

# How embodied is time?

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It is a standard understanding that we live in time. In fact, the whole physical world as described in sciences is based on the idea of objective (not absolute) time. For centuries we have defined time ever so minutely, basing them on finer and finer event measurements (uncoiling springs to atomic clocks) that we do not even notice that we have made an inductive leap when it comes to time - we can measure time, so we experience time. In the current work I wish to critique this inductive leap and examine what it means to experience time. We are embodied and embedded cognitive agents, constrained by our body as well as in continuous interaction with our environment. So another way to ask the question of temporal experience would be - how embodied is time? I posit that experience of time spoken of in general literature is a linguistic construct, in that, the idea of experience of time overshadows the actual phenomenal contents of time perception. Moreover, time perception itself comes from a post-facto judgment of events. It has also been observed that the order of events in time can be altered to create an illusion of violation of causality itself. This points to the possibility that events are arranged in a temporal map that can be read off by higher cognitive substrates. In the current work we go on to explore the nature of such a map as it emerges from an embodied mind.

## Introduction

We live in time – it holds us and moulds us – but I’ve never felt I understood it very well. And I’m not referring to theories about how it bends and doubles back, or may exist elsewhere in parallel versions. No, I mean ordinary, everyday time, which clocks and watches assure us passes regularly: tick-tock, click-clock. Is there anything more plausible than a second hand? And yet it takes only the smallest pleasure or pain to teach us time’s malleability. Some emotions speed it up, others slow it down; occasionally, it seems to go missing – until the eventual point when it really does go missing, never to return.

*The Sense of an Ending*, Julian Barnes

Our experience is malleable. We retain traces of emotions generated from a beautiful melody even long after the actual music stops. Sometimes, we experience the same event alongside another in the form of a déjà vu. We are also in a constant state of growth and maturation, with malleable beliefs and imports, so that we have a sense of a unified ego (cogito encased in flesh) that moves through time<sup>1</sup>. In all standard theories of cognition, time is taken as an a priori category of consciousness. It is even hard to imagine how one can talk about the conscious experience and cognition in general if one did not have an ontological commitment to the idea of a subjective experience of time not only as embodied (our cognition is constrained, regulated and dependent in the

body) and embedded/situated beings, but also as biological entities (our development, growth, and maturity form a linear progression).

However, such an ontological commitment to an a priori category of time leads to some very acute problems, both philosophically as well as theoretically. In the following section, I would try to show the difficulties with the ontological commitment to the subjective experience of time. However, merely questioning subjective experience of time leaves us without a sound account of temporal phenomena in cognition. The challenge lies in giving an account of temporal existence on the basis of some other a priori category without giving in to the trap of Cartesian ontology.

In Section Three, I re-examine conceptual frameworks within the embodied stance of cognition to locate spatial representations as a possible solution. Although spatial representation has been shown to serve as an explanation of temporal phenomena in cognition, we must also locate the possibility of relative autonomy of spatial representation from a linguistic one, as a completely linguistic representation leads inevitably to Cartesian ontology.

However, spatial representation only forms one part of the story. It still leaves the question of the substrate of such a representation. In Section Four, I posit ontological priority of events and show how a possibility of a phenomenological account of event might operate. If events coupled with spatial representations replace the idea of subjective experience of time, it leads to a very interesting consequence for the em-

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<sup>1</sup>Even though the present ego might not identify with the beliefs and import of the ego-construct

bodied stance and intentionality defined therein. In the last section, I discuss the future directions that follow from this new ontological commitment.

### Anatomy of time

In this section we are concerned with the time that is subjective - the time we are nostalgic about, the time that we are afraid of losing, the time we spend, the idea of time on the basis of which we plan for future, organize our day, the time through which we claim we move through and mature, and so on - as opposed to objective time. In the current work we take a realist position on objective time, but anti-realist position on subjective time. Subjective time is mostly in the domain of language. We talk about our subjective time through the categories of language and thus the subjective time is subject to linguistic relativism (Núñez, 2008). We also make a distinction between subjective time and subjective experience of time<sup>2</sup>.

