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Editorial

Conscious experience of time: Its significance and interpretation in neuroscience and philosophy



The subjective experience of time has been an important topic in philosophy and psychology since the beginning of these respective disciplines. This interest continues, but has recently increased and become more visible. A number of special issues, books, and review articles on topics connected to psychological time appeared in just the last few years.

The range of these topics has been impressive. Philosophy of mind yielded a number of new theoretical models of the experience of passage, duration, and timing of events. At the other end, research in psychology and neuroscience has been uncovering the cognitive and neural mechanisms that underlie time perception and consciousness.

Bringing the common strands in the work of philosophers and neuroscientists together has tremendous potential to advance our understanding of the subjective experience of time in general. This interdisciplinary issue offers a forum for just that. Our motivation for this volume and the workshop that was its inspiration was to foster comprehensive understanding of the role of time in conscious experience that can bear directly on issues of concern not only to philosophers and scientists, but to the public at large. The work of scientists and philosophers contained here also represents the cutting edge of research in the area. We hope that the collaborative and interdisciplinary dialogue that has driven the work of these researchers will generate even more future discussion and make the common strands in their work more visible.

The issue begins with an empirical contribution by Silvie Droit-Volet and her co-authors. They study how established effects of stimulus-induced emotions on the perceived duration of these stimuli are affected by prior beliefs about the effects. Participants performed a temporal bisection task on face stimuli that showed either angry or neutral expressions. One group of participants performed this task without any additional information, replicating the established effect that angry faces are judged as longer in duration compared to neutral faces.

To test whether prior beliefs about effects of emotion on perceived duration could influence the actual effect, another group of participants was informed prior to performing the task that emotional stimuli affect perceived duration. Importantly, half of the participants in this group received correct information, namely, that angry faces prolong perceived duration, while the other half received incorrect information, namely that angry faces shorten perceived duration. The true information group showed an enhanced duration effect compared to the no-information group. The false information group showed a reduced effect (no significant difference to the no-information group), but no reversal of the effect (as the declarative information predicted). In sum, these findings reveal that declarative information about emotion-duration effects can modulate perceived duration, but the modulation cannot reverse the actual effect. In a second experiment, the authors show that if there is no effect of a particular emotional stimulus on perceived duration a priori, as is the case for faces depicting shame or disgust, declarative knowledge cannot induce such an effect. Declarative knowledge thus can only modulate existing effects on perceived duration.

This is important in further supporting the already established view that emotion-duration effects are caused by bottom-up perceptual processing. It goes further in establishing that once generated, such effects can be affected by top-down influence from higher levels of cognition. These influences are discussed in the context of the internal clock framework, which suggests a hierarchy of processing stages of temporal information. Furthermore, the results stress the relevance of assessing or controlling participants' beliefs about experimental effects themselves.

John Wearden's article concerns passage of time judgments (POTJs), which are typically verbal reports on what is commonly thought to be a salient aspect of our conscious experience of time, namely, how fast it appears to pass. Up till now passage received little attention in contemporary empirical literature on time perception. Extant treatments, Wearden suggests, contain a number of paradoxes and conceptual muddles that may leave one dubious about future progress. Nonetheless, Wearden remains optimistic that it is possible to learn more about the processes that underlie POTJs by relying on

established methods for studying time perception, such as temporal generalization or bisection. The synthesis offered here gives good reason to adopt Wearden's optimism.

The first problem to overcome in understanding the conscious experience of passage is the lack of clarity about what POTJs are about. The most obvious answer—and the one that Wearden rejects—is that POTJs are about the rate of passage relative to some standard rate. For example, time passes faster when a duration that normally would be experienced as, say, 2 s, appears to last less than 2 s. Conversely, time passes slower when 2 s appears to last more than 2 s. On this view, POTJs are essentially duration judgments in disguise.

The view that POTJs are duration judgments is hard to defend given evidence of dissociations between POTJs and judgments of duration. For one, there are several empirical studies, which show that reports of time passing faster or slower are independent of both prospective and retrospective judgments about duration. Furthermore, judgments about duration of repeated film clips have been shown to remain the same even though judgments about “how long does it feel” change. Finally, judgments about passage in emergency situations have been shown to track arousal while judgments of duration have been shown to be independent of arousal. Consequently, Wearden rejects the view that POTJs are judgments of duration in disguise. The view that emerges from the aforementioned studies and what we know independently about the mechanisms of perception is that POTJs reflect allocation of attention and level of arousal instead. This is the view that, somewhat tentatively, Wearden adopts himself.

