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Animals are not cognitively stuck in time

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Abstract. We argue that animals are not cognitively stuck in time. Evidence pertaining to multisensory temporal order perception strongly suggests that animals can represent at least some temporal relations of perceived events.

Hoerl & McCormack's (H&M's) dual system approach to temporal cognition holds that animals cannot represent temporal properties of events given the limitations of the temporal updating system. But even if H&M are right that animals are not capable of mental time travel (MTT) and lack certain forms of episodic representation, there are other forms of temporal representation that they are likely to possess. In this commentary, we argue that considerations having to do with multisensory temporal order perception strongly suggest that animals are not cognitively stuck in time.

In adult humans, MTT and related capacities for episodic thinking are dissociable from more rudimentary perceptual capacities for keeping track of time at very short timescales (Craver et al. 2014a; 2014b; Wittmann 2011). Importantly, some of these perceptual timekeeping capacities exceed the limitations of the temporal updating system. Consider a well-known study by Stetson et al. (2006). Subjects were asked to press a button and then a flash of light would appear on a screen approximately 35ms later. In this initial condition, subjects reliably perceived the flash of light as occurring after the button press. Next, a delay of 135ms was inserted between the button press and the flash of light. After subjects adapted to this longer delay, it was removed, and they were once again presented with the light flashing 35ms after they pressed the button. In this post-adapted condition, despite the stimuli having the same temporal structure as the initial condition, subjects reliably perceived the flash of light as occurring prior to the button press.

Notice that the temporal updating system cannot explain the way that these sorts of events are experienced. The temporal updating system can only track the temporal sequence of incoming stimulation. But clearly the timekeeping capacities that are needed to account for these two different experiences are not constrained in this way; they rely on the perceptual system being able to represent the temporal order of distal events in the world.

Examples of perceived temporal order coming apart from the order of sensory stimulation are common in the literature on adult human timekeeping capacities—from the recalibration of temporal order perception within and across modalities (Chen & Vroomen 2013; Vroomen & Keetels 2010; Vroomen et al. 2004) to the flexible recalibration of multisensory simultaneity perception (Mégevand et al. 2013). In all of these cases, the same general explanation can be given for why the perceptual system should show this flexibility. Modality-specific signals from distal events travel at different rates (e.g., light vs. sound), are processed by modality-specific transducers at different rates, and are even transmitted to their respective primary sensory areas at different rates (Vroomen & Keetels 2010). Somehow the perceptual system must have a way of discounting these different asynchronies in the arrival times of sensory signals to produce a coherent picture of how events in the environment are temporally structured. This requires psychological capacities that can represent temporal relations.

At this moment, the critical studies to determine whether animals possess these flexible timekeeping capacities have yet to be conducted, because it is only recently that paradigms for temporal order perception have been modified for animal studies. Nonetheless, if the full range of existing evidence is taken into account, there are good reasons for expecting that animal time-keeping capacities will show a similar sort of flexibility that goes beyond the constraints of the temporal updating system.

First, animals are subject to the same sorts of external and internal factors that create the need to discount asynchronies in the arrival and processing of sensory signals (e.g., the different rates of modality-specific transduction). Second, evidence from hippocampal damage in rats shows that despite losing the ability for sophisticated temporal sensitivity over longer timescales, they nevertheless perform well with timekeeping tasks at very short timescales (suggesting that lack of MTT doesn't imply anything about timekeeping at very short timescales) (Cordes & Meck 2014; Fortin et al. 2002; Yin & Troger 2011). Third, in the few studies that have modified experimental paradigms first used with humans to study temporal order perception in rats (Schormans et al. 2017), macaques (Mayo & Sommer 2013), and starlings (Feenders & Klump 2018), the psychophysical results have been very similar to those found in humans. Fourth, the models of the mechanisms that underpin temporal order perception in adult humans, and that also account for the flexibility of those capacities, are largely modeled off known features of multisensory systems in nonhuman animals (Cai et al. 2012).

All of this speaks to how plausible it is that animals can represent temporal relations. To properly navigate the world, the perceptual system must interpret the incoming temporal structure of sensory stimulation to properly represent how events in the environment are temporally structured. Although this doesn't amount to the full-fledged ability to reason about moments in time that H&M describe as being the hallmark of the developed temporal reasoning system, it nevertheless shows that animals are not cognitively stuck in time.