TIME

Perspectives at the Millennium (The Study of Time X)

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Chapter 11

Psychological Time at the Millennium: Some Past, Present, Future, and Interdisciplinary Issues

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The history of the psychology of time reveals interesting intradisciplinary and interdisciplinary connections. Most psychologists remain unaware of the findings and implications of the past century of research on psychological time, which we review here. We also discuss four influential topics of modern time psychology: prospective and retrospective duration judgments, scalar timing theory, temporal perspective, and pace of life. Interdisciplinary connections, which have especially involved physics, philosophy, forensics, and biomedical sciences, may increase substantially and become important cross-fertilizations. Cognitive science may play a central role as it encompasses recent developments in cognitive psychology, neuroscience, chronobiology, and animal behavior. Even before the "decade of the brain" (the 1990s) had ended and the new millennium had begun, researchers attempted to reveal the complex involvement of various brain areas in psychological time. Within psychology, the relative neglect of issues concerning psychological time may abate as interdisciplinary research gains momentum.

INTRODUCTION

Several psychologists have written comprehensive monographs summarizing research findings and theories on the psychology of time. However, historical accounts on time psychology include only brief parts of books (e.g., Boring, 1950; Fraisse, 1957/1963), book chapters (e.g., Block 1990; Michon & Jackson 1985), encyclopedia articles (Michon 1994), and journal articles (e.g., Richelle 1993). In this chapter, we provide a selective historical review and prospectus of time psychology at the millennium. It is not possible to write a comprehensive

review, because psychological time is multifaceted. Researchers have explored an incredibly wide range of topics from anchor effects to zeitgebers. We mainly focus here on the experimental psychology of time, commenting only briefly on the extensive literature on personality and clinical issues.

Psychological time refers to an organism's time-related experiences, behaviors, and judgments. As Cohen said, it is "the subjective time that for each person is more or less independent of objective time" (Cohen 1964, 116). In this view, psychological time is a dependent variable. The psychology of time does not treat time merely as a ubiquitous independent variable, as most of psychological science (and other science) does. However, we restrict our definition of psychological time in two major ways. First, although there is some connection between biological time (e.g., circadian rhythms) and psychological time, these are dissociable constructs. Genetic biologists have discovered time-related genes in various animals, such as fruit flies. However, human biological rhythms and psychological time are based on somewhat separate processes (Aschoff 1998). Second, considerable psychological research has studied reaction time as a dependent variable. Although a fruitful theoretical connection may be made between reaction time and measures of psychological time, it has not yet been made. We necessarily must exclude this large literature.

Several researchers have noted that the study of psychological time has not had much impact on mainstream psychology. Our historical review clarifies this odd state of affairs, in the process revealing something about most psychologists' biased views concerning such a fundamental and important aspect of human nature as time. Fortunately, European psychology has a richer history of the study of time than does North American psychology.

We also speculate on future developments that are likely to enrich the study of psychological time and to extend its impact across disciplinary boundaries. Some of the major developments will result from a partial dissolution of the walls between psychology and the biological sciences and neurosciences. We will also mention connections with several other disciplines, such as physics, philosophy, and forensics (the law).

In order to trace at least part of the history of the psychology of time, we calculated the total number of publications (9,971) listed in the most comprehensive database for the psychology of time (Block & Eisler 2000). We also calculated the total number of publications (1,634,717) listed in the most comprehensive database for psychology, PsycINFO (1887–1999). (Only about 0.6 percent of all psychology publications focus on the psychology of time as we have defined it here.) Then we calculated the proportion of each total that was published during each decade. Figure 11.1 shows this relative proportion for each of the twelve decades from 1880 to 1889 through 1990 to 1999. (A very small number of publications on the psychology of time appeared before 1880.) The overall publication rates have increased greatly, especially since World War II. An increasingly large number of researchers are engaged in psychological research, including research on psychological time. However, the publication

