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CONCERNING THE TIME SENSE: THE SEVEN PILLARS OF TIME PSYCHOLOGY

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What does it take to formulate a coherent psychological theory about our experience of time? There is no received view from which we can draw an undisputed set of criteria for qualifying such a theory. It will be argued, however, that there is enough common territory among the prevailing views on psychological time to propose a preliminary and perhaps incomplete set of seven such basic criteria.

INTRODUCTION

The history of psychology could well be written in terms of an interesting periodic phenomenon: periods of extensive theory building alternate with periods in which fact finding gets the upper hand, even to an extent that theory building is considered suspect. The latter trend is, in fact, likely to cause an explosion of data that some authors consider a sure sign of the deplorable state of psychology as a serious scientific enterprise. Recently an increasing number of authors declared themselves bothered by what they perceive as an incoherent accretion of useless data (e.g., Koelega, 1993; Newell, 1992; Staats, 1983). This may well be indicative of another era in which theorists are getting, once more, the upper hand. Tell-tale signs are, among others, such recent books as Allen Newell's (1990) *Unified Theories of Cognition*, or Daniel Dennett's (1992) *Consciousness Explained*. Following this trend it would seem timely and appropriate to establish a coherent theoretical frame for the psychology of time. This is a Herculean task, however, perhaps even an impossible one and I am not about to attempt such a framework in this paper; neither will I question the likelihood of success of such an effort in the future. Instead I wish to

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consider what it will minimally take to formulate such a coherent theory of our notions of time. Although there is, as yet, no undisputed set of criteria, the seven foundational questions to be discussed in this paper all must be answered in the context of any psychological theory of time that merits our attention. I start from the assumption that there is something we may well call a *time sense* This term does not refer to anything like a sensory system; at best it is a metaphorical label for a complex of mechanisms, processes and strategies allowing us to cope with the dynamic world around (and inside) us. The first question deals with the nature of the input to this 'time sense.' The second question requires the theorist to explicate the level or levels of explanation at which the phenomena covered by his or her theory are to be explained. Preferably a theory should be concurrently explicit at all three levels defined in this section. The third question deals more specifically with the assumptions a theory makes about the first level, that is, about the underlying architecture of the time sense. As is argued in relation to the fourth question such an architecture should be able to accommodate the two main appearances of psychological time: *implicit timing*, the unreflective answering to the requirements of the dynamic world in which we are living and the conscious reflective act of *constructing 'time'* as our advanced ways of coping with that world. Implicit timing and explicit constructive time both rely to a major extent on spatial relations, either directly, in the timing of behavior, or indirectly by using space as a metaphor; the fifth question to be discussed demands that theories of the time sense be explicit on this issue. The last two questions deal with the ways our experience of time is connected to the dynamic properties of our psychophysical apparatus as such, that is, with dynamic memory as the carriage for acquired skills and knowledge (question 6) and the development of our time sense (question 7).

QUESTION ONE: WHAT ARE THE FUNCTIONAL STIMULI FOR OUR "SENSE OF TIME"?

This first question concerns the functional stimuli that serve as the building bricks for our experience of time. Psychologists usually take it for granted that the experienced world is real and, at least to a first approximation, pretty much the way we perceive it. If reality were totally different from the way we experience it, so the argument runs,