In the perceptual domain time enters as instant of time (occurrence of an event) and duration (gap between two events in question), i.e., as a relation between events. Subjective experience of time thus refers to the experience of the relation itself. Subjective time on the other hand is a construct of language that helps us build a narrative around events in our memory. In the following we will try to show the relation of events can appear as a map (similar to the maps that are common in discussions on visuo-spatial attention). We will now explore two examples within the literature of time perception to explore the two aspects of instant of time and duration of time.

**Motor-sensory recalibration.** There have been several demonstrations of temporal asynchrony in the visual domain (Moutoussis & Zeki, 1997b, 1997a). More recently, Stetson, Cui, Montague, and Eagleman (2006) have shown that by adapting to a fixed delay between a keypress by a human participant followed by a sensation, they could introduce illusory reversals by negating the delay after adaptation. This interesting case of reversal points us to a direction where instants of time-events are not integrated immediately, but rather an illusion-specific activation in anterior cingulate/medial frontal cortex point to a malleable representation of time events being compared to a more rigid representations (Stetson et al., 2006).

Johnston and Nishida (2001) have shown that attempts to explain the perceptual anomaly with neural processing delays raises very important philosophical issues. They have shown that, if we assume what they refer to it as ‘brain time’ hypothesis (equating perceptual time to processing time), we will run into two kinds of problems. In the explicit form, the relative time of events get encoded in higher level ‘metaneurons’. However, it appears that it simply substitutes higher level processes for the events themselves. In the implicit form of brain time hypothesis, then Johnston and Nishida

(2001) explains, “If our perception of the time of an event is coded implicitly, as the time at which a perceptual state of the brain is established - tantamount to the time at which we become aware of the contents of the event - then the medium of temporal sensory experience is no longer physical, as it is for the other five senses, it is conscious experience itself”. Rather we should try to find answers within common spatio-temporal processing of percepts themselves.

**Temporal oddball.** Events have a subjective duration. It remains an open question whether duration is perceived directly, like a visual feature, or if it depends mainly on a comparison process. Numerous studies have shown that subjective time experience depends on low-level visual properties and also the attentional focus. In the oddball paradigm, Tse, Intriligator, Rivest, and Cavanagh (2004) reported that duration judgments for stimuli longer than 120 ms showed temporal expansion. In another work we used a computational model to determine whether a decision-based account of temporal judgments could account for temporal expansion. We used a single layer recurrent dynamic on-center off-surround network of fully connected nodes with self-excitation and lateral inhibition (based on Usher and Cohen (1999)) optimized for winner-take-all dynamics for duration judgments (Sengupta, Surampudi, & Melcher, 2014). The ‘winner’ node, out of the two that receive the inputs of different duration values, determines the duration judgment. One node received the habituated input (standard) and the other received novel input (oddball). We ran a simulation over a range of durations (from 30 ms to 1200 ms) in order to calculate the subjective expansion factor for these durations if they were used as standard duration for oddball trials. The simulation results closely match the pattern of experimental results collected by Tse et al. (2004), including the 120 ms cutoff for TSE. These findings suggest that the TSE effect might arise out of comparison process rather than perceived difference in time itself (Sengupta, Bapiraju, Basu, & Melcher, 2014).

It seems extremely plausible from above discussion that temporal processing of events follows a map of events with spatial representation<sup>3</sup>. Given the above, there are two ways that subjective experience of time is possible. Firstly, the map’s representation is completely dependent upon linguistic representation and thus cannot be separated from the content of experience. Secondly, the relation of events as given by map is itself a content of experience. In the following we will

<sup>2</sup>We are not dealing with the question of biological time - in terms of circadian rhythms, heart beats, pulses, and so on. Organisms have a way of biological time keeping, in that, there is a periodicity that the organism can rely on for its survival. However, here we are more interested in the time that is taken as content of subjective experience.

<sup>3</sup>For instance the illusory reversal of events could also be accounted for within a temporal map following spatial on-center off-surround representation.

try to show that on both counts subjective experience of time is impossible. In the next section I challenge the first point by locating a possibility of non-linguistic representation within the embodied paradigm.