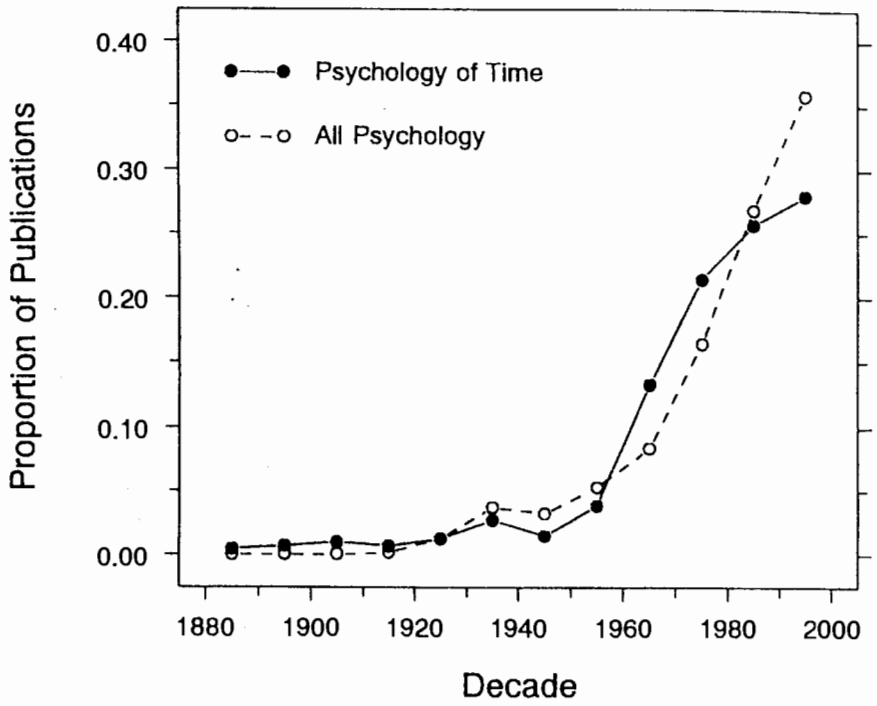

Figure 11.1. The relative proportion of the total number of publications for the psychology of time that was published during each of twelve decades, along with the relative proportion of the total number of publications for all of psychology that was published during each of twelve decades. The relative proportion for each decade (e.g., January 1980—December 1989) is shown at the midpoint of the decade (e.g., 1985). See text for additional explanation.

rate of articles and books on the psychology of time shows a few interesting differences from those on psychology in general. We will comment on those differences later.

PREHISTORY OF THE PSYCHOLOGY OF TIME (BEFORE 1890)

Why does psychology have such a short history (Ebbinghaus 1908/1973)? More particularly, why does the psychology of time have such a short history? We can partially blame some early philosophers, especially Kant (1781/1998, 1786/1970). Kant held that time was an a priori dimension of human experience and that the mind was outside the realm of the causal structure of time and, hence, could not be studied scientifically. Fraisse noted that "it is obviously wrong to think that [Kant] believed in the innateness of the notion of time" (Fraisse 1957/1963, 5). Even if many early philosophers misinterpreted Kant,

their misinterpretation delayed the experimental study of psychological time. Observations and inventions from outside of philosophy ultimately shattered the Kantian framework.

Experimental psychology is usually said to have emerged in the late 1800s, but several important developments occurred earlier, during the middle 1800s. They finally allowed experimental psychology, including the psychology of time, to emerge. They came from physics, medicine, and the emerging psychology itself. Let us now briefly consider these major developments.

Physics and Time Instruments

In a recent article, Wade and Heller argued that "the advance of psychology as an experimental discipline, initially in perception, then in attention, and finally in memory research, has essentially been determined by the invention of instruments like the . . . chronoscope, and tachistoscope" (Wade & Heller 1997, 227). Although in this context we prefer to say *influenced* instead of *determined*, we tend to agree. Wheatstone devised the chronoscope in 1840; its main function was to estimate the velocity of projectiles. Hipp adapted it for use in astronomy, in which its main function was to measure what was called the *personal equation* (i.e., individual differences in recording the time of star transits). Soon after, experimental psychologists used it in timing short intervals. Volkmann invented the tachistoscope in 1859, and it was used to present stimuli for very brief durations. These two instruments enabled some of the first time psychologists to present brief stimuli and time fast responses to them. Much later, the cognitive psychologist Neisser criticized the lack of ecological validity of such research. Neisser said these stimulus displays "come very close to not existing at all. They last only a fragment of a second, and lack all temporal coherence with what preceded or what will follow them" (Neisser 1976, 35).

Medicine and Brain Damage

Another influence on the emerging experimental psychology of time came from a somewhat unlikely source: medicine. Beginning in the 1860s, several physicians, especially the French surgeon Broca and the German neurologist Wernicke, reported that damage to certain regions of the brain resulted in language difficulties. In the late 1880s, the Russian neurologist Korsakoff examined some amnesic patients and noted that in some cases they remembered events, but not the time when they had occurred (Victor & Yakovlev 1955). By the late 1920s, other physicians also reported that disturbances of the *sense of time*, as it was called then, resulted from chronic alcoholism and the assumed brain damage that accompanies it. A loss of the "temporal signs of events," or chronoagnosia, was observed to accompany Korsakoff's syndrome (Bouman & Grünbaum 1929; van der Horst 1928, 1932).

It is possible to interpret the finding that localized brain regions subserve

various aspects of psychological time as evidence supporting Kant's (1781/1998, 1786/1970) view that time is an a priori dimension of human experience. After all, if the brain is preprogrammed with particular time analysis mechanisms, learning about time may be unnecessary. There are three problems with this analysis. First, even genetically controlled brain development is influenced by environmental factors. Second, controlled (learned) processing of information interacts with relatively automatic (innate) processing. Third, most high-level time judgments require a conscious construction by the person (Ornstein 1969).