the effort required to cope with the contingencies of the environment would become infinite and the human species could not have evolved. Apparently our mental models of the world work so well because they are constrained in ways that quite closely resemble the laws of nature. The argument was introduced by Herbert Spencer, who thought of evolution as "adjustment of inner to outer relations" (Spencer, 1855, p. 374), but found its modern formulation in the work of Lorenz (1977) and Piaget (1980). Within the uncontroversial context of garden-variety scientific realism most philosophers and physicists will acknowledge the changing nature of the world (e.g., Davies, 1981; Grünbaum, 1968). Psychologists also subscribe to this position, the crucial questions for them being (a) what mechanisms and brain-based processes are there to help us represent change and (b) how can a conscious experience of time eventually proceed from these processes? In the opinion of most natural scientists the raw materials from which we can build our experience of time, are quite impoverished: simultaneity and succession of events may be the only attributes that can be defined without reference to a sentient observer *imposing* a temporal structure. Other fundamental aspects of time are not represented directly by anything in nature. Davies (1981), for instance, maintains that the *flow* of time is not a property of the physical world, but an addition "to the world as we perceive it in absence of specific physical stimuli that could possibly generate [this flow]" (o.c., p. 63). This view, however, does not answer the question why there should be such a thing as the experience of temporal flow in the first place, if there would be nothing in the physical world that the notion of flow would represent. Psychologists and biologists, therefore, usually adopt the view that the world has an intrinsic temporal structure which is, somehow, picked up by the organism. Among the most outspoken defenders of the latter position are Jones (1976; see also Jones & Boltz, 1989), Freyd (1987, 1992), and most recently Leyton (1992). Jones holds the view that there are rhythmic patterns that people (and animals) will spontaneously attend to and that influence their perception and manipulation of reality in specific ways. Freyd stipulates the dynamic character of information inherent in perceived events: a picture of a windblown tree contains information about its history. This view has been carried to a rather radical position by Leyton who holds that time, understood as the causal history of objects, is precisely what is extracted from forms perceived in the present. Recently Dennett and Kinsbourne (1992) have added another

dimension to this debate. They argue against the classical view that conscious awareness of the present is based on an integrated representation of the situation, and in favor of what they have called the Multiple Draft Model. This model holds that the manifold of perceptual and cognitive mechanisms that the organism has at its disposal when it acts *vis à vis* its world, will yield a multitude of outputs, each of which may be processed further depending on the evolving situation. In other words, results become available to higher processing units in a partially ordered fashion. The authors do, however, claim that the Multiple Draft Model can explain a number of empirical results that other approaches fail to accommodate, a claim that has met with considerable scepticism (see the peer commentary accompanying Dennett & Kinsbourne, 1992).

QUESTION TWO: HOW DOES THE THEORY DEAL WITH "LEVELS OF EXPLANATION"?

Paul Fraisse has acknowledged the need for several modes or levels of explanation (see Michon, 1993). At the same time he warned for the dangers of mixing or confusing explanations of different levels. The consequences may be disastrous: mixing levels is likely to introduce pernicious homunculi and vicious circles in our theories. Numerous authors, among them Dennett (1978, 1987), Herrmann (1982), Michon (1984) and Newell (1982), have identified various dangers facing the theorist who wishes to establish a cognitive theory. This general *caveat* also applies to theories of the time sense. In the context of time psychology I have, elsewhere, distinguished three levels of theoretical discourse: (a) time as the product of an array of psycho-biological clocks and regulators (or 'switches'); (b) time as the product of temporal information processing; and (c) time as the product of a dynamic and potentially selforganizing structure (Michon, 1985b). In a sense these three levels are independent. Although every temporal behavior is ultimately constrained by the available psychobiological architecture, there is no need to assume that the conceptual units in which we describe temporal behavior at the higher levels must correspond with units at the lower clock- and-regulator level. Different combinations of clock mechanisms may generate identical behavior in different individuals, or even in the same person at different times. Similarly different behaviors may achieve the same goal. It should be

emphasized that there is a strong and non-arbitrary resemblance between these three levels and the levels of psychological explanation in general that have recently been proposed by Dennett (1978, 1987), Pylyshyn (1984), and others. The clock-and-regulator level coincides to all practical extents and purposes with physical or architectural levels identified by these authors. Considering time as information is inherently the same thing as viewing it from the point of view of design, function, or syntax. Finally the third, dynamic level of time-in-context bears all the marks of being an intentional, or semantic level of explanation. This co-incidence suggests that time psychology has indeed acquired a structure similar to mainstream psychology, something it has been lacking for a very long time (Michon & Jackson, 1985).