### Autonomy of space

In essence embodiment stance in cognitive science asserts a fairly simple but deep departure from the standard approaches that are commonly labeled as Cognitivism (i.e., both functionalism and connectionism along with other derivatives of physical symbol systems stance) - human cognition is located within a dynamic goal-directed action-oriented process involving both the body and the environment (M. Wilson, 2002). Even if specialized cognitive functions are served by different parts of the brain, the involvement of body and environment amounts to much more than input-output circuitry. We ascribe meaning to our world based on the constraints posed by the body (R. A. Wilson & Clark, 2009) and our roles as being-in-the-world is regulated by the body (Dreyfus, 1990). The embodied stance is far from uniform. Early proponents like Lakoff and Johnson (2003) propose a view where a metaphorical process deriving from the body and its structure is central to human cognition. Dreyfus (1990) derives a Heideggerian account from his consideration of AI and robotics, to propose an anti-representational process using the world as its model (Dreyfus, 2007). Freeman (1995) proposes an intentional arc (following Merleau-Ponty (2002)) through which an organism has its cognitive dispositions (determined by corresponding attractor states) altered through its action in the environment. These three major viewpoints have their advantages and also some inherent distinctions. In the next few paragraphs I would like to point out conceptual distinctions between these positions and will attempt to arrive at the necessary conceptual apparatus needed to address the question of the temporal experience of human cognition.

Lakoff and Johnson (2003)'s account in some form does adhere to at least a moderate stance of the Sapir-Whorf hypothesis (Sapir, 1983; Whorf, 1956) for linguistic relativism (seen more explicitly in their later work, (Lakoff & Nuñez, 2000)). Metaphoric process within the unconscious can impinge upon the meaning formation because the linguistic categories determine our world view. To extend their argument, one has to assume at least a linguistic representation of the world, but one that is grounded in the body rather than being arbitrary like in the case of physical symbol systems hypothesis (PSSH, see Newell and Simon (1976)). Figure 1 elucidates the major import of their position on embodiment.

Dreyfus (1990) has rejected Cartesian ideas inherent in traditional AI and Cognitive science (i.e., the position that context-free, disembodied, representations governed by rule-like algorithms separated from and independent of the cognitive being and the world inhabited by it, are sufficient for

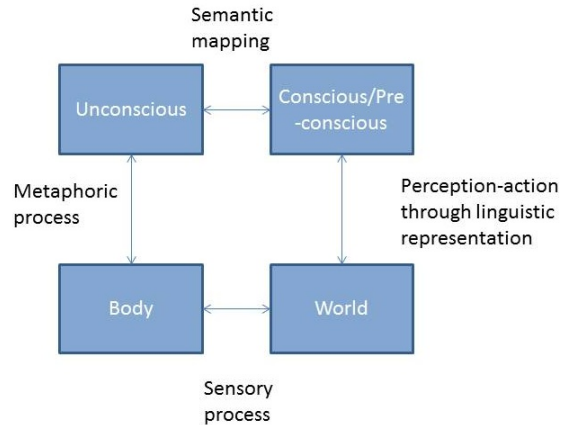


Figure 1. Embodied stance of Lakoff and Johnson (2003).

building AI or understanding cognitive psychology). From his analysis of Frame problem in AI (writing a closed set of axioms for all given and novel situations), Dreyfus (2007) points out that the fundamental difficulty of a Cartesian ontology where one does not just see something, but sees it as something - there is always an extra step of deciding how to apply meaning to a given situation. On the other hand in the Heideggerian approach meaning is always ready-at-hand,

To say a hammer has the function of being for hammering leaves out the defining relation of hammers to nails and other equipment, to the point of building things, and to our skills all of which Heidegger called readiness-to-hand and so attributing functions to brute facts couldn't capture the meaningful organization of the everyday world. -Dreyfus (2007)

In his account, embodiment exists in "being-in-the-world" relation between cognitive agent and the world, what Dreyfus (2007) describes as 'background coping'. He uses Gibson (1987)'s idea of affordances to explain how the world affords the actions available for the cognitive agent in a continuous and non-representational manner. In fact, he criticizes the idea of Cartesian self-enclosed entity itself, rather thinking of experience as a flow during 'everyday coping' Dreyfus (2000).