Wearden's view gives us an insight into a relatively understudied subject. But this work does not end with the discussion about POTJs as much as it sketches exciting avenues for future research. One question that remains is whether POTJs are indeed as independent from duration judgments as Wearden suggests. Arousal, attention, and information processing that are offered as the determining processes for POTJs also influence duration judgments, albeit in a different way. Future research may shed light on this relationship and tell us more about the variables that contribute to the dissociations between POTJs and duration judgments that Wearden rests his case on.

Marc Wittmann's review article shows us just where such a richer theory of duration judgments may be found. Wittmann argues that the “feeling states,” which are arguably just the states that Wearden identifies with processes that underlie passage of time judgments, figure prominently in our current understanding of awareness of the self. Such awareness increases in a variety of situations, which Wittmann helpfully catalogues and pins together with a common thread: effects on conscious experience of time. The catalogue of evidence that Wittmann brings forward is impressive. Altered states of consciousness, meditation, schizophrenia, interoception, and emotions all show strong correlations between awareness of self and changes in the conscious experience of time.

The message is that the subjective feeling of time slowing or quickening, among other things, strongly correlates with increased attention to the experience of the self and this relationship ought to play a more prominent explanatory role in time perception literature. Given the breadth of evidence that Wittmann musters, the case for this view seems overwhelming.

Another contribution of Wittmann's review is placing philosophical work in context of recent neuroscientific studies concerned with the mechanisms underlying time perception and awareness of self. Wittmann outlines, in broad strokes, how neural systems as disparate as the default mode network, insular cortex, and the dorsolateral frontal cortex may come to interact and thus give rise to different aspects of the conscious experience of time. Particularly useful in this context is Wittmann's discussion of the relationship between ‘explicit time’ and sensory experience of here and now, on the one hand, and ‘implicit time’ associated with mind wandering and the so-called narrative self, on the other.

In a theoretical paper, Dan Zakay addresses the question of how attention is allocated to temporal processing in prospective duration judgments. It is an established effect that attention allocated to time alters duration judgments. When timing is not the only requirement in a given situation, the amount of attention allocated to time depends inversely on the amount of attention dedicated to the concurrent task. Information processing models of prospective duration judgments postulate that this effect results from an attentional gate or a dynamic switch determining the flow of temporal information from a pacemaker to an accumulator.

The question addressed by Zakay is how the allocation of resources to time—especially attention—is determined. He proposes that attention is allocated to time based on an interplay of two variables: temporal relevance (TR) and temporal uncertainty (TU). TR reflects the importance of judging duration adequately in a given situation and varies dynamically. TU refers to the amount of information that is available about the duration to be judged. If the interval's duration is familiar or known TU is low, while if the interval is unfamiliar or unknown, TU is high.

In the proposed TR-TU model both variables interact to govern a dynamic allocation of attention to time. According to the model, attention is allocated to time when TR passes a certain threshold, that is when timing becomes relevant for the situation. Allocation of attention to time evokes a search for existing temporal information, i.e. an assessment of TU. The amount of attention allocated to time thus depends on an interaction between TR and TU. If TR is low, no attention is allocated to time and if TR is high, the amount of attention allocated to time depends on TU.

The model bridges a gap in the current literature, which to date assumes resource sharing between temporal and non temporal processes, but does not yet specify which processes govern the allocation of available resources. The feasibility of the TR-TU model is discussed in various real-life scenarios in which duration judgements are altered, e.g. under anxiety or when comparing the duration of a return trip to a trip taken for the first time.

In our view, Zakay's model explains in new way how temporal and non-temporal processing interact and how this interaction might result in altered duration judgments. The TR-TU model can be applied to a broad range of situations, while at the same time offering testable predictions based on a small amount of variables, some of which are suggested by the author.

Martin Riemer's paper concerns the relationship between psychological time and world time, which is a topic often neglected in both philosophical and empirical work on time perception and conscious experience of time. Riemer argues that, perhaps because of this neglect, empirical research concerned with psychological time has run into serious methodological problems. The most serious of these is startling in the scope of its implications: there are no durations in the world and what psychologists and philosophers have been calling perception of duration is, for all intents and purposes, a misleading fiction.

Riemer's argument for this conclusion starts with an observation of anisotropy, that is, the well-known asymmetry between world time and psychological time. Physical laws remain valid even if the direction of time were reversed. Psychological time, however, cannot be reversed without upsetting some of the fundamental platitudes of folk psychology. This is peculiar to the temporal dimension of perception, which suggests that time perception itself is a theoretical construct and has no psychological reality.