QUESTION THREE: WHAT MAKES UP THE ARCHITECTURE OF THE HUMAN SENSE OF TIME?

The third question deals more specifically with the three-tiered approach discussed in the preceding section in concrete terms, that is, in terms of mechanisms, processes, and strategies.

Mechanisms: Clocks and regulators

Humans (and animals) have an almost unlimited number of timing mechanisms at their disposal (Moore-Ede, Sulzman, & Fuller, 1983; Richelle & Lejeune 1980; Lejeune, 1993). The ability to resonate or tune to exogenous regularities is one of the fundamental characteristics of living organisms, anchored deeply in their genetic endowment. Almost every physical or mental function can be recruited to assist in this tuning. The importance of the ability to pick up order in the environment should be evident: any organism that does not possess such a disposition would be fundamentally maladaptive and consequently stand little chance of survival. However, the tremendous flexibility of our clock architecture makes it a rather opportunistic system from the point of view of the cognitive psychologist. Richelle and Lejeune conclude at the end of a comprehensive analysis of the available literature, that "multiple time bases are continuously constructed in response to the particular requirements of each situation and replaced by others when they become useless" (Richelle & Lejeune,

1980, p. 165). Apparently then, there are no systematic rules that can unambiguously explain why one internal clock is, or should be, preferred over another. In other words, as a theory about human time experience this level of explanation does not impose enough constraints on the situation. The limitation of the clock-and- regulator level of discourse is that it underdetermines the processes that are required to account for a whole range of behaviorally and cognitively meaningful distinctions. In other words, clocks can only keep time, but psychologically there is more to time than just the keeping of it.

Processes: Time as information processing

A different frame of reference is indeed needed if we wish to describe how different temporal contingencies (sequential patterns of events) elicit coping responses or strategies, irrespective of the way the organism can neurophysiologically encode or store these patterns. The question now becomes what functional relations about order and change in the world are encoded, stored, retained, retrieved and used. In short, the question is how the rich 'phenomenology' of our experience of time can be derived from the rather simple temporal information the world is actually offering us. When the information processing approach was first adopted in time psychology several attempts were made to account for the variations in subjective duration. Michon (1964, 1967) for instance, held the information transmission rate in the organism (complexity per time unit) responsible. Following this lead, Ornstein (1969) suggested the memory capacity required for storing the information contained in an interval. Block initially proposed the effort required in the encoding and retrieval of information (Block, 1974), but later moved to what he called "contextual change" (Block & Reed, 1978; Block, 1990). Since then numerous further serious attempts have been made to distinguish temporal information (about order, date, and duration of events) from non-temporal information (such as phonological or syntactic information in speech) and to specify the various ways in which the two interact. Indeed every full blown theory of the time sense will have to provide an explicit account of the syntax of temporal information processing: unless a consistent and coherent syntax can be formulated for our temporal information processing no well-formed theory of the time sense can possibly emerge.

Strategies: Time as a dynamic conceptual structure

It is now becoming more widely accepted that interactions between temporal and non-temporal information are in fact the body and substance of time experience. Temporal information cannot be separated in a meaningful way from the structure of events as such. On this view events (meaningful transitions from one definite state of the world to the next) and episodes (meaningful series of events) carry an intrinsic temporal structure. This structure imposes constraints on the possible representations of time. Meaningless sequences of stimuli - such as they regularly occur in the psychological laboratory, but hardly anywhere else in the known universe - do not qualify as events or episodes, and consequently they are unable to impose constraints on the ways people will represent time. If a series of events has no inherent structure that can be comprehended by the observer and if, moreover, the observer does not succeed in imposing some invented regularity on the input, no temporal representation of that series of events will ensue. Indeed, only to the extent that some invented -perhaps arbitrary or socially induced - regularity can be made to fit the input events, a temporal representation of sorts is established and the temporal information can accordingly be encoded and retained. Jackson (1986) has described several elementary strategies of coping with event sequences that have little or no intrinsic temporal structure. A detailed account of these aspects of our time sense is demanded by the next question.