Although Freeman (1995)'s account is very similar to that of Dreyfus (2007), there are some key differences. His account derives from the works of Aquinas (1990) and Merleau-Ponty (2002). The key concepts here are unity (by the mind's assertion of a boundary against the outside) and an intentional relation (between intellect and material objects) which shapes itself by changing its scales to accommodate the object through the process of knowing it. Intentionality

as defined here is not “about-ness” (Searle, 1992). Meaning is achieved through action in the world, and the self is altered by that action. Although Aquinas (1990) describes intentionality as directing action towards some future defined and chosen by the actor, intentionality is fundamentally an unconscious process, i.e., the self is not necessarily a conscious agent. Merleau-Ponty (2002)’s formulation of “the intentional arc” that completes an organic loop from action through the world and back into the brain, resembles Aquinas’ active intellect. The intentional arc names the tight connection between the agent and the world, perception and action. The skills acquired by the agent are not stored as representations but as dispositions to respond to directing situations in the world. Thus for Freeman (1995), the term intentionality means the “process of a brain in action having the properties of unity, wholeness, and intent.” Unity refers to a state of integration by which a self distinguishes itself from non-self. Wholeness refers to a bounded process by which through stages a self actualizes its mature form, ultimately to die. Intent refers to a relation in which a self modifies itself in conformance with aspects of non-self. A living brain thus capable of actualizing these properties by purposive behavior is an intentional structure.

From the above discussion it emerges that we can distinguish the three afore-mentioned strands within the embodied cognition literature along three dimensions: representation, idea of self, and basis of cognition. The differences are summarized in Table 1.

The above table makes it explicit that there are some major irreconcilable differences within the three strands of embodiment. Lakoff and Johnson’s idea of linguistic representation is incompatible with the others, but their idea of an unconscious process as a basis of cognition is fairly in line with Freeman’s account. However, it is unclear how much the metaphoric process can be reconciled with the intentional arc in the perceptual domain. On the other hand, Dreyfus’s idea of “being-in-the-world” relation is not compatible with Freeman’s notion of self that distinguishes itself from non-self through unity.

In both Dreyfus and Freeman’s account representation is disposed off almost completely. However, we know that there is some validity to the idea of representation from researches in retinotopic and topographic maps in the brain. It is not confined just to the visual domain either (Chen, Zhou, Chen, He, & Zhou, 2013). The main problem is that thinking of representation in a linguistic manner guarantees a Cartesian ontology. However, any idea of a representation that is completely non-linguistic is doomed to fall flat in the case of human cognition. As shown by Dreyfus (1990), on-line cognition can be traced to a state of flow (being-in-the-world) that does not require any mediating representation. However, we do employ quite a lot of off-line cognition that do definitely rely on representation. These representations may be

derived from the body as some views of embodiment literature hold (M. Wilson, 2002). Even so, it does not discount the possibility of a representational matrix (as seen in saliency map literature by Melcher and Piazza (2011); Roggeman, Fias, and Verguts (2010) or in literature on topographic maps, like Seelke et al. (2012)) which is essentially a spatial one.

The idea of a spatial saliency map representation underlying perception and action is not limited to just vision, but involves auditory (Kayser, Petkov, Lippert, & Logothetis, 2005) and tactile (Diederich, Colonius, Bockhorst, & Tabeling, 2003) modalities as well. These saliency maps are part of pre-attentive visual stream and may not be cognitively penetrable (Pylyshyn, 1999). A subsequent decoding of a saliency map requires linguistic features of cognition. Moreover, Bonato, Zorzi, and Umiltà (2012) have recently summarized an array of literature that points to various similarities between spatial and temporal processing and suggest that space, time, and number processing might be grounded in neuronal structures for spatial attention and sensori-motor processing. Spatial numerical abilities in other animals (Dehaene & Changeux, 1993) suggests that spatial processing might operate at least partly in an independent manner from linguistic ability. Given the above we can make a case for spatial representations that are grounded in sensori-motor process, i.e., embodied, and also can maintain relative autonomy from linguistic representations.

