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## Letter to the Editor

# On subjective time

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Perhaps one of the most remarkable, and under appreciated, achievements of the human brain is our capacity to be aware of the subjective time in which we exist. Although we do not think much about this sense of time, we make use of it whenever we remember something that happened to us in the past or imagine something that might happen to us in the future. In what follows, I (i) define subjective time, (ii) explicate how we might begin to understand the capacity to be aware of subjective time, also known as “chronesthesia” [a concept whose name is derived from the Greek words *Chronos* (time) and *Aisthesis* (to feel) (Tulving, 2002)], and (iii) speculate about the relation of subjective time to the human brain.

## 1. What is subjective time?

In recent years, the fields of psychology and cognitive neuroscience have seen a steady increase in the number of studies examining the relation between remembering the past and imagining the future, or what is sometimes metaphorically referred to as ‘mental time travel’ (Suddendorf and Corballis, 1997, 2007). An important question that this line of research raises has to do with the nature of “time” in which such metaphorical travel takes place. Simply put, what kind of time are we talking about? It cannot be the same ‘clock and calendar’ time that figures prominently in physical sciences and governs many practical affairs of everyday life, because ‘past’ and ‘future’, necessarily defined with respect to a sentient observer, do not exist in the physical reality but are products of the human mind (Tulving and Szpunar, *in press*). Hence, I refer to the time of which past and future moments

are parts as ‘subjective time’—our sense of continued existence in the world.

## 2. How to approach the study of subjective time?

Before the study of subjective time can be meaningfully pursued, there must first be in place a clear understanding of what it is that we are interested in learning. An important distinction to consider in this regard is one between (i) the capacity to be aware of subjective time, or “chronesthesia,” and (ii) its associated mental activities. Tulving and Kim (2007) have used the terms ‘medium’ and ‘message’ to refer to these two aspects of mental time travel and pointed out that the ‘medium’ (capacity) makes the ‘message’ (time-related mental activities) possible. That is, much in the same way that vision enables us to perform a variety of tasks, such as reading, so to does chronesthesia (e.g., remembering the past and imagining the future). Taking the vision analogy a step further, although reading is a fascinating mental activity in and of itself and one that we have learned much about, it would not be possible in the absence of the visual capacity. Hence, if we are to begin to understand subjective time then we might want to know something about the capacity to be aware of such time in the first place.

It is important to note that the concept of “chronesthesia,” as originally outlined by Tulving (2002), is closely related to various other concepts in the literature. Perhaps most closely related is Dalla Barba’s concept of “temporal consciousness” which has been defined as a kind of conscious awareness that “opens the possibility of a temporal existence for the subject” (Dalla Barba

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and Boissé, 2010, p. 106; see also Dalla Barba, 2002). Another related concept is “autoeotic consciousness” (Tulving, 1985). Both chronesthesia and autoeotic consciousness have to do with the conscious awareness that one’s self exists in subjective time. The difference between the two concepts is in terms of their emphasis. The concept of “chronesthesia” emphasizes awareness of the subjective time in which one’s self exists. The concept of “autoeotic consciousness” emphasizes awareness of one’s self existing in subjective time. The distinction is subtle but it is necessary because time can be dealt with, and usually is dealt with, independently of self and self can be dealt with independently of time.

Nonetheless, the close relation between self and time should not be understated. For instance, Buckner and Carroll (2007) speculated that the ability to “self-project” one’s perspective away from the immediate moment and toward the personal past and future might be closely related to the ability to consider the mind-set of other individuals (i.e., theory-of-mind). However, Rosenbaum et al. (2007) demonstrated that amnesic individuals who lack chronesthesia, and who are limited to thinking about their immediate surroundings, could nevertheless imagine what others might be thinking. Hence, although human beings possess the ability to mentally project themselves to a myriad of “non-present” situations (for relevant discussion, see Rabin et al., 2010; Spreng and Grady, 2010; Spreng et al., 2009), there may indeed exist a special status for the capacity to be aware of the subjective time in which we ourselves exist.

Accordingly, if chronesthesia represents a unique achievement of the human brain, then how does the brain support this capacity? Next, this important question is considered in more detail.

### 3. Subjective time and the human brain

Although it would be premature to make any definitive statements about chronesthesia and the brain, some modest contributions to our understanding of this relation have been reported in the context of brain imagining studies of mental time travel and neuropsychological observations of people with damage to the prefrontal cortex.

With regard to brain imaging, we now know that a common network of frontal, temporal, and parietal brain regions is involved in remembering the past and imagining the future (Addis et al., 2007; Szpunar et al., 2007; for relevant reviews, see Schacter et al., 2007, 2008; Szpunar, 2010). However, it remains unclear what aspects of this network reflect chronesthesia as opposed to characteristics of the events that people think about. As was alluded to above, it will be important for future studies of mental time travel to attempt to distinguish between the capacity to be aware of subjective time and the mental activities that it enables.

With regard to neuropsychology, case studies of people with damage to the prefrontal cortex have consistently demonstrated impairment in the capacity to think about one’s continued existence (for a relevant review, see Wheeler et al., 1997). Although there are many reasons why neuropsychological case studies should be considered cautiously, such observations nonetheless provide us with clues as to the

possible neural substrates of subjective time and, more importantly, that the systematic study of subjective time may be a worthwhile endeavor (for speculation of the possible role of the medial temporal lobes in subjective time, see Dalla Barba and Boissé, 2010).

Of course, other hypotheses regarding the relation of subjective time to the brain are possible. For instance, one alternative is that subjective time is not a unique property of the human brain and that ‘pastness’ and ‘futureness’ are rather attributed to memories and future imaginings as a means of maintaining some level of organization for our thoughts (cf. Jacoby, 1984; see also Hassabis and Maguire, 2007).

At this point, there does not exist enough evidence to make any absolute claims about the true underlying nature of subjective time. However, given the extent of recent interest in mental time travel, the time has come to start asking serious questions about how the human brain makes such metaphorical travel into the personal past and future possible.

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