QUESTION FOUR: IMPLICIT TEMPORALITY VS. REFLECTIVE TIME

Behavior is not usually based on an explicit representation of time, but rather on an information processing mode that may properly be called *implicit timing*. Most circumstances allow the organism simply to *express* temporal relations on the basis of what may be called its *temporal skills*. Richelle and Lejeune (1980), from a comparative point of view, Freyd (1987, 1992) and Mandler (1984), among others, from a cognitive stance, have argued that this is possible because the organism is equipped with a great many cognitive scenarios for coping with the dynamic cues provided by the environment. Freyd goes a long way in identifying a number of what she calls "emergent properties

of processes unfolding over time", taking her terminology directly from J.J. Gibson (1975, 1979). She illustrates her point of view with several impressive phenomena: representational momentum, apparent motion of the human body, and a well-known example of 'naive physics,' perceived curvilinear momentum. To explain these phenomena she adopts a biological point of view: temporal affordances to which humans (and perhaps animals) can tune are not physical but species-specific and geared to the social context in which humans (and animals) are living. These studies follow a line that is quite similar to that followed by Jones (1976; see also Jones & Boltz, 1989). Both authors have provided us with a concrete insight in what we can possibly mean by 'implicit time.'

Implicit time: Timing one's mind

The first temporal mode to be considered is the direct, implicit tuning of our actions to the dynamics of the surrounding world. Concrete, adaptive, goal-directed behavior determines on so-called action field (also known as the *Now* or, with a term borrowed from Gestalt psychology, the *Präsenzfeld*). In this field retentions of earlier experiences and anticipations about the future are implied in a manner similar to the way a specific chess position may reveal much about the earlier stages of the game and its possible continuation, despite the fact that none of this is explicitly represented on the board (and even if one has not followed the game developing). The implicit temporal structure or temporality of behavior, that is, the dynamic tuning to the objects and events that the behavior is about (the so-called intentional objects), is cognitively inaccessible or impenetrable. It is characteristic of what has been called data- driven processing, procedural knowledge, and various other names. Altogether the action level is difficult to grasp. However, in recent years progress has been made in the experimental analysis of what Schacter (1987) has called *implicit memory*. This is a form of memory which expresses itself in and through our knowledge or performance although it cannot be represented in propositional (verbal) terms. It has been established that in habitual behavior patterns duration is not an explicit control parameter of behavior. This means that variations in the (required) duration of certain perceptual-motor activities play no systematic role in the quality (and the duration!) of the performance of these activities.

Representations of time: Minding your time

The transition from the implicit, non-reflective awareness of temporality to an explicit representation of time and of events-in-time is functionally significant. The organism will switch from automatic information processing to the reflective mode whenever the organism finds itself in a processing impasse (Schneider & Shiffrin, 1977). The encoding of temporal information may take three forms: literal or episodic, figurative or analogical and formal or abstract (Michon, 1990). At the first level concrete episodes (Tulving, 1983) and generalized episodes or scripts (Schank & Abelson, 1977) are used to support our awareness of the temporal organization of what is happening. Failing appropriate episodes or scripts one turns to the figurative level at which we use strategies for finding and using analogies or metaphors (Lakoff & Johnson, 1980; Carbonell, 1982; Carbonell & Minton, 1985) for the same purpose. Finally, in some cases we can rely on formal representations that, in an effort of decades or centuries, have achieved the status of scientific theories, sometimes to such an extent that we accept them as "true" representations of the real world. Thus, for instance, we now tend to dress the universe in spacetime garments designed by Einstein and tailored by the mathematician Minkowski (e.g., Rosen, 1985).

Rather than being independent, structurally incompatible forms of representation, these three categories seem to be arranged along a continuum with rather smooth and indistinct transitions between the forms, especially be-tween the figurative and formal representations. What ultimately unites the three forms of representation, however, seem to be the following important issues: (1) the conspicuous role of (visual) space as a medium or analogy for the representation of time, and (2) the structure and function of dynamic memory, including our memory for personal experiences, our autobiographical memory. These two issues will be discussed in the context of the next question.

