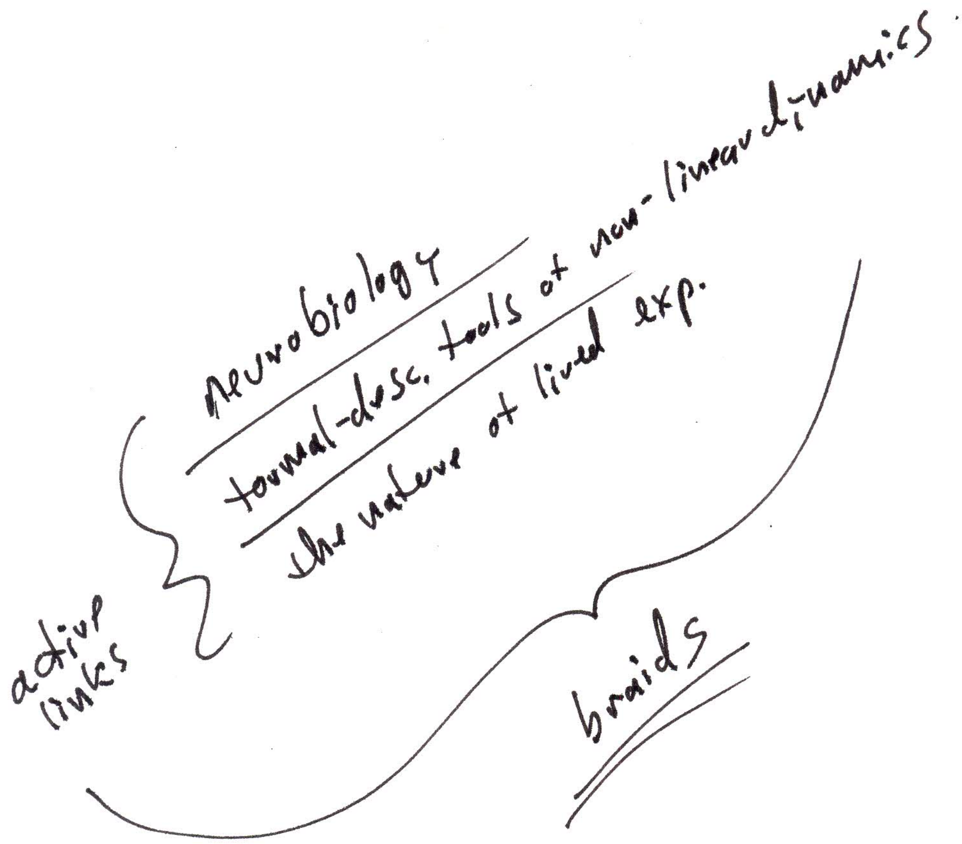
We are now in a position to stand back and reconsider our analysis of temporality. Has neurophenomenology passed the acid test? Let us return to the neurophenomenological research program: the circulation between the external and the experiential. In Varela 1996 the neurophenomenological working hypothesis was stated as follows:

> *Phenomenological accounts of the structure of experience and their counterparts in cognitive science relate to each through reciprocal constraints.*

On the one hand, we are concerned with a process of external emergence with well-defined neurobiological attributes, on the other, with a phenomenological description that stays close to our lived experience. The nature of the sought-after circulation one seeks is no less than that of *mutual constraints* of both accounts, including both the potential bridges and contradictions between them. What is the specific nature of the passages between these two accounts in the case at hand? What have we learned in the specific case of immediate temporality?

One thing is clear: the specific nature of the mutual constraints is far from a simple empirical correspondence or a categorical isomorphism. Three ingredients have turned out to play an equally important role: (1) the neurobiological basis, (2) the formal descriptive tools mostly derived from nonlinear dynamics, and (3) the nature of lived temporal experience studied under reduction. What needs to be examined carefully is the way in which these three ingredients are *braided together in a constitutive manner*. What we find is much more than a juxtaposition of items. It is an *active* link, where effects of constraint and modification can circulate effectively, modifying both partners in a fruitful and complementary way.

A proper analysis of this relationship cannot be done here, and I must close by referring the reader elsewhere for its presentation (Varela 1997). But at least it could be said that the neurophenomenological research program that emerges from this study reaches beyond hopeful declaration to reveal an open road for exploration.