### Ontology of the event

Phenomenology, either in the line of Heidegger or Merleau-Ponty, forms the theoretical kernel for much of the philosophy of mind in the embodied tradition. Thus, it comes as no surprise that the idea of a discreet mental event seems contrary to the embodied stance. The phenomenological idea is to explore how reality appears to consciousness. Consciousness is continuous. Then where will be the scope of something as discreet as an onset of an event, and what is the meaning of the order of events given in time? As Dastur (2000) explains

As Maurice Merleau-Ponty shows in his *Phenomenology of Perception ...*, philosophy can give neither a realist nor an idealist solution to the problem of time. It does not succeed in locating it either in things themselves or in consciousness. If, on the one hand, we consider time to be no more than a dimension of reality, we can no longer explain the relationship between what comes first and what follows. The succession of events can only be established by consciousness, a consciousness which requires, in order to have a general view of the succession of events, not to be completely immersed in time. But what if, on the other hand, we consider time to be a mere

	Representation	Idea of self	Basis of cognition
Lakoff & Johnson	Linguistic	Through metaphoric processes connecting the body and the world	Unconscious metaphoric process
Dreyfus	Non-representational account	Not self-enclosed, thus even unaware of self during 'everyday coping'	"Being-in-the-world" relation between cognitive agent and the world
Freeman	Ordered dispositions act as surrogates to representation	Through unity and intent self distinguishes from and is modified by non-self	Intentionality rooted in the unconscious mind

Table 1

*The relation between different strands of embodied stance*

construction of consciousness? Temporality itself becomes incomprehensible, insofar as it is the essence of time to be incompletely present to consciousness, to remain incompletely constituted, as Husserl would say. For time, precisely, is not identical to being, it is a process which is always in becoming. It is always of the order of the process, the passage, and that which comes. Therefore realism (which immerses the subject in time to the point of destroying all possibility of a time-consciousness) and idealism (which places consciousness in a position of overlooking a time which no longer proceeds), are both unable to clarify what they pretend to explain, that is, the relation of consciousness to time. For in both cases, what remains out of range for a philosophical inquiry which wants to see in time either a reality or an idea is precisely its transitional character, its non-being or non-essence, which is not, but proceeds.

Dastur (2000)

The problem of temporality rather appears in giving time a priori ontological basis in consciousness. Rather, we should try to understand the phenomenal character of the event and proceed from there. We propose here an ontological priority of the event - in that it is not that event is something that breaks the continuous flow of consciousness through time as a surprise<sup>4</sup>, rather we should understand how a limited consciousness would construct the flow of events post-priori due to its inability to cope with them all at once. Attending to many events is expensive for the organism in terms of energy. To deal with multitude of events we need coherence, repression of events, we need order - we construct time. This is inexorably linked to how the organism forms an idea of

self.

In autism, subjects display "pattern of impairment in cognitive tasks that demand contextual processing, coupled with ... superiority at tasks that demand piecemeal processing of individual features" (Belmonte, 2008). Thus for the autistic, the surrounding is 'threateningly intractable'. Thus they exhibit repetitive behavior akin to what Belmonte (2008) calls re-viewing the 'Cartesian cinema', to come to terms with their selves and surrounding. However, one can also look at this as multiple events as constituting a single instant of integrated time for the self.

The other side of the spectrum appears to be Schizophrenia where a de-coherence of internal integration leads to hallucinations and delusions and a host of other symptoms. Schizophrenia presents an unique problem for embodiment - how can the same embodied being embedded in a single environment have different minds so to say. To put it better, we can ask how an embodied being can fail to integrate its own temporal existence. The failure of integration would not arise if time is more fundamental to embodied existence than an event is. Rather we propose here that events are prior to an embodied being. The flow of consciousness itself might arise due to a finite organism's strategy to keep track of multiple events.

A serious objection to the above position can be raised from the perspective of Dreyfus - how does the primacy of

<sup>4</sup>"The event constitutes the "dehiscence" of time, its coming out of itself in different directions, which Heidegger calls "ekstasis," the fact that it never coincides with itself, and which Levinas names diachrony ... For the event, as such, is upsetting. It does not integrate itself as a specific moment in the flow of time. It changes drastically the whole style of an existence ... It does not happen in a world-it is, on the contrary, as if a new world opens up through its happening. The event constitutes the critical moment of temporality—a critical moment which nevertheless allows the continuity of time."-Dastur (2000)

events allow us to explain on-line cognitive activity like hammering the nail example. The question hinges upon the assumption that, on-line cognition by virtue of its unconscious fluidity negates the ontological priority of events that enter consciousness. However, there is no reason to think so. The unconscious dynamical processes are driving forces of cognition, but conscious experience may get its structure from events. Both are not mutually incompatible.

### Magnitude of intentionality

As an alternative to this understanding of volition, I want to describe a neural basis for goal-directed actions that is common to both humans and other animals, because it reflects the evolution of human mechanisms from simpler animals, in which intent can operate without will. The concept - "intentionality" - was first described by Thomas Aquinas in 1272 to denote the process by which humans and other animals act in accordance with their own growth and maturation. An intent is the directing of an action toward some future goal that is defined and chosen by the actor. It differs from a motive, which is the reason and explanation of the action, and from a desire, which is the awareness and experience stemming from the intent. A man shoots another with the intent to kill, which is separate from why he does it and with what feeling.

Freeman (2000)

In light of the above discussion it is important to address some very important issues. Our biological growth and maturity is linear, so is the goal-directed intentional arc. In other words the intentional arc that doubles back to the individual, is forward seeking. If we have an event-based spatial ontology to replace time, we still leave out another possibility. We experience linearity in time because things happen linearly. So, in spite of all my previous arguments, a forward seeking, goal-directed intentional arc can still experience time relation because the world affords linearity in cognition.

I have a series of interconnected arguments against the possibility.

1. As far as linearity in thinking goes, the idea of linearity itself is subservient to the recognition of simultaneity and order (event A and event B occurred together, but prior to event C, and so on), which themselves possibly have spatial representation and thus are subject to the limits of capacity.
2. The limits of capacity appear only in the case of conscious recognition of this simultaneity and order (i.e.,

operating on them with working memory). However, it does not preclude the very large storage of patterns in long term memory.

3. With regard to ideas of biological linear progression, I think evolution is as parallel as it is linear (one can even say probably more parallel than linear). Evolution operates in jumps and parallel mutations that accumulate for an environment, which itself undergoes drastic change to halt the progression and lead through another parallel branch (consider the reptilian to mammalian evolution).
4. Regarding the idea of change from life to death and of physical time itself, we know that Newtonian and Quantum physics are both time-symmetric (i.e., they do not distinguish between  $t$  and  $-t$ ). Only when we come to macroscopic results (in the realm of statistical physics and thermodynamics) do we get time as the direction of increase of entropy in a closed system. However, there are some recent works that lean towards the possibility that a recorder/measurement itself is involved in giving the arrow of time.

Keeping in mind the above, there is a need to probably let go of the idea of non-reducible intentionality. We must reduce intentionality at least at a theoretical level if not at the entity level. We need to operationalize intentionality in terms of other *a priori* ontological categories in order to get the full blooded idea of intentionality promised by Freeman.

The future of embodiment stance will lie in the way we use the tools available to us to get a much better idea of human cognition. For instance, categorical off-line thinking has been a challenge to embodiment paradigm. However categorical thinking or conceptual thought depends upon the idea of sets, sets depend upon the notion of numbers. We have made progress in establishing numbers on the foundation of spatial representation (Grossberg & Repin, 2003; Sengupta, Surampudi, & Melcher, 2014). The other steps are sure to follow to give us a full fledged "dynamical systems" ontology of mind.

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