QUESTION FIVE: THE ROLE OF SPACE

What modes of representation do we have for the encoding, storage and recall of information? Most contemporary authors (but not all, see e.g. (Pylyshyn, 1984) will agree that there is at least an abstract, propositional medium for the representation of knowledge and, very

likely, also a concrete spatial one (Jackendoff, 1983; Kosslyn, 1983; Johnson-Laird, 1983; Shepard & Cooper, 1982). A few authors, moreover, claim that there is some evidence for a special independent conceptual structure for temporal information. Thus, Anderson (1983) postulated a special mode for temporal strings, in addition to the conventional propositional and spatial modes. A temporal string representation would be especially useful for representing information that is crucially dependent on order. To appreciate the merit of a string representation consider repairing a vacuum cleaner. Instead of remembering how to dismantle it by propositionally representing the functional relations between various parts, or the spatial relations between them, one will do better by representing the order in which each part is removed. But such an example casts immediate doubt on Anderson's proposal: doesn't one, after all, represent this temporal order in a spatial medium? Wouldn't one, for instance, put the loose parts on the work bench in the order one took them from the vacuum cleaner? How could we possibly remember the order if not by using a spatial, or a functional analogy of that order? This and other, similar examples from the literature on the art of memory (Yates, 1966; Luria, 1968) should warn us that the temporal mode may be not nearly as independent as Anderson claimed. Though there are numerous arguments against a visual correlate of spatial representations (Pylyshyn, 1984), the privileged character of spatial relations - even if they would be encoded propositionally rather than quasi-visually - seems beyond doubt. One picture is worth more than ten thousand words, and we even know why (see Larkin & Simon, 1987).

QUESTION SIX: DYNAMIC MEMORY

Memory has been claimed to be simply a way of effectively and efficiently using the strategies by which we organize our representations (Guyau, 1890). This does apply in particular to our next question: what is the role of memory in keeping our experiences temporally organized so that we are able to reconstruct a train of events more or less reliably at a later time. It was Tulving (1972) who introduced the important distinction between semantic and episodic memory. Semantic memory contains generalized factual and, in principle, timeless knowledge; episodic memory, in contrast, serves our personal history by storing and retaining real life experiences. The structure and function of

episodic memory have become a most active area in memory research in recent years. Two aspects appear to be of special interest for our discussion. One of these, dynamic memory, has been developed by Schank and his colleagues (Schank & Abelson, 1977; Schank, 1982, 1986), the other did derive from the pioneering work of Linton (1975, 1986) on autobiographical memory. Both approaches together seem to go a long way towards an understanding of the encoding and retention of temporal information. Schank's theory of dynamic memory, in particular, rests on the concept of schema instantiation. If we are facing a new situation of a kind with which we are already familiar, then understanding that situation involves the instantiation of a schematic structure with details specific to that particular input. From the temporal perspective research along this line of reasoning confirms that the organization of memory is heavily dependent on socially induced (more often than not *cyclical* reference systems, such as clocks, calendars and public events. As a rule there is a considerable interfacing between the public and the personal domain. Autobiographical memory has come under close scrutiny in recent years. First of all historically, philosophically and, not least, in literary criticism (e.g., Ricoeur, 1983; Brockelman, 1985; Casey, 1987). The experimental study of autobiographical memory by psychologists is seriously lagging behind; researchers are only just beginning to scratch the surface of this extremely rich domain of creative cognition. Theoretically speaking a lot remains to be sorted out along these lines; a proper theory should be expected to explain the functional role of dynamic memory and the apparent ease with which we succeed in knitting, from fairly incoherent sequences of experience, coherent narratives of our lives, our professional career, and our daily routines. Several such narratives may be maintained in parallel, apparently without interference.