Appendix A: Edmund Husserl's Research on Time Consciousness

Husserl's work on time has been a difficult and active field of investigation for phenomenologists for half a century. Since the avatars of the publication of Husserl's work and the secondary literature is of some significance for us here, I will briefly outline it. The saga unfolds in four acts.

1. THE *LESSONS* (1928)

In 1917 Husserl requested his assistant Edith Stein to prepare his work on temporality for publication. He provided her with texts from his 1905 seminar, but included some from as far back as 1901 and as late as 1917. Stein carried out her task during 1917, putting aside more than half of the sources and rewriting the texts extensively, including titles and section headings. She turned her work in to Husserl in September 1917. But, as was often the case with Husserl's requests to his assistants, he then decided to introduce new, significant revisions and postponed its publication. It was only in 1927, after discussing with Heidegger the imminent publication of *Sein und Zeit*, that Husserl apparently went back to Stein's work and sent it to Heidegger. Although Heidegger added only minor changes, the book appeared under his nominal editorship with the title *Vorlesungen über das innere Zeitbewußtsein aus dem Jahre 1905* (Halle 1928). (The English translation by J. S. Churchill, *The Phenomenology of Internal Time Consciousness*, appeared in 1966.)[40] For modern presentations based on this early material, see McInerney 1991 and Miller 1984.

2. THE BOEHM EDITION (1966)

The *Lessons* can adequately be described as Stein's very personal rendition of the original texts. Shortly after publication, several readers realized to what extent her influence had marked the only available material of Husserl's research. The French translator of the *Lessons*, Henri Dussort, had already raised this issue but could not complete a new edition closer to the originals. In 1966 Rudolf Boehm produced a critical edition, available as Husserliana X, *Zur Phänomenologie des inneren Zeitbewußtseins (1893–1917)* (abbreviated here as *PZB*). Boehm's work provided the public with a wider selection of writings, a careful chronological analysis of the 1928 edition, and several unpublished appendices and sketches. Rudolf Bernet has also provided some comments on the complementary texts to the Boehm edition (Bernet 1985), with some new indications about dating and an introduction. This edition provided for the first time a broader reading of his work, and it has been the main source of virtually all published work since. It is also the main source for this essay, along with the excellent introduction by Brough (1989) who has provided an English translation of *PZB* (1991).

3. THE BERNAU (1917–18) MANUSCRIPTS

Interestingly, Husserl wrote a significant amount of work during 1917–18 in Bernau. Sometime later (in 1928?), he turned his notes over to his assistant Eugen Fink for revision. Revising these *Bernauermanuskripten* was to take Fink from 1928 to 1935, a long adventure indeed and one that can now be traced in detail thanks to the meticulous work of Richard Bruzina (1993, 1994) and that constitutes in itself a rich source of information about the research carried out jointly by Husserl and Fink. Fink kept these manuscripts until his death, and they were not available at Louvain for Boehm's edition in 1966. A critical edition is not yet available (but is in preparation by Iso Kern and Dieter Lohmar); some texts also appear in *Analysen zur passiven Synthesis (1918–26)*, Husserliana 11, 1996.[41]

4. THE "SPÄTEN ZEITMANUSKRIPTEN" (1929–35)

The so-called late manuscripts are the last addition to the saga we are tracing. They compose Husserl's last corpus of work on time, space, and intersubjectivity. They are as yet entirely unpublished, and correspond to Group C of the manuscripts in the Husserl Archives in Louvain. Nevertheless, important extracts have been made available in books by Gerhard Brand (1955) and Klaus Held (1966). For this essay, I have relied on Depraz's (1994) discussion on temporality and affect in these late manuscripts.

Appendix B: Nonlinear Dynamics and Neurocognitive Events

This is a bird's-eye view of nonlinear dynamics from the point of view of its relevance to neuroscience. It is intended only as a complement for the readers of this essay for whom this is an entirely foreign domain of modern science. For further reading, Port and van Gelder 1995 and Arbib 1995 are excellent recent sources; Ott, Sauer, and Yorke 1993 is more technical but of great value.