Riemer's paper touches on an important topic that needs highlighting in a literature that typically focuses on psychological time and largely ignores world time and physics. The most important of these, it seems, is the timing of events in the world and the relationship of that physical timing to the timing of events in the brain and finally to the timing of events as they are presented in our conscious experience.

The editors invited Sean Enda Power to write a special commentary on Riemer's paper. Power takes a dim view of Riemer's claim that anisotropy somehow threatens standard practice in psychology. According to Power, the key distinction to make in this context is that between practical anisotropy and theoretical anisotropy. The former applies to physical laws as well as to psychological time. The latter is, to a large extent, a consequence of one's theoretical commitments in other domains of inquiry.

Power explains that practical anisotropy is, all things considered, not possible. In consequence, whatever the status of theoretical anisotropy turns out to be, it cannot bear on psychological practice. In other words, even if one's theoretical commitments lead one to believe that anisotropy is possible in physics or metaphysics, that would have no practical consequence on psychology or neuroscience. The dialogue between these two philosophers might not move the discussion forward much, but it certainly stakes out positions on an important issue of anisotropy and carves out important ground for future work on the topic. This could be the beginning of a fruitful dialogue between philosophy, physics, and psychology on the relationship between world time and mental time.

The issue of the relationship between the timing of events in the brain and conscious experience of time is central in Valtteri Arstila's paper. Arstila offers and defends the non-linear latency difference view, which consists of two empirically falsifiable theses: (1) perceptual stimuli are presented in conscious experience as soon as they are processed and (2) perceived stimuli are presented in the order in which that processing completes. When Arstila applies this framework to recent empirical studies of postdiction effects, such as apparent motion, flash-lag illusion, and metacontrast masking, his framework proves its usefulness and sustains possible objections.

The article also offers an analysis of other extant accounts of the neural mechanisms of postdiction, which in itself is useful as a review of the literature and its theoretical landscape. Arstila argues that all of these accounts of postdiction have to reject at least one of their starting assumptions to be able to account for all the postdictive effects. So this shortcoming motivates Arstila's unified account, which is both philosophically and empirically simpler.

Several of the papers in this issue concern the role of attention in temporal processing. Attention to the bodily self, attention to temporal features, and attention in connection with arousal are all shown to have an important role in modulating conscious experience of time. This is important and consistent with our introspective experience about the relationship between perception and attention. Other papers in the volume demonstrate that an equally complex interplay occurs between conscious experience of time and automatic processes, such as those that control emotions. All papers in this volume, however, put on display the diversity of temporal experience. In sum, we see that conscious experiences of duration, timing and passage of time enter into a complex interplay with attention and high-level cognitive processes and low-level processes. The result of this interplay is a modulation of conscious experience that manifests itself in judgments and reports about time.

This wide range of effects and complex relationships is, to some extent, what makes mental time so interesting. It is also what makes it so difficult and sometimes frustrating to study. Some of this excitement, as well as frustration, comes from the fact that mental time is ubiquitous. Wherever we look in the perceptual-cognitive hierarchy, time seems to play an important role. Because of this, we cannot isolate time perception, say, from perception of other features. This is perhaps the main source of the frustration, since mental time can never be studied in isolation. No experiment in the world could come up with a condition that excludes timing and no experiment could study timing without some context.

Just as well as the diverse topics raised in the issue, all of this suggests that temporal processing is not one unitary phenomenon. What seems likely is that there might be different modi of temporal processing for many of the processes that make use of perceptual information about timing and duration. What is left is a set of pressing questions for future research. Do comparative duration (timing, passage, etc.) judgements and temporal reproduction (bisection, verbal reports, etc.) measure the same underlying process? Is our conscious experience of duration (timing, passage, etc.) merely the result comparisons in other non-temporal features? Is time perception, as Martin Riemer suggests, merely a theoretical construct

embedded in psychological practice in the lab? There is a somewhat desperate air to these questions and a critical observer might get the sense that, at this stage, psychologists, neuroscientists, and philosophers are poking around in the dark in their attempts to understand mental time.

We see this as good reason for more interdisciplinary work and these questions as guides for testable hypotheses. We continue in thinking that future research on mental time needs unifying taxonomies and models. These should give us multi-level, vertical explanations of how different timing processes relate to one another. Such ambitions will require interdisciplinary dialogue with special consideration given to philosophy, psychology, and neuroscience.

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