QUESTION SEVEN: THE ONTOGENESIS OF TIME

Finally the question remains how the theoretical frame can be made to accommodate the ontogenesis of the various mechanisms, processes, and strategies, and how it will explain why one is chosen instead of another if certain conditions prevail. Acquiring cognitive procedures and strategies means acquiring ways of interpreting and representing the facts about the world. Having a repertoire of such

coping possibilities brings with it the potential of representing the same facts in a number of different ways, as we saw already in the preceding sections. One of the most remarkable features of the human mind is the exceptional ease with which it can switch from one context to another, a pervasive cognitive relativism that enables us to sidestep a great many practical problems. If the human mind has its limitations, single-mindedness is not one of them. The most systematic, theory-driven, effort to study the developmental dynamics of representing our time experience is, still, the work of Montangero (1977, 1985). Montangero, working in the tradition of Piaget, has outlined the gradual development of an integrated structure consisting of three separate subsystems (or metaphors). We may label these *movement*, *change*, and *repetition*. In this overall structure time qua duration is the connecting concept, the glue that holds this intricate mental representation together. Montangero claims that children first acquire the separate concepts within each of the subsystems - e.g. number and frequency in the case of repetition. Later they will gradually be able to combine these concepts into dyadic and eventually complete triadic relations, but only when they ultimately attain the insight that duration in all three subsystems is to be treated as one and the same concept can we say that their notion of time is complete. The development of such rather abstract forms of temporal representation does not result in a permanent state of reflective temporal thought in the adult mind. Under everyday circumstances other, simpler forms of presentation may prevail. Also subjects will tend to regress to one of the partial set of relations identified by Montangero. This was evident already for Guyau, who argued that even for the adult mind the more primitive mode of "acting and undergoing" remains available (Guyau, 1890, p. 30). This is particularly evident in dreams, and this is presumably what led Guyau to this statement. In his recent study on dreaming (Foulkes, 1985) attributes the primordial confusion of the dream to the failure to apply syntactic rules (or cognitive strategies) in the dream state, although isolated elements of the dream can indeed be meaningful. A primitive, unorganized state of mind may, however, also prevail in other circumstances. Recently it has been argued by a number of authors that simpler types of representation will as a rule be adopted, even by sophisticated adults, whenever the situation does not require a more complicated representation. Their argument rests on a variation of the principle of least effort (see, e.g., Dennett, 1992; Michon, 1985b).

Conclusion

It has been suggested to me more than once that these seven questions, if properly worked out in much greater than I have done in this paper, would qualify as a *Unified Theory of Time Experience.* Although the idea sounds exciting, I wish to stipulate that unified theories are something quite unattainable in psychology. Physicists have a lot to say about such theories (see, e.g., Georgi, 1989): they are meant to provide definitive answers to basic questions such as why there are four rather than, say, three or seven forces of nature, or why the universe has exactly three spatial and one temporal dimension (discounting the possibility of some six or seven additional, very small, spatial dimensions). A 'unified theory' of the human time sense is something I find quite difficult to envision, simply because we are, thus far, utterly uninformed about what constitutes a basic, unifying question. Yet, the work by Freyd (1987, 1992) and Leyton (1992) may represent a step in the right direction. As I explained before, Leyton starts from the assumption that mental activity is essentially the construction of a causal history to account for a presently perceived state of affairs. Perception is essentially the extraction of *time from shape*. This unifying thesis places time experience right in the middle of the computational theory of mind. Leyton has applied his thesis to a number of problem areas in vision and audition, including the perception of paintings, the understanding of sentences, and the lot of prisoners and refugees. The seven questions posed in this article, on the other hand, should be considered in a different light. In their accounts of the various manifestations of time in human (and animal) experience authors appear to use a comparatively small set of basic explanatory processes and mechanisms. These are frequently ill-defined or left implicit. If any theory of human time experience is to be taken seriously at the descriptive level, however, it should incorporate a proper, explicit specification of these processes and mechanisms. To argue for such a litmus test has motivated this paper.

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