1. BRIEF HISTORY

Probably the first to see the difficulties and possibilities of chaotic dynamical systems was Henri Poincaré at the turn of the twentieth century when he was working on the problem of three celestial bodies under mutual gravitational attraction. Poincaré analyzed orbits resulting from sets of initial points and found very complicated behavior, which we would call chaotic today. Despite theoretical work on chaotic dynamical systems by several mathematicians (like Stephen Smale or the Soviet school of A. N. Kolmogorov in the 1950s), it took a long time for researchers in other fields to recognize the "reality" of chaos in nature and to turn their attention to the strange behavior of some nonlinear dynamical systems. Milestones on the way toward public recognition of the new phenomena in the 1970s were articles by Edward Lorenz (on the weather), Robert May (on animal populations), and Otto Rössler (on chemical reactions), who announced their findings with titles like "Simple Mathematical Models with Very Complicated Dynamics." The accent was on the fact that these systems produced irregular and almost random-*looking* behavior though they are perfectly deterministic. Immediately the question arose, how many of the observed irregularities found in nature were due to such nonlinear motion, that is, follow deterministic rules despite their random appearance.

2. BASIC CONCEPTS

Nonlinear dynamics (= chaos theory = complexity theory) is a recent field of research rooted in mathematics but also in physics and other natural sciences. Rigorous definitions have only evolved with the discovery of more and more surprising dynamical effects.

It is perhaps best to start with the notion of a *state or phase space*: a domain of variables or measurements which attempts to completely specify a given process. Such specification is a law or a *rule*, and these systems are therefore *deterministic*, in contrast to random dynamical systems. The sequence of subsequent states evolving according to the dynamical rule describes a *trajectory* in state space. In the case of continuous time, the system is defined as a *flow*,

$$f{:}S \rightarrow S \quad z_{t+1} = f(z_t)$$

Smooth flows can be differentiated with respect to time, giving a differential equation

$$\frac{dz}{dt} = F(z, t)$$

The number of first-order differential equations, or equivalently the *dimension* of the state space, is referred to as the order of the system, sometime as its number of degrees of freedom. A *periodic* point is one to which the flow or map returns after some time. Experimentalists are mostly interested in dynamical systems defined on a state space $\Re^n$ (n real-valued measures) or subsets thereof, since these state spaces have been proved useful for the description of natural phenomena. We distinguish finite dimensional systems, which may be defined as maps or ordinary differential equations and infinite dimensional systems, defined for example by partial differential equations or time-delay differential equations.

We speak of *linear dynamical systems* if the function F is linear, that is, if

$$F(\alpha x_1 + \beta x_2) = \alpha F(x_1) + \beta F(x_2)$$

holds. Stated in ordinary language: for linear systems the whole *is* the sum of its parts. Solutions that move away from the origin exponentially in time are called *unstable*, while solutions converging exponentially toward the origin are called *stable*.

All dynamical systems which are not linear are called *nonlinear*. This name by exclusion might seem surprising. As Stanislav Ulam is said to have remarked: "Calling a science 'nonlinear' is like calling zoology 'the study of non-human animals.'" Yet the distinction has been necessary in the natural sciences, which is so accustomed to linear systems. The discovery of new forms of dynamical behavior unrestricted by linearity is one of the greatest achievements of the twentieth century.

3. DEFINING CHAOS

There is as yet no universally accepted definition of chaos. Typical characterizations of chaos are based on low-dimensional (i.e., not higher than five or six), bounded dynamics with sensitive dependence on initial conditions. The bounded region where the dynamics turns may not be decomposable into separate parts. Note that the first two parts of this description are common. Linear systems with stable dynamics remain bounded in phase space; linear systems with unstable dynamics show sensitivity to initial conditions. What makes a system chaotic is the combination of the two. This combination can only be obtained in nonlinear systems.

The mathematically rigorous definition of chaotic behavior in deterministic systems still raises problems, particularly since not all kinds of behavior that would intuitively be called "chaotic" are known yet. For example, the older definition of chaos requiring a dissipative system with a strange attractor is out of date. As more and more of the unexpected behavior of nonlinear dynamical systems is found, the mathematical concepts eventually will converge. In fact, the science of nonlinearity resembles a sea of ignorance with some small islands where results are known and applicable, as shown in the sketch below (which I owe to Thomas Schreiber).

