The Interactive Timescales of Cognition and Action

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Introduction

In the literature adjacent to this conference, and in talks given to this point, I have found many references to history, as in the evolutionary history of an organism that underwrites biological functions within that organism according to Ruth Millikan—and many references to anticipation, as in the anticipations whose interactive success or failure constitutes truth value, according to Mark Bickhard. Talking about diachronic processes is challenging, and it is doubtless unreasonable to expect anyone doing so, whether in a retrospective or a prospective mode, to explain precisely what frame of reference they have in mind when they talk about the past, or the future. Our evolutionary history unfolded over at least a billion years, possibly much longer. By contrast, a frog's interaction with a fly crossing into its visual field takes perhaps 70 milliseconds, by the end of which the prey has been ingested. I am not the first to make the point that *timescale matters*. The point itself may be uncontroversial, but it is frequently neglected. While it is unreasonable to expect retrospective or prospective discussions of process to be fully explicit, lack of precision in such discussions can leave one feeling that the relevant timescale has been chosen arbitrarily.

So let me begin by choosing one completely arbitrary timescale. In intellectual history, a century makes for a nice round number. One hundred years ago today the marked page proofs of Roy Wood Sellars's *Evolutionary Naturalism* may well have been making their way by rail from the author's home in Michigan to Open Court Press in Chicago, in time for publication in 1922. This nearly forgotten classic of 20th Century Philosophy, seldom read but with tendrils of influence reaching well into the present, helped to shape both Sellarsian naturalism and process metaphysics, approaches dear to many of those in attendance. Roy Wood Sellars envisioned evolutionary naturalism as a *philosophical system*, in a sense of "system" that was very much out of fashion, though he hoped to bring it back. If Mark Bickhard's interactivism has not gotten quite the traction that he and others here might have wished, it is at least in part because the hope Sellars expressed in 1922, for a renewal of philosophy's systematic ambitions has never been fulfilled. Interactivism, too, is a philosophical system: an attempt to simultaneously address the complementary or competing demands of ethics, metaphysics, and epistemology. I take it this is precisely what Mark meant yesterday when he spoke of interactivist efforts to establish the "normative metaphysics of emergence" (see e.g. Bickhard 2002, 2017). Like Roy Wood Sellars's Evolutionary Naturalism, interactivism assumes from the outset that

> Knowledge is a human affair, even though that which is known is distinct from the knower. But man is a part of nature, and so [the] capacities and processes operative in science and philosophy must find their natural explanation. Intelligence must be given its locus and attachments. In other words, science and philosophy are properties of man. To explain them, we must comprehend man's capacities and his place in the world. The final problem of philosophy is to connect the fact and content of knowledge with its conditions. How does knowing occur in the kind of world that is actually known? Knowing is a fact and must be connected up with the world which the sciences study. Thus a system of philosophy answering this question is the capstone of science…Philosophy is the science which explains the other sciences as human achievements and thereby completes science. (Sellars 1922, 2)

Science and philosophy, like other human activities, take place within the same natural world that gave rise to human beings, including the practitioners of science and philosophy. Our interactions with each other and our actions in the world constitute our shared epistemic objects;

in turn, our interactions with each other, and with those shared epistemic objects, constitute the meanings we ascribe to those objects, and to any representations we form of them.

It has become commonplace to say that all of these interactions must take place "in real time." This phrase—"in real time"—has been in common use in cognitive science for decades, and may be found in much the same sense in roboticist Rodney Brooks's now classic 1991 paper, "Intelligence without Representation," in which he insists that the intelligent performance of what he calls his "creatures" must be validated "in real time," and that toward that end it is unnecessary to build such creatures to form explicit representations either of their world or of themselves. What is somewhat less commonplace, though by no means uncommon, is an explicit account of the scale, boundary conditions, or fine-grainedness of real time. Many such accounts take as their point of departure the "multiple overlapping timescales" of biological time described in Arthur Winfree's 1980 classic, *The Geometry of Biological Time*. These include, to cite just three, Robert Port and Timothy Van Gelder's treatment of the dynamics of cognition in their 1995 book, *Mind as Motion*, James Crutchfield's 1999 paper, "Is Anything Ever New? Considering Emergence," and Hanne De Jaegher and Ezequiel Di Paolo's enactivist approach to social cognition in their 2007 paper, "Participatory Sense-Making." Another common point of departure, shared by Roy Wood Sellars and, at the other end of the twentieth century, Francisco Varela, is William James's proto-phenomenological diagnosis and critique of what he called "the specious present" in his 1890 *Principles of Psychology*.