Psychology and Psychophysics

Weber (1846; Weber, Ross, & Murray 1996), a German physiologist, and Fechner (1860/1966), a German physician, physiologist, and philosopher, invented new ways to measure behavioral responses. In the process of doing so, they became the first psychophysicists. Although they disagreed slightly on specific mathematical details, they developed a means to investigate the effect of slight changes in stimuli on a person's ability to discriminate and judge those changes. Stimuli such as lights, sounds, and distances were soon investigated. Many early time-psychology experiments were conducted in the psychophysical tradition begun by Weber and Fechner (for a review, see Woodrow 1951). Duration estimates, for example, were studied as a function of actual duration. One of the first experiments on psychological time revealed that people tended to overestimate short durations and to underestimate longer durations, with a so-called *indifference point* of accurate judgment at about 0.75 seconds (Vierordt 1868). (Later research suggested that the overestimation-underestimation phenomenon is a general tendency revealed in judgments of other magnitudes, and theorists therefore ascribe no special importance to the indifference point.) Other early experiments also revealed that psychological time was almost a linear function of physical time, increasing almost as much as physical time increased (Eisler 1976). In other words, the best measure of psychological time seemed to correspond closely to units of physical time, such as seconds and minutes.

THE EARLY YEARS: PSYCHOLOGY GETS TIME (1890–1926)

Although a few authors began to write about psychological time in the preceding decades, the early 1890s were monumental for the psychology of time. This subarea was an important one in psychology (see figure 11.1). Modern time psychologists usually abundantly credit and cite the psychologist and philosopher James (1890) for this early impetus. His book *The Principles of Psychology* contained a chapter on "The Perception of Time." In it, he both reviewed the limited earlier experimentation and speculated about many of the issues that would come to dominate research for the next century. He distinguished between such temporal aspects of experience as simultaneity and successiveness, the

specious present, and memory for duration. James's account has been widely viewed as a major impetus for much subsequent research on the subject, even extending into present-day research (Block 1994).

In the same year, the French psychologist Guyau (1890/1988) published a fascinating book that was largely centered on issues concerning how children develop adult concepts about time. It also focused on the results of the process. This book, along with that of Janet (1928), firmly established the important role of time in French psychology, a tradition that continues to the present.

At around the same time, much of the important experimental work centered on the question of individual differences in judgments of time, especially durations. Investigators (e.g., Gilbert 1894; Seashore 1899) conducted large-sample experiments that were basically inventories of abilities demonstrated by people of different ages and sexes, including time-estimation abilities.

In 1891, Nichols published an extensive review of experiments on the psychology of time. Although this article did not make an important theoretical contribution, it was published in the first and only extant psychological journal, and it therefore received widespread attention among the few people calling themselves psychologists. His famous quote probably stimulated much subsequent research: "Casting an eye backward, we can but be struck by the wide variety of explanations offered for the time-mystery. Time has been . . . deduced from within and without, from heaven, and from earth, and from several things difficult to imagine as of either" (Nichols 1891, 502). Unfortunately, this early interest in psychological time soon led to fragmented, disjointed efforts to understand many overly specific time mysteries (Ornstein 1969).

THE MIDDLE YEARS: PSYCHOLOGY LOSES TIME (1927–1958)

From 1927 to 1958, the publication rate for the psychology of time decreased relative to that for all of psychology (see figure 11.1). What transpired during that thirty-year period? We attribute much of the blame to a shift in the Zeitgeist of mainstream American psychology. Behaviorists such as Watson and Skinner renounced the "mentalistic" emphasis of psychology. Although they did not specifically mention the psychology of time, that topic clearly was not the kind of behavioristic one that they advocated. Woodrow sympathetically reviewed considerable research, but even he remarked about the "mentalistic nature of the data" (Woodrow 1951, 1224).

There may have been another reason for the thirty-year recession. In 1964, one psychologist discouragingly remarked, "Time perception is a venerable, tired topic in psychology that interests very few active investigators any more, perhaps because no one bothered to explore the mechanisms of time perception and how it might enter into meaningful interaction with other mechanisms" (Adams 1964, 197). Adams was partly correct in that many time psychologists had been researching narrow phenomena, and they had been doing so in a way

that seemed to detach their theoretical accounts from those of mainstream psychology.

To say that psychology lost its sense of time from the middle 1920s to the late 1950s is, of course, a misleading generalization. Consider one of the more positive developments during this period. A remarkable and important interdisciplinary connection between physics and psychology occurred because of the influence of Einstein's theories on Piaget, a Swiss epistemologist and developmental psychologist. In the foreword to his classic work *Le développement de la notion de temps chez l'enfant* Piaget related that in about 1930 Einstein had asked him whether a person's "intuitive grasp of time [is] primitive or derived" and whether "it [is] identical with our intuitive grasp of velocity" (Piaget 1946/1969, vii). Consequently, Piaget turned his attention to relationships between distance, speed, and duration. He embarked on his pioneering studies on how children acquire the notion of duration only when they begin to coordinate their conceptions of velocity and distance. Unfortunately, we do not know whether Einstein was influenced by Piaget's findings. Einstein's notion that time is relative to one's frame of reference also does not seem to be intimately related to the conscious experience of simultaneity and duration under ordinary conditions. We agree with Fraisse that "the time of relativity brings us beyond the bounds of the psychological problem of temporally organized behavior" (Fraisse 1957/1963, 287).

During the 1930s, 1940s, and early 1950s, many other German and French psychologists, along with some Americans, advanced our understanding of psychological time. Some focused on abnormal personality (Israeli 1936) and on disturbances in temporal experience attributable to organic brain disorders (e.g., Häfner 1953). Others conducted basic experimental research on simultaneity, successiveness, and duration judgments made by normal children and adults (Fraisse 1957/1963). The psychology of time progressed, especially in Europe, although it was somewhat crippled by the radical behavioristic movement in American psychology.