Apart from the basic ideas sketched above, in the study of neural systems some tentative ideas (some indicated in the chart below) have proved quite important for neuroscience and are used in the present study as well. In fact, when considering a large ensemble of complex interacting components such as the brain, one is quickly confronted with the issue of *self-organization*. These are distinguished, salient states of motion in phase space which arise from the *reciprocal or collective cooperation between components*, quite independently of outside inputs. These patterns can be modeled by the same tools as other dynamical systems, and are constrained by order parameters (such as initial and boundary conditions). An explicit example is found in Appendix C, and a less formal description in the way in which visual multistability was presented earlier in this essay. These large collective ensembles are typically quite *unstable*, as we saw before (see Figure 9.4). This instability leads to more or less frequent shifts from one pattern to another, and these transitions are a topic of intense interest today. These are referred to as *bifurcations* (from a given state), or as *phase transitions* (see Figure 9A.1).

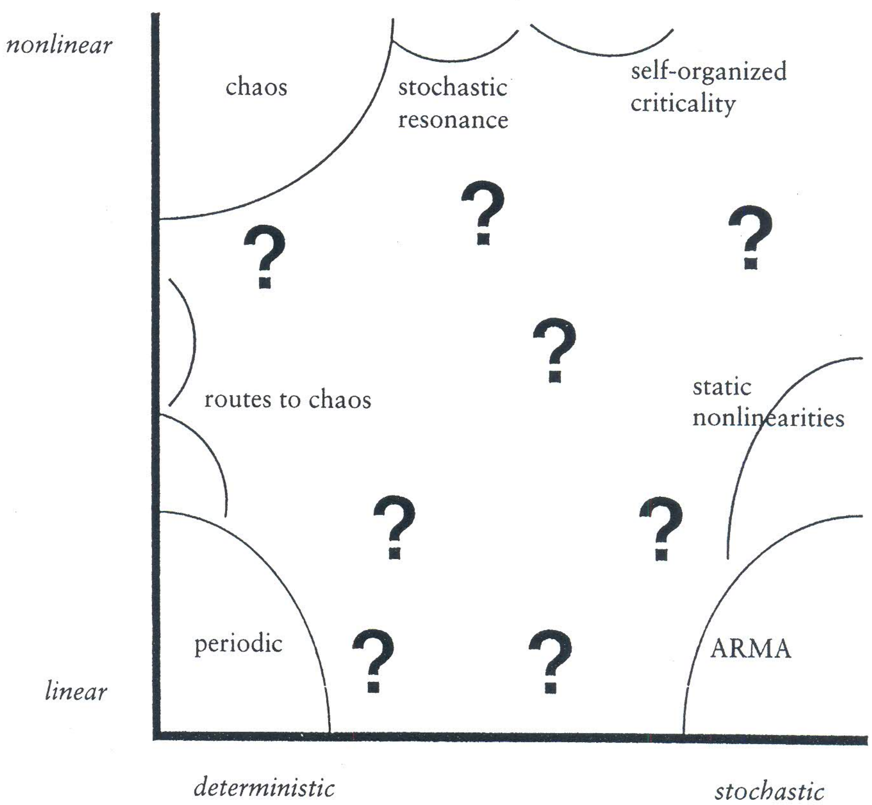


FIGURE 9.A1. Dynamics: a current cartography.

4. A BRIEF SKETCH OF SOME LINEAGES IN NEURODYNAMICAL RESEARCH

The use of dynamical tools in cognitive neuroscience has come from several relatively independent lineages of research.

The early tradition of Gestalt psychology founded by Wolfgang Köhler and W. F. Koffka is explicitly dynamical although they did not couch their results in that language. But their influence has echoes even today. One of the influential representatives is René Thom with his neo-gestaltist ideas issued from his work in bifurcations, and elaborated extensively by Jean Petitot.

A second lineage comes from the interest of physiologists working in motion and behavior. In the early 1950s in Russia, A. Bernstein produced the first fully dynamical account of coordination on neural terms, and at the same time in Germany, Erich von Holst provided pithy detailed examples that were among the first to incorporate phase portraits and instabilities. This tradition is still active today in the work of J. J. Gibson and J. S. Kelso, for example.

A third trend issued from the early cybernetics movement in the 1950s in the United States, especially from the influential work of Warren Mculloch, Arthur Rosenblatt (who is the pioneer of modern connectionist views), and Heinz von Foerster. From this lineage we owe the inspiration of Walter Freeman, who was the first to explicitly introduce the notion of ensemble synchrony and phase coherence as a key mechanism in neurocognitive pattern formation.