I have neither the time nor inclination to attempt any systematic critical survey of this literature here. My intention is instead to draw attention to what I take to be an invitation, in interactivism, to think through the content, or meaning, of cognition and action in a way that divorces it from reliance on any privileged timescale. Like many of you I've had the pleasure of lurking on the pre-conference reading group for the past several weeks, so I shall take as my critical focus the exposition of teleosemantics in Ruth Millikan's 2020 paper, "Neuroscience and Teleosemantics."

1. Teleosemantics

As Millikan observes,

> Most of those who examined or adopted the teleosemantic position assumed that a thing's function was what it had been designed or selected for doing, by a person, by natural selection or by some analogous developmental or social learning process. If there are representations in the brain they were produced by mechanisms selected by natural selection for producing representations. The body is filled, after all, with thousands of the most intricate and clever mechanisms that no Darwinian would doubt are there owing to natural selection. (Millikan 2020, 3)

I want to take a closer look at the claim that "a thing's function [is] what it had been designed for or selected for doing, by a person, by natural selection or by some analogous developmental or social learning process." I do not think the claim is false, but it *is* imprecise. When the imprecisions gloss over radical disparities in timescale, they may matter quite a lot.

There are two analogies at work in this gloss of the teleosemantic position. The first is an analogy sometimes attributed to Darwin himself, the analogy between agential design and natural selection. The first two chapters of *Origin of Species* are "Variation under Domestication" and "Variation under Nature." Those chapters establish similarities between the breeds of a given domesticated organism, on the one hand, and species of a given naturally occurring genus on the other. Together with Chapter 3, "Struggle for Existence," they set the stage for Chapter 4, "Natural Selection." The very use of the term "selection" in the phrase "natural selection" implies some kinship with human choice. What is less clear is how close a kinship this really is. In his *Autobiography* Darwin speaks of his admiration, during his college years at Cambridge, for the reasoning of William Paley, the Anglican theologian destined to be remembered for his watchmaker analogy, dutifully taken out of context in so many textbooks over the past century. Paley, too, offered an analogy between the function of a thing designed or selected for the performance of that function by a person, and the functions of naturally occurring things or aspects of those things. Darwin would offer an argument from analogy similar to Paley's, but founded on what he clearly understood to be a very different analogy, one that dispensed with the need to attribute agency to nature. If design and natural selection were operationally equivalent, then natural selection could underwrite function in the same way as design. If that were the case, we could apply what Daniel Dennett (in his 1987 book) called the "Design Stance" to biological systems without having to take too much care to treat such applications merely instrumentally. But whether natural selection and design are operationally equivalent in the relevant sense is surely an empirical question, one for which the answer is a resounding "no." Anyone still unconvinced of this in 1988 should have been fully persuaded by the results coming out of Richard Lenski's laboratory at Michigan State for the last 33 years (see Card et al., 2019).

The elegance of Lenski's experiment resides in its use of a bacterial model organism to study natural selection in the laboratory on the timescale of a human scientific career. Though it has been underway for only one human generation, the disparity between the human lifecycle and that of E. coli has allowed to measure the divergent evolution of populations under reproductive isolation over 50,000 bacterial generations. 50,000 human generations would take about 1.5 million years, a span of time inimical to the funding cycle of laboratory science. The last 1.5 million years of human evolution are instead the province of paleoanthropology.

The second analogy at work in Millikan's capsule summary of teleosemantics assimilates design and natural selection, on the one hand, to "analogous developmental or learning processes" on the other. Development and learning may indeed involve something like Darwinian random variation and selective retention; certainly neural development appears to turn in part on such processes. Once again, however, timescale matters. Evolution, for organisms the duration of whose lifecycles fall within an order of magnitude of our own, takes place over geological time. Even if the individual organism is the primary or sole unit of selection, it is not the unit of evolution. An individual organism does not evolve—populations or lineages evolve. Development and learning take place on a timescale defined by the organism's lifecycle, and are localized to particular individual organisms in their interactions with their environments. In turn, the random variation and selective retention that takes place within populations of the organism's somatic cells may help constitute the organism's development and learning, but it is the organism that develops and learns, not the cells. In some respects, cells, organisms, and lineages may all be analogous. There are also very significant differences in kind. For example, when a new species evolves—when a speciation event takes place—the members of the parent species need not in any way be less complex than those of the daughter species. The same is true of two species themselves. A daughter species is not an embryo, or an infant, in any way remotely analogous to the embryo or infant offspring of an organism like us, bound by Weissmannian segregation of germ and soma. Each of us begins as a single-celled zygote, compelled in each generation to develop all of the complexity of which we are capable, and of learning all we can learn. Such disanalogies are significant in ways teleosemantics cannot capture. To be fair, teleosemantics, at least as Millikan has expounded it, does not pretend to capture them. Such differences are, however, the province of the normative metaphysics of emergence, so to be successful the interactivist program must do them justice.

2. The historicity of anticipations

For the interactivist, the truth value of an organism's representations, and with it such other semantic properties as they might have, consists in the interactive success or failure of its anticipations. From an interactivist perspective, I am not especially troubled by the apparent failure of teleosemantics, with its retrospective orientation, to account for the causal powers attributable to functions in the present and future, because I am not any more troubled by the idea of a causal connection between timelike separated events A and B that fails to reduce to causal connections along a continuous chain between A and B than I am by the idea of a causal connection in general. As Richard Campbell pointed out this morning, neither current philosophy nor current physics furnishes us with an account of either. A teleosemantic account of the functions of anticipation may well prove an important step toward laying the groundwork for the normative metaphysics of emergence interactivism demands. It cannot help, however, unless it can first succeed on its own terms, where to do so it must squarely address the timescales of historicity in a way that answers the objections I have just rehearsed.

Returning for a moment to Roy Wood Sellars's *Evolutionary Naturalism*, I want to point toward an object lesson to be gleaned from the present obscurity of this centenarian book. Sellars had almost all of the ingredients for both a teleosemantics and a normative metaphysics of emergence compatible with interactivism. First of all, he was a philosophical naturalist who understood that philosophical naturalism had to be informed not just by physics, but by all of the special sciences, including the life sciences. Naturalism should not collapse into reductive physicalism. Second, he was a careful student both of Darwin and of post-Darwinian evolutionary theory, including the work of his contemporaries then in the process of compiling what would come to be called the "modern synthesis." Third, he had a robust concept of emergence, though he rejected the idealism on which the British Emergentists had founded that concept. Finally, he understood that the foundation of Kantian philosophy, consideration of the conditions for the possibility of experience and knowledge, could itself be naturalized, informed by scientific insights, whether physical, biological, or psychological, into the historical emergence of human experience and knowledge. That most of his work now gathers dust in libraries in in part a function of historical contingency—bad luck, if you will. But such contingency is evident in a great many historical processes, as we now understand them. I take it that this is the insight enshrined in the title of the magnificent 2001 collection edited by Susan Oyama, Paul Griffiths, and Russell Gray, *Cycles of Contingency*.

What, then, are some of the relevant timescales of historicity relevant to the normative metaphysics of emergence, specifically to the emergence of the normativity of human and human-like interactions "in real time"? In the vein of a naturalized Kantianism, I consider the conditions for its possibility. Some of the most fundamental boundary conditions have surely been established on the cosmological timescale. The universe is about 14 billion years old. Protons arose quite early in that history, but heavier baryonic matter took considerably more time. Our Sun is a third- or fourth-generation star; it and its satellites contain heavy elements dispersed in the large supernovas that punctuated the end-of-lifecycle events of prior stellar generations. Without an abundance of such elements, terrestrial life as we know it would be impossible.

For its part, the Earth is about four billion years old. Evidence suggests its early atmosphere was weakly reducing, primarily N2 and CO2, dense enough to trap heat from a less luminous sun, and to allow liquid water to exist in abundance. Photosynthetic life arose perhaps 3.5 billion years ago, producing O2 as a waste product. This waste set to work oxidizing everything it could, beginning with the vast repository of dissolved iron in the oceans. Only when the planet had reached nearly half its present age had this process progressed far enough to allow free oxygen to accumulate in ocean shallows and the atmosphere, which until about a billion years ago had been nearly anoxic. Subsequent aerobic life began to evolve various modes of multicellular complexity, including such multicellular animals as parazoa and metazoa. At our best guess, metazoa evolved perhaps 800 million years ago. I single them out because it is in metazoa that we see the emergence of Weismannian segregation of germ and soma. Metazoan complexity is thus constrained by reproductive bottlenecks of the sort we face, with each individual organism starting life as a single-celled zygote.

The Ediacaran formations, approximately 555 million years old, contain the first evidence of bilaterians, the clade of bilaterally symmetrical metazoa that includes arthropods, annelids, platyhelminthes (flatworms and the like), molluscs, and of course chordates (see e.g. Darroch et al. 2018). Though modern bilaterians are extremely diverse, most of them have through-guts (as opposed to cnidarian blind guts), and in most of those the most important sensory organs are situated near the orifice of ingestion, opposite the orifice of excretion. Animals in general move, or behave. Bilaterian animals do not just move: they are *going somewhere*. Their body plans impose *intrinsic direction*: they are travelling *toward* the food and potential mates, and *away from* the waste. Many metazoa have nervous systems like cnidarian nerve nets, but only bilaterians have *central* nervous systems, including brains and brainlike-structures for the coordination of motion in bodies with implicit direction.

Evidence for the first chordates is equivocal, but sufficient to allow us to date the emergence of our own phylum to no later than 540 billion years ago. Chordates, too, are extremely diverse, displaying a vast range of sensory structures and modes of locomotion. Many of us rely on smell and sight. As Don Campbell frequently observed, we chordates often find ourselves moving through media, such as water and air, that are both transparent to sight and olfaction, and penetrable to locomotion. When we consider real-time interactions of the sort on which human agents test their anticipations, it is perceptual transparency and locomotive penetrability that makes them possible.

By this point it should be clear that our temporal scope has narrowed from the cosmological timescale to the geological timescale, within which most Darwinian evolution can be seen to operate. The emergence of the hominin lineage is an extremely recent event in geological time, and crucial events in its subsequent evolution are both too recent and too fast-paced for the resolution of many of the core methods of geology to capture them. In focusing on the hominin lineage, we thus find ourselves on the boundary between the geological timescale and the finer-grained timescale of paleoanthropology. It is within this boundary zone that we find that natural selection is constrained by environmental changes that cannot themselves be understood as a consequence of natural selection in the canonical sense. One recent event in hominin evolution that has proved very distracting to cognitive science is the emergence of really large brains, against which there are many *prima facie* selection pressures. Large cranial volume at birth imposes greater risks of infant- and maternal mortality. Together with extended neoteny, such factors make reproduction extremely expensive. The development and operation of a large brain is also a huge metabolic burden. Of interest for our purposes is the fact that the evolution of large brains is preceded not only by bipedal locomotion, but by the shrinkage of the abdominal cavity and the concomitant descent of the thoracic cavity. For the past two million years, hominins appear to have had large intestines much shorter both than those of their australopithecine ancestors and of our closest living relatives. As Richard Wrangham and others have hypothesized (Carmody and Wrangham 2009; Wrangham 2009), these changes were conditioned by the invention, by some of the earliest members of genus Homo, of the cultural and technological means to reduce the physiological burden of metabolizing food and eliminating waste by shifting part of that burden to an environment in which safe and reliable access to fire could be taken as given. In short, Homo habilis or some similar hominin developed cultural mechanisms for the consistent transmission of technologies for the ignition, maintenance, and quenching of fires, and for cooking foodstuffs. Access to cooked food allowed subsequent hominins to get by with shorter intestines, to spend less of their time eating and digesting, and to make vast quantities of glucose readily available to brains. Only then, on this argument, could the prima facie selection pressures against large brains be overcome. Evolution by natural selection is thus conditioned by cultural change.

If the paleoanthropological timescale arises at the resolution limit of geological time, so the historical timescale arises at the resolution limit of paleoanthropological time. Human history and pre-history properly so-called, understood as defined by written records, are as constitutive of human anticipations as is our evolutionary trajectory. In late pre-history, following the Neolithic demographic transition, we once again find evidence for human culture's changing the environmental constraints under which natural selection operated on our ancestors. The evolution of adult lactose tolerance appears to have taken place in post-agrarian populations;

only in a post-agrarian society would adult lactose-tolerance increase fitness. The anticipations with which I approach my interactions with the block of cheddar in my fridge must be understood as having been constituted in part by these evolutionary events, events unfolding on the timescale of historical time, not geological or paleoanthropological time.

At its limit, the historical timescale overlaps with the timescale of learning and development. There are numerous examples that show how human history, understood as history properly so-called, co-constitutes the anticipations of individual human agents. I content myself with the historical emergence of universal literacy. I daresay that all of us, regardless of where we live, take it for granted. In universal literacy, the "universality" is defined relative to a particular society. Though not all contemporary societies satisfy this definition, the phenomenon continues to spread, with the active encouragement of policy-makers and civil society groups worldwide. What many of us find surprising when we learn of it for the first time is the fact that, with a few exceptions, universal literacy is essentially unknown prior to the 20th century. When I was born, in the middle of that century, I had six living great-grandparents, two of whom were illiterate. I daresay most of us had illiterate ancestors within the past three generations.

As universal literacy has become entrenched, social pressure to instill literacy in children has increased, and the age of median onset for literacy has decreased. We read to our children from birth, and begin to teach them to read and write as soon as they develop sufficient fine motor control. Some take to it eagerly. In other cases, it's a struggle, for children and adults alike. As parents, we persist in that struggle even when we know it is traumatic for our children. We would not inflict such trauma for the sake of developmental goals of lesser value, nor would we tolerate our neighbors inflicting such trauma on their own children. Literacy is instilled wherever possible, even at a significant cost. Instilling literacy in very young children, with their plastic brains, opens up to them numerous interactions to which they could not otherwise aspire. It also rewires those brains, such that literate humans exposed to text in their primary language no longer have the option of not reading it. Literate brains read text faster than we perform a host of other visual perceptual tasks. Short of looking away, we cannot not-read it, even if it is systematically misspelled. In universal literacy we have an example of a historically emergent phenomenon that sets the boundary conditions for human ontogenesis—development and learning—and with it another clear example of the normative metaphysics of the emergence of anticipations, an example whose specific timescale is not cosmological, geological, paleoanthropological, or even historical, but rather developmental. Early-onset literacy in turn makes possible the emergence of interactive anticipations for interactions on the millisecond timescale of frog predation.

3. The interactive timescales of cognition and action

I began by inviting you to consider interactivism as a philosophical system, one whose goals and whose tools largely coincide with those of the system envisioned a century ago by Roy Wood Sellars. If, as Sellars argues, "Philosophy is the science which explains the other sciences as human achievements and thereby completes science," then interactivism can pursue the completion of science by addressing the normativity of the anticipations inherent in human interactions, interactions with each other and with our shared environments. Pursuing this goal requires many parallel efforts. One such effort consists in showing how the timescales of the other special sciences we invoke in explaining the diachronic emergence of humanity, and of particular humans, set boundary conditions for each other. One product of this effort is a more nuanced account biological function, and thus of the kinds of historicity presupposed by teleosemantics.

Another outcome might well be a more nuanced understanding of what it means for humans, or other agents, to interact with each other and with their environments "in real time." "Real time" interactions can occur on various timescales. Which of them are relevant to the validation of intelligent interactions will depend on the particular normativities applicable to the success or failure of the interactions in question.

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