

INTRODUCTION*

Motor timing and perceptual time judgements play a major role in the adaptation of animals and humans to their environment. This is clear in two major fields between which future research will perhaps establish stronger connections than exist nowadays: chronobiology and psychological time. Chronobiologists have extensively analysed the wide range of biological rhythms by which living organisms adjust to periodic external events (Aschoff, 1981; Binkley, 1990). In this range, the endogenous circadian rhythm, whose period approximates 24 hours, has long been a favourite topic: this rhythm monitors the partition of sleep and wakefulness, body temperature, endocrine functions and innumerable other processes. Rhythms having longer or shorter periods, ranging from years to seconds, are fascinating as well. Besides these, other forms of adaptation to duration, not necessarily involving periodic processes, have come under scrutiny, due to the development of procedures adapted to animal and human subjects. Facts and theoretical models, as well as physiological correlates of time-related behavior have recently enjoyed a renewal of interest, as several books dealing with one or the other aspect of timing behavior have been published since 1980 (Allan & Gibbon, 1984; Blackman & Lejeune, 1990; Block, 1990; Crépault, 1989; Fraser & Rowell, 1993; Friedman, 1982, 1990; Leconte & Lambert, 1990; Levin & Zakay, 1989; Macar, 1980; Macar, Pouthas & Friedman, 1992; Michon & Jackson, 1985; Michon, Pouthas & Jackson, 1988; Richelle & Lejeune, 1980, among others). In particular, speculations loom large about the generality of Weber's law as well as about the different processes (from a pacemaker to memory, to decision or attention) thought to be involved in time related behavior. Which common features of time processing are shared by humans and animals, and how this type of processing develops with age, are other exciting questions to solve.

This special issue of *Psychologica Belgica* presents fifteen invited European contributions to the study of temporal processes. This sample of studies, obviously limited by comparison with the multiple facets of the field and the large variety of research teams concerned with it,

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offers a representative set of data, dealing not only with chronobiology or chronopsychology, but also with developmental, comparative and epistemological dimensions of timing behavior. Theoretical models and field-oriented research are presented as well. The authors assembled here briefly explain their own questions of interest, take stock of the available knowledge and describe the means by which they try to clarify each topic. In sum, this special issue aims at illustrating what can be done and what is effectively done in Europe to investigate temporal processes through one or another avenue.

The first article, presented by Richelle, reviews the current situation in the study of time. Starting from its early European roots, the author visits several arms of the "temporal maze" which are currently explored or offer attractive goals for future investigations.

In the field of chronobiology, Jürgen Aschoff describes the relationship between subjective time and the sleep-wake cycle of human subjects in temporal isolation; he also evaluates the role of metabolic processes and body temperature in the passage of subjective time. Guerrien, Leconte-Lambert and Leconte emphasize the fact that biological rhythms cannot be ignored when studying mental efficiency of human subjects and point to the importance of intraindividual studies as a means of clarifying interindividual data and masking effects.

Four contributions highlight the developmental approach. Pouthas follows the development of timing abilities in infants and young children, using language-free procedures. She discusses the relationship between contingency shaping and the progressive development of rule-governed temporal behavior. With a different methodology and a neo-piagetian theoretical background, Montangero describes how reasoning about time and understanding of the evolution of events in time develop in children up to 12 years. Crépault further climbs the age scale and, within a structural stability model, tracks temporal reasoning about kinematic (time, velocity and distance) and non-kinematic events (duration, beginning and ending times) from childhood to adulthood. Finally, Drake approaches the representation of musical rhythms and discusses the influence of age and musical experience on the ability to incorporate a metric structure in a mental representation.

Between species comparisons are reviewed by Lejeune, who emphasises the generalisability of animal processes to human subjects and discusses the role of language and the relevance of developmental studies to animal-human comparisons.

Another set of papers specifically concerns timing processes operating in judgment of short durations. Starting from the clock-comparison model of scalar timing theory, Wearden focusses on the decision and memory processes involved in time estimation in analog experiments conducted with human and animal subjects. He contends that between species differences do not necessarily entail fundamental differences in the representation of time. Miall further delves into the representation issue. Time encoding in artificial neural networks is compared with the behavior of the biological nervous system, in an attempt to decipher the precise mechanism adapted to count or accumulate the output of the internal clock. A simple network model is proposed, which could be used for this purpose. The hypothesis of a temporal sensory system based on a biological source of temporal information located within the nervous system is presented by Treisman. An interference procedure designed to detect the frequency of the temporal oscillator is illustrated with data from human subjects performing time estimation or production tasks. Finally, within the framework of the attentional model of time estimation, Casini and Macar analyze electrophysiological and behavioral data suggesting that prefrontal areas specifically process temporal information in human subjects under prospective timing conditions.

Temporal processes include many aspects besides those currently explored in laboratory settings. Time horizon, i.e. the representation of behavior in time, including notions of past and future is one of them. Jackson, Michon and Melchior deal with the future time perspective in relation to criminal lifestyles. After briefly reviewing past and current criminological theories, they argue that rational choice theory, which emphasizes planning, might lay the foundations of an integrative view of time and crime. In other respects, computer simulations may help us to understand real-life situations and even to prevent human errors: Sougné, Nyssen and De Keyser compare theories of reasoning that might be used to simulate the dynamics and temporal constraints typical of a definite situation, the anaesthesia of a patient before surgery.

To conclude this eclectic, though admittedly not exhaustive overview of the study of time, epistemological aspects are represented by Michon. He describes what the terms "time sense" do and do not signify and proposes seven criteria to define a unified theory about time experience.

The contributions as presented here above have been classified mostly according to their focal point. Nevertheless, other common threads run as a filigree across categories. For instance, between-species comparisons are not limited to the paper by Lejeune but are also discussed in Wearden's contribution. Temporal reasoning is addressed by Crépault and Montangero as well as Sougné, Nyssen and De Keyser. The relationship between language and timing behavior (or between rule-governed and contingency-shaped performance) concerns Pouthas, Wearden and Lejeune. The representation of time appeals not only to Wearden or Miall, but also to Drake and Michon. Finally, the hypothesis of a "sense of time" is envisioned from viewpoints as different as those from Treisman and Michon, and is basic to a number of other papers.

Sixteen centuries ago, Saint Augustin asked: "What then is time? If nobody asks me, I know; if I want to explain it to whoever asks me, I no longer know".

Let us discover how current experimental research has started disavowing this view !

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