THE MODERN YEARS: PSYCHOLOGY REGAINS TIME (1959–1999)

Beginning in 1956, a "cognitive revolution" in psychology occurred mainly because of the impact of developments in the fields of cybernetics, artificial intelligence, linguistics, and neuroscience (Bechtel, Abrahamsen, & Graham 1998). Along with a revitalization of subfields such as social psychology, this revolution set the stage for modern studies of psychological time. Fraisse's (1957) landmark book *Psychologie du Temps* also undoubtedly stimulated much subsequent research. Other psychologists (e.g., Doob 1971; Michon 1967; Ornstein 1969) soon continued to relate temporal experiences and judgments to cognitive processes and structures that were beginning to be revealed by the newly mainstream cognitive psychologists. The study of psychological time

blossomed in many directions. From 1959 to 1985 the publication rate for the psychology of time increased relative to that for all of psychology (see figure 11.1).

Beginning in about 1984 and continuing through the end of the millennium, the publication rate for the psychology of time continued to increase, although it had once again decreased relative to that for all of psychology, as shown in figure 11.1. There is no obvious explanation for the relatively decreased rate. It may reflect an increase in the number of psychologists being trained in areas such as clinical and industrial-organizational psychology, which historically are not as closely linked to the psychology of time, relative to the number being trained in areas such as experimental psychology, personality, and social psychology. It may reflect some other trend that may become apparent only in the coming decades. Whatever the reason, we hope that the trend does not continue.

We now consider four examples of some modern work on the psychology of time.

Prospective and Retrospective Duration Judgments

The experience of duration is the most heavily researched aspect of psychological time, possibly because it is the most complex and important aspect in terms of environmental adaptation. James made a crucial distinction between different kinds of duration experiences. He proposed that different variables influence the "retrospective and prospective sense of time" (James 1890, 624). He claimed that a duration seems longer in passing whenever "we grow attentive to the passage of time itself" (626), whereas whether a duration seems relatively long in retrospect depends on "the multitudinousness of the memories which the time affords" (624). Some modern researchers think that the duration judgment paradigm (i.e., prospective versus retrospective) is perhaps the most important factor influencing timing behavior (Block & Zakay 1997). In the prospective paradigm, a person knows in advance that he or she will be asked to judge the duration of a time period. In the retrospective paradigm, a person does not know until afterward that he or she needs to judge the duration. Some theorists have emphasized differences in processes subserving prospective and retrospective judgments, or experienced duration and remembered duration (e.g., Block 1990). Most of them think that experienced duration increases when a person allocates more attentional resources to processing temporal information. According to attentional models, attending to time requires access to the same attentional resources as does attending to external information (Macar, Grondin, & Casini 1994), and a person may divide resources between nontemporal (stimulus) and temporal information. Thus, experienced duration increases if the number of stimuli requiring processing is small, if a processing task is easy, if participants do not need to actively respond to presented information, or if they do not need to divide attention between two sources of stimuli. Remembered duration, on the other hand, increases as a function of the amount of stored and retrieved

information (Ornstein 1969), or the number of encoded and available contextual changes (Block 1990). Thus, theorists typically propose memory-based models of remembered duration. Attention to time may play little or no role in remembered duration unless a person has little information to process, frequent feelings of boredom, and so on. In short, research on prospective and retrospective duration judgments has begun to connect time psychology with mainstream cognitive psychology. This is an important first step.

Scalar Timing Theory

Many contemporary behavioral psychologists have proposed and tested an internal-clock model of prospective duration judgment. These researchers study time-related behavior of animals such as pigeons and rats during relatively short time periods (seconds to minutes). The general finding is that animals are sensitive to different stimulus durations and time-based schedules of reinforcement. The canonical model of such behavior is called *scalar timing theory* or *scalar expectancy theory*. Because this model provides an excellent account of a wide variety of evidence, many researchers have adopted it (e.g., Allan 1992; Church 1984, 1989; Gibbon & Church 1984). The model accounts for duration perception and production by proposing an internal clock, memory stores, and a decision mechanism. The internal clock consists of a pacemaker, a switch, and an accumulator (for details, see Block & Zakay 1996; Church 1989). However, the scalar timing model does not take into account factors that are more prominent in humans than in other animals. In particular, it is not easily able to explain why cognitive factors (e.g., attention, strategies, information-processing task) influence temporal behaviors. This seems largely a consequence of methodological limitations or neglect: few animal timing researchers have explored or discussed the effects of attentional manipulations, which have been a focus of considerable research on human prospective duration timing. A refinement of the scalar timing model, the attentional-gate model (Zakay & Block 1996, 1997), takes into account an organism's attention to time, some of the evidence on which we mentioned in the preceding section.

Temporal Perspective

The term "temporal perspective" refers to a person's subjective focus on and relative emphasis on the past, the present, and the future. Many studies have investigated the ways that temporal perspective is expressed by normal individuals, by arguably normal individuals (such as inner-city residents of New York), and by individuals with diagnosable psychopathologies. Researchers have developed questionnaires and other methods to assess individual differences in temporal perspective (Block, Saggau, & Nickol 1983–84; Zimbardo & Boyd 1999). From a socioeconomic perspective, a society in which individuals are characterized as being relatively present-centered may have difficulty interacting

with other societies in the new millennium. Many psychologists have emphasized the importance of developing an adequate future time perspective, both on an individual level and on a societal level (Zaleski 1994). Zimbardo and Boyd (1999) provided evidence concerning the impact of temporal perspective on human behavior, and they also emphasized that a balanced time perspective is important. They said that individuals and societies should have "the mental ability to switch flexibly among [time perspectives] depending on task features, situational considerations, and personal resources" (Zimbardo & Boyd 1999, 1285).

Pace of Life

In a pioneering set of studies, Levine (1988) recorded various measures of the pace of life in different cities around the world. There is a historical connection to the earlier writings of Hall (1966, 1983), a cultural anthropologist who discussed the role of the "silent language" of time in social behavior. Levine's research goes well beyond this in its use of various behavioral measures of the pace of life. Levine measured the speed of postal transactions, the speed of pedestrians walking in urban areas, and the accuracy of bank clocks in various cities around the world. The authors of some other chapters in this volume discuss the common feeling that time seems to pass at a faster and faster rate in modern industrial societies at the turn of the millennium. We note here some recent advertising for an executive helicopter: "Bell Helicopter has just perfected time travel. Our engineers have built a device for creating time, the Bell 430. . . . Use it to invent time for yourself." Levine's recent book (1997) reveals interesting insights into possible reasons for the millennial focus on "creating time," as well as its concomitants.

PRESENT AND FUTURE INTERDISCIPLINARY CONNECTIONS

Now that we have reviewed the psychology of time, we focus on some present and future connections to several other disciplines: physics and astronomy, philosophy, forensics (the law), and biological sciences and neurosciences.

Physics and Astronomy

Early observations of the personal equation in the timing of astronomical observations led to early interest in time psychology, such as individual differences in reaction time. However, modern physicists have relatively little use for the concept of time. As Harrison wrote:

> Time and space have no distinction in four-dimensional space-time. Events . . . are fixed and never change, and space-time decomposes into the different spaces and times of observers in relative motion. The becoming or transience aspect of time (the part that cannot be spatialized), which consists of an awareness of change in the sensible world, is banished from the physical world as a psychological or metaphysical characteristic of the observer. (Harrison 1994, 46)

Thus, each event is simply a particular point in the fabric of spacetime. As such, events do not change or endure. More complex levels of temporality are phenomena of higher levels of organization, such as organisms and societies (Fraser 1990; see also the fascinating, whimsical book by Lightman 1993). Unless physicists somehow modify their conception of time, psychology will have little or no impact on physics.

Philosophy

Recent findings in cognitive science, especially cognitive psychology and cognitive neuroscience, have influenced a few contemporary philosophers. The evidence includes studies in time perception, especially concerning experiences of simultaneity and successiveness. In particular, Dennett (1991), along with a psychologist (Dennett & Kinsbourne 1992), has displayed no reluctance to propose philosophical interpretations of such evidence. Dennett's view, greatly simplified, is that the mind/brain system constructs "multiple drafts" of experiences, including information about temporal relationships among them, in an attempt to interpret sensory stimuli.

Forensics (The Law)

Modern memory research has begun to stimulate interesting connections with the science and practice of law. In particular, eyewitnesses often give distorted accounts of their experiences. These include severe inaccuracies in the ability of people to estimate the duration of criminal and other such episodes (e.g., Loftus, Schooler, Boone, & Kline 1987). Individual (age-related and sex-related) differences in such estimates are also beginning to be revealed and understood (Block, Zakay, & Hancock 1998, 1999, in press). Psychological evidence on these individual differences may become more important in future courtroom proceedings.

Biological Sciences and Neurosciences

Hoagland (1933) was one of the first researchers explicitly to state a biologically based hypothesis about duration experiences and judgments. He proposed that the "sense of time" in organisms depends on a biological clock, which is influenced by body temperature. Since then, many researchers have looked, largely unsuccessfully, for a mechanism underlying this proposal (Block 1990). Most researchers now think that a simple biological clock hypothesis cannot

possibly suffice, because many information-processing variables influence duration judgments.

Several biologists (e.g., Aschoff 1984; Pittendrigh 1960) have collected important evidence on circadian pacemakers and their possible relationship to temporal behavior and judgments. Most psychologists now think that these discoveries represent only part of the puzzle of the biological basis of time. For example, other areas of the brain apparently subserve the timing of relatively short durations (on the order of seconds). Even before the "decade of the brain" (the 1990s) had ended and the new millennium had begun, the involvement of various brain areas in psychological time was gradually being revealed (Block 1996; Church 1989). For example, Binkofski and Block (1996) reported the case of a man with a localized tumor in his superior (dorsal) left-hemisphere prefrontal cortex. He experienced events as occurring at a very fast rate, much like he was viewing a modern videotape recording on "fast forward." This and other important brain areas must also necessarily interact with those that subserve attentional processes (Block & Zakay 1996; Zakay & Block 1996, 1997). Within the next decade or two, it seems likely that a convergence of research from neurobiology, cognitive psychology, and cognitive neuroscience will reveal these mechanisms in greater detail, including how they interact in the normal time-related behavior of organisms.

The development of neural network models by psychologists and computational biology models by biologists will also gradually converge (see, for example, Miall 1996). The importance of testing neural network models of timing and identifying brain mechanisms associated with timing will increase. Along with this, the study of timing in nonhuman animals will continue to be an important topic in psychology (see, for example, Clayton & Dickinson 1998). A better understanding of time-related differences between species will play an important role in clarifying the psychology of time.

In this regard, we note what was recently billed as the first interspecies online chat—the first live conversation involving a nonhuman animal on the World Wide Web. The key participant was Koko (e-mail address: Koko@gorilla.org), a lowland gorilla who had been taught sign language. Her trainer, Patterson, has estimated Koko's IQ at 86 (i.e., about one standard deviation below the mean for humans). A segment at the beginning of the chat is particularly interesting. (In this quotation, HaloMyBaby is the moderator, DrPPatrsn is Patterson, and LiveKOKO is Koko; Koko's comments were, of course, made in signs that Patterson translated into English.) The transcript begins:

HaloMyBaby: Welcome, Dr. Patterson and Koko, we're so happy you're here!

DrPPatrsn: You're welcome!

HaloMyBaby: Is Koko aware that she's chatting with thousands of people now?

LiveKOKO: Good here.

DrPPatrsn: Koko is aware.

HaloMyBaby: I'll start by taking questions from the audience now, our first question is MInyKitty asks Koko are you going to have a baby in the future?

LiveKOKO: Pink

DrPPatrsn: We've had earlier discussions about colors today.

LiveKOKO: Listen, Koko loves eat

HaloMyBaby: Me too!

DrPPatrsn: What about a baby? She's thinking . . .

LiveKOKO: Unattention

DrPPatrsn: She covered her face with her hands . . . which means it's not happening, basically, or it hasn't happened yet.

LiveKOKO: I don't see it.

HaloMyBaby: That's sad!

DrPPatrsn: In other words, she hasn't had one yet, and she doesn't see it happening. . . . ("Transcript of the chat" 1998)

Arguably, Koko seems to have some notion of the future. In the coming millennium, we predict that there will be even more animals on the Internet than there are now.

Future Directions

In the near future, the study of psychological time will undoubtedly continue to extend its impact across disciplinary boundaries. In part, some of these developments will represent a partial dissolution of the walls between the disciplines of psychology and biology, as well as other disciplines, such as medicine. Cognitive science, a multidisciplinary endeavor, will partially contribute to this, especially as it includes recent developments in the neurosciences. The study of timing in nonhuman animals will continue to be an important topic in psychology, and a better understanding of time-related differences between individuals and between species will play an important role in clarifying the psychology of time.

New directions for interdisciplinary connections may enrich the study of time. One possible thread that may unify several disciplines is the answer to the old question of individual differences in the experience and judgment of time. Research has not yet resolved the complex issues involved. However, my colleagues and I recently concluded that children and older adults make longer and more variable numerical estimates of duration than do young adults, and that females make slightly longer and more variable numerical estimates of duration than do males (Block, Zakay, & Hancock 1998, 1999, in press). Additional studies on individual differences may suggest productive new directions for future research and theories on psychological time. Extending this question across disciplines may be very useful, because progress in other disciplines has

often involved the same issue (e.g., the "personal equation" in astronomical observations).

In his presidential address, a former president of the International Society for the Study of Time suggested how to link cognitive psychological approaches and time (Michon 1989). As psychologists become increasingly interested in time, we hope nonpsychologists also will become interested in what psychology has to offer.

REFERENCES

Adams, J. A. (1964). Motor skills. *Annual Review of Psychology, 15*, 181–202.

Allan, L. G. (1992). The internal clock revisited. In F. Macar, V. Pouthas, & W. J. Friedman (Eds.), *Time, action and cognition: Towards bridging the gap* (pp. 191–202). Dordrecht, Netherlands: Kluwer Academic.

Aschoff, J. (1984). Circadian timing. *Annals of the New York Academy of Sciences, 423*, 442–468.

———. (1998). Human perception of short and long time intervals: Its correlation with body temperature and the duration of wake time. *Journal of Biological Rhythms, 13*, 437–442.

Bechtel, W., Abrahamsen, A., & Graham, G. (1998). The life of cognitive science. In W. Bechtel & G. Graham (Eds.), *A companion to cognitive science* (pp. 1–104). Oxford, UK: Blackwell.

Binkofski, F., & Block, R. A. (1996). Accelerated time after left frontal cortex lesion. *Neurocase, 2*, 485–493.

Block, R. A. (1990). Models of psychological time. In R. A. Block (Ed.), *Cognitive models of psychological time* (pp. 1–35). Hillsdale, NJ: Erlbaum.

———. (1994). James, William (1842–1910). In S. L. Macey (Ed.), *Encyclopedia of time* (pp. 320–321). New York: Garland.

———. (1996). Psychological time and memory systems of the brain. In J. T. Fraser & M. P. Soulsby (Eds.), *Dimensions of time and life: The study of time, Vol. 8* (pp. 61–76). Madison, CT: International Universities Press.

Block, R. A., & Eisler, H. (2000). *The compleat bibliography on the psychology of time, 1839–1999* [Machine-readable data file]. Bozeman, MT: Montana State University, Department of Psychology [producer and distributor].

Block, R. A., Saggau, J. L., & Nickol, L. H. (1983–84). Temporal Inventory on Meaning and Experience: A structure of time. *Imagination, Cognition and Personality, 3*, 203–225.

Block, R. A., & Zakay, D. (1996). Models of psychological time revisited. In H. Helfrich (Ed.), *Time and mind* (pp. 171–195). Kirkland, WA: Hogrefe & Huber.

———. (1997). Prospective and retrospective duration judgments: A meta-analytic review. *Psychonomic Bulletin & Review, 4*, 184–197.

Block, R. A., Zakay, D., & Hancock, P. A. (1998). Human aging and duration judgments: A meta-analytic review. *Psychology and Aging, 13*, 584–596.

———. (1999). Developmental changes in human duration judgments: A meta-analytic review. *Developmental Review, 19*, 183–211.

———. (in press). Sex differences in duration judgments: A meta-analytic review. *Memory & Cognition.*

Boring, E. G. (1950). *History of experimental psychology* (2nd ed.). New York: Appleton-Century-Crofts.

Bouman, L., & Grünbaum, A. A. (1929). Eine Störung der Chronognosie und ihre Bedeutung im betreffenden Symptomenbild [A disturbance of chronoagnosia and its meaning in the corresponding picture of the syndrome]. *Monatsschrift für Psychiatrie und Neurologie, 73*, 1–39.

Church, R. M. (1984). Properties of the internal clock. *Annals of the New York Academy of Sciences, 423*, 566–582.

———. (1989). Theories of timing behavior. In S. B. Klein & R. R. Mowrer (Eds.), *Contemporary learning theories: Instrumental conditioning theory and the impact of biological constraints on learning* (pp. 41–71). Hillsdale, NJ: Erlbaum.

Clayton, N. S., & Dickinson, A. (1998). Episodic-like memory during cache recovery by scrub jays. *Nature, 395*, 272–274.

Cohen, J. (1964, May). Psychological time. *Scientific American, 211*, 116–124.

Dennett, D. C. (1991). *Consciousness explained.* Boston: Little, Brown.

Dennett, D. C., & Kinsbourne, M. (1992). Time and the observer: The where and when of consciousness in the brain. *Behavioral and Brain Sciences, 15*, 183–247.

Doob, L. W. (1971). *Patterning of time.* New Haven, CT: Yale University Press.

Ebbinghaus, H. (1973). *Psychology: An elementary text-book* (M. Meyer, Trans.). New York: Arno Press. (Original work published 1908)

Eisler, H. (1976). Experiments on subjective duration 1868–1975: A collection of power function exponents. *Psychological Bulletin, 83*, 1154–1171.

Fechner, G. T. (1966). *Elements of psychophysics* (H. E. Adler, Trans.). New York: Holt, Rinehart and Winston. (Original work published 1860)

Fraisse, P. (1957). *Psychologie du temps [Psychology of time].* Paris: Presses Universitaires de France.

———. (1963). *The psychology of time* (J. Leith, Trans.). New York: Harper & Row. (Original work published 1957)

Fraser, J. T. (1990). *Of time, passion, and knowledge: Reflections on the strategy of existence.* (2nd ed.). Princeton, NJ: Princeton University Press.

Gibbon, J., & Church, R. M. (1984). Sources of variance in an information processing theory of timing. In H. L. Roitblat, T. G. Bever, & H. S. Terrace (Eds.), *Animal cognition* (pp. 465–488). Hillsdale, NJ: Erlbaum.

Gilbert, J. A. (1894). Researches on the mental and physical development of schoolchildren. *Studies from the Yale Psychology Laboratory, 2*, 40–100.

Guyau, J.-M. (1988). The origin of the idea of time. In J. A. Michon, V. Pouthas, & J. L. Jackson (Eds. and Trans.), *Guyau and the idea of time* (pp. 93–148). Amsterdam: North-Holland. (Original work published 1890)

Häfner, H. (1953). Psychopathologie der cerebralorganisch bedingten Zeitsinnesstörungen [Psychopathology of disturbances of the time sense as caused by organic brain disorders]. *Archiv für Psychiatrie und Nervenkrankheiten, 190*, 530–545.

Hall, E. T., Jr. (1966). *The hidden dimension.* Garden City, NY: Anchor Press/Doubleday.

———. (1983). *The dance of life: The other dimension of time.* Garden City, NY: Anchor Press/Doubleday.

Harrison, E. R. (1994). Atomicity of time. In S. L. Macey (Ed.), *Encyclopedia of time* (pp. 46–47). New York: Garland.

Hoagland, H. (1933). The physiological control of judgments of duration: Evidence for a chemical clock. *Journal of General Psychology, 9*, 267–287.