Appendix C: Neuronal Synchrony via Coupled Oscillators

To make my ideas quite precise, it is important to work on the basis of an explicit dynamical model for the emergence of synchronous neuronal assemblies. The model introduced here focuses on a subset of middle-layer pyramidal neurons known to play a role in cortical coherences: the intrinsically bursting cells (IB).[42] The IBs are distinguished by their ability to generate clustered bursts of several spikes riding upon a slow depolarization wave, followed by a large hyperpolarization. Since the IBs possess an extensive tree of divergent axons extending far into the horizontal dimension of layers IV–V, they are likely to contribute to an excitatory interconnected network responsible for the organization of large numbers of neurons into macroscopic space-time patterns of transiently coherent activity. Furthermore, many of the cells in layer V can generate rhythmic bursts in the range of 4–10 Hz and are believed to play a significant role in cortical rhythmogenesis.

Relatively little attention has been paid to the possible significance of such slowly bursting components for temporal binding. We suggest that populations of interacting bursting neurons with slow rhythms, such as IBs, are a natural candidate for the generation of synchronous assemblies. Our analyses of synchrony among a network model of intrinsically bursting neurons demonstrate that cellular discharges can aggregate into separate phases and display regular time lags between their rhythmic spike trains. Global feedback inhibitions associated with the tonic depolarization of the coactivated bursts play a leading role in the phase aggregation by the sculpturing of the activities with hyperpolarization. If our conjecture is relevant, various brain oscillations (including the gamma range, 30–80 Hz) may be considered as time sequences of more elementary components, as discussed in section 2.2.

Two basic questions are raised by our view. First, how can the slow rhythmic bursting neurons become mutually synchronized fast enough, and, second, how can coexisting synchronous aggregates be distinguished or labeled for further integrative processes? IB cells are characterized by two distinct time scales of the membrane potential: a slow dynamic corresponding to the smoother phases (bursting and the quiescent repolarization), and a fast one corresponding to the sharp transition between them. Generically, systems that exhibit such behavior can be characterized as relaxation oscillators. The Fitzhugh-Nagumo equations (FN) are representative of this class and provide a mathematical formulation of IB intrinsic rhythmicity on the basis of ionic gatings. Basically, these two-dimensional equations describe the repetitive interplay between fast and slow time scales in biological membranes:

$$\frac{dV}{dt} = f(V) - u(t) + I(t)$$

$$\tau \frac{du}{dt} = aV - (1 - a)u$$

ing the cell, t is a time constant specifying the scale difference between fast and slow time scales, and $f(V) = V(V - 1)(V + 1)$ is a nonlinear function that mimics the N-shaped relationship between the fast membrane currents and the cell potential V. In the phase plane (V, u), V increases during the upper solution of u (depolarization) and decreases during the lower stable solution (hyperpolarization). When either end of the bistable region is reached, V abruptly jumps to the other branch, the transitional points being given by the nullclines $dV/dt = du/dt = 0$.

A realistic feature of this model is that when the oscillator is perturbed by an arriving spike, the oscillation may be rapidly reset via the fast jump onto a new phase, depending on the moment of arrival of the perturbation. A phase resetting can be induced by briefly making I negative during the depolarization: the key consequence of this inhibitory pulse is to displace the nullcline $dV/dt = 0$ in the space (V, u) of the oscillator, and therefore modify the position of its transitional regions, leading to a premature hyperpolarization. Because of their sudden-transition possibilities and because the rate of change of the slow variable $u(t)$ before the sudden transition is less than after the jump, a spike shared by two oscillators can readily induce a quick phase-locking of their activities.

In brief, this dynamical behavior means that neuronal relaxation oscillators (such as cortical IBs) naturally afford a mechanism for synchronization as a consequence of various excitatory and inhibitory feedbacks mediated by recurrent local circuitry. In fact, fast GABA-mediated inhibitory interneurons are known to play an important role in the organization of local coherence in the neocortex. This synchronization of ensembles is validated by simulations concerning populations of IB-like neurons randomly connected with varying degrees of strength in connectivity, and all under a common GABA-like common inhibitory control. Increased common inhibition increases the degree of spatial synchronicity, that is otherwise patchily distributed over the array of simulated neurons. Recent results from hippocampal slices confirm this idea quite elegantly (Traub et al. 1996).