

Complex System Identity: The Challenge to Resilience

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Although related to the problems of *personal* identity and the *self*, in this paper I intend primarily to explore the topic of identity *simpliciter*, the tangled philosophