Physical time, perceived time, and their interrelation

Martin Riemer *Postdoctoral Researcher at RUG*

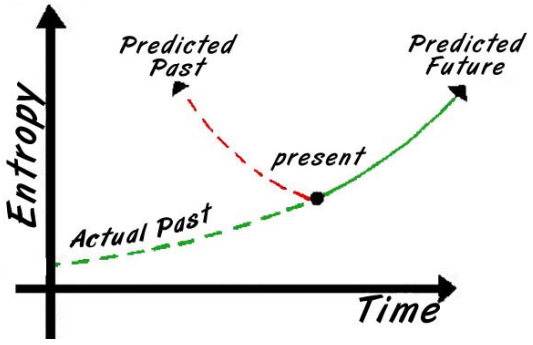
"I know well enough what it is, provided that nobody asks me; but if I am asked what it is and try to explain, I am baffled." This statement about time, made by Saint Augustine in his Confessions at the end of the fourth century A.D., is still a valid description of what most contemporary philosophers and physicists would declare today. There is rarely another aspect of our reality that feels so familiar, but is yet so little understood, as the concept of time.

What, then, is time? A useful starting point in answering this question might be to divide it into two partitions: "What is time?" and "What is time as it appears to us?" In other words, we might differentiate between physical and psychological time. Could we understand Augustine's words in the sense that he knows well enough what psychological time is, but that he is baffled when asked about physical time?

In his seminal work Elements of Psychophysics, Gustav Theodor Fechner (1860) defined psychophysics as the scientific study of the functional interrelations between the physical and psychological realms. As for other quantities like weight, luminance, or loudness, psychophysical laws for time intend to describe how physical durations are translated into perceived durations and to understand why the same physical time interval sometimes appears shorter (for example during an enjoyable activity) than at other times (for example when we are bored). Since the days of Fechner we have made great progress in understanding this relation, but the task is hindered by a very unique constraint regarding the psychophysics of time. A constraint that is so deeply rooted in our psychological experience that we often fail to pay adequate attention to it.

In contrast to other psychological magnitudes, perceived time only has one direction. It flows from the past to the future, and there is no means by which we can change this direction. Other magnitudes can increase and decrease. A weight in our hands, the loudness of a sound, the spatial size of an object et cetera. All these quantities can both increase and decrease. But the perception of time is constrained to one direction. It is important to note here that this constraint only pertains to the psychological realm. With respect to the physical realm, the matter gets more (or less) complicated. It has often been discussed that physical laws are time-reversal invariant, which means that they maintain their validity under the theoretical assumption of a reversed time flow. There is nothing in the physical laws that implies a specific direction for time.

This is the essence of the Loschmidt paradox: If physical laws are time-reversal invariant and entropy-decreasing phenomena should be, in principle, as likely as entropy-increasing phenomena, why is it then that we never observe pheno-mena of the former type? The Loschmidt paradox has almost entirely been considered from the perspective of the underlying physical laws, and not from the perspective of phenomenal experience. However, the question is not whether entropy-decreasing processes can happen. The question is why we cannot perceive these processes. And this is more a question regarding phenomenal experience than regarding the physical processes to be experienced. It is a question about the psychological, not about the physical realm.



The standard approach in psychophysics consists in a systematic manipulation of the physical sti-

muli in order to probe the corresponding effects on perception. For example, we can change the sound pressure level of an auditory stimulus (quantified in decibel) and probe the corresponding change in the perceived loudness of this stimulus. Experiments like this have revealed a logarithmic relationship between physical and psychological stimulus intensities. This approach, however, critically depends on the assumption that we possess complete experimental control over the physical stimuli. That we can systematically manipulate the independent variable in any way we want.

With respect to the psychophysics of time, the Loschmidt paradox highlights a fundamental discrepancy between the physical and the psychological realm. And if we take the abovementioned definition of psychophysics seriously, if we really want to describe the functional interrelations between physical and psychological realms, then we have to take into account that we are not capable of deliberately manipulating physical time to observe the corresponding effects on our perception of time. We can decrease the sound pressure level of an auditory stimulus and describe our perception of the sound's loudness, but we cannot present a time interval that continuously decreases in its duration. We can instantaneously place a physical weight on our hand and describe our perception of this weight, but we cannot instantaneously experience a time interval of ten seconds without having experienced a time interval of one, two, five, etc. seconds shortly before. We can experience the spatial size of an object in a holistic manner and describe our perception of this size, but we cannot directly perceive a time interval without either waiting for its end or recalling the moment of its beginning. In contrast to loudness, weight or spatial size, a duration is - per definition - never present.

All these examples show that, in the psychophysics of time, we are uniquely constrained in the control that we have over the experimental stimuli, an essential prerequisite for psychophysical studies. This anisotropy of time is so fundamentally embedded in our conscious experience that it can easily escape our attention. In his recommendable book Time's Arrow and Archimedes' Point the physicist Huw Price (1996) argues that we often ignore the temporal character of the viewpoint which we have on reality. He writes that "we are creatures in time, and this has a very great effect on how we think about time".

Neither in the field of physics nor in psychophysics will we be able to step outside of our time-asymmetric viewpoint and observe the world from a more neutral perspective. But this inability only makes it more important to be aware of our biased point of view. Being aware of this limitation can help us to approximate a "view from nowhen" on reality and to gain a better understanding about physical time, about perceived time and about the psychophysical laws that determine the interrelation between both domains.

Martin Riemer is a cognitive neuroscientist. His research interests are widely spread between time perception, spatial cognition and body representations. Currently he is working at the University of Groningen, in the laboratory of Hedderik van Rijn. In his research he uses a wide range of methods, including psychophysical and -physiological techniques, electro-encephalography (EEG), transcranial magnetic stimulation (TMS), and functional magnetic resonance imaging (fMRI). For more information about him and his research see martinriemer.com

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