Israeli, N. (1936). *Abnormal personality and time*. New York: Science Press.
James, W. (1890). *The principles of psychology*. (Vol. 1). New York: Holt.
Janet, P. (1928). *L'evolution de la memoire et de la notion de temps [Evolution of memory and of the notion of time]*. Paris: Chahine.
Kant, I. (1970). *Metaphysical foundations of natural science* (J. Ellington, Trans.). Indianapolis, IN: Bobbs-Merrill. (Original work published 1786)
———. (1998). *Critique of pure reason* (P. Guyer & A. W. Wood, Trans. and Ed.). Cambridge, UK: Cambridge University Press. (Original work published 1781)
Levine, R. V. (1988). The pace of life across cultures. In J. E. McGrath (Ed.), *The social psychology of time: New perspectives* (pp. 39–60). Newbury Park, CA: Sage.
Levine, R. (1997). *A geography of time: The temporal misadventures of a social psychologist, or how every culture keeps time just a little bit differently*. New York: Basic Books.
Lightman, A. (1993). *Einstein's dreams*. New York: Pantheon.
Loftus, E. F., Schooler, J. W., Boone, S. M., & Kline, D. (1987). Time went by so slowly: Overestimation of event duration by males and females. *Applied Cognitive Psychology, 1*, 3–13.
Macar, F., Grondin, S., & Casini, L. (1994). Controlled attention sharing influences time estimation. *Memory & Cognition, 22*, 673–686.
Miall, C. (1996). Models of neural timing. In M. A. Pastor & J. Artieda (Eds.), *Time, internal clocks and movement* (pp. 69–94). Amsterdam: North-Holland/Elsevier Science.
Michon, J. A. (1967). *Timing in temporal tracking*. Assen, Netherlands: Van Gorcum.
———. (1989). Timing your mind and minding your time. In J. T. Fraser (Ed.) *Time and mind: Interdisciplinary issues* (pp. 17–39). Madison, CT: International Universities Press.
———. (1994). Psychology of time. In S. L. Macey (Ed.), *Encyclopedia of time* (pp. 507–511). New York: Garland.
Michon, J. A., & Jackson, J. L. (1985). Introduction: The psychology of time. In J. A. Michon & J. L. Jackson (Eds.), *Time, mind, and behavior* (pp. 2–17). Berlin: Springer-Verlag.
Neisser, U. (1976). *Cognition and reality*. San Francisco: Freeman.
Nichols, H. (1891). The psychology of time. *American Journal of Psychology, 3*, 453–529.
Ornstein, R. E. (1969). *On the experience of time*. Harmondsworth, England: Penguin.
Piaget, J. (1969). *The child's conception of time* (A. J. Pomerans, Trans.). New York: Basic Books. (Original work published 1946)
Pittendrigh, C. (1960). Circadian rhythms and the circadian organization of living systems. *Cold Spring Harbor Symposia on Quantitative Biology, 25*, 159–184.
Richelle, M. (1993). A concise guide to the temporal maze. *Psychologica Belgica, 33*, 135–145.
Seashore, C. E. (1899). Some psychological statistics. *University of Iowa Studies in Psychology, 2*, 1–84.
Transcript of the chat with Koko. (1998, April 27). Retrieved April 30, 1998, from the World Wide Web: <http://www.envirolink.org/kokotranscript.html>
van der Horst, N. (1928). Over de psychologie van het syndroom van Korsakow [On the psychology of Korsakoff's syndrome]. *Psychiatric en Neurologic Bladen, 32*, 59–77.

———. (1932). Über die Psychologie des Korsakowsyndroms [On the psychology of Korsakoff's syndrome]. *Monatsscrift für Psychologie und Neurologie, 83*, 65–94.
Victor, M., & Yakovlev. (1955). Psychic disorders in conjunction with multiple neuritis. *Neurology, 5*, 394–406.
Vierordt, K. (1868). *Der Zeitsinn nach Versuchen [Empirical studies of time experience]*. Tübingen, Germany: Laupp.
Wade, N. J., & Heller, D. (1997). Scopes of perception: The experimental manipulation of space and time. *Psychological Research, 60*, 227–237.
Weber, E. H. (1846). Der Tastsinn und das Gemeingefühl [The sense of touch and the common feeling]. In R. Wagner (Ed.), *Handwörterbuch der Physiologie, mit Rücksicht auf Physiologische Pathologie* (Vol. 3, pp. 481–588). Braunschweig: Vieweg.
Weber, E. H., Ross, H. E., & Murray, D. J. (1996). *E. H. Weber on the tactile senses* (2nd ed.). Hove, England: Erlbaum.
Woodrow, H. (1951). Time perception. In S. S. Stevens (Ed.), *Handbook of experimental psychology* (pp. 1224–1236). New York: Wiley.
Zakay, D., & Block, R. A. (1996). The role of attention in time estimation processes. In M. A. Pastor & J. Artieda (Eds.), *Time, internal clocks and movement* (pp. 143–164). Amsterdam: North-Holland/Elsevier Science.
———. (1997). Temporal cognition. *Current Directions in Psychological Science, 6*, 12–16.
Zaleski, Z. (Ed.). (1994). *Psychology of future orientation*. Lublin, Poland: Towarzystwo Naukowe KUL.
Zimbardo, P. G., & Boyd, J. N. (1999). Putting time in perspective: A valid, reliable individual-differences metric. *Journal of Personality and Social Psychology, 77*, 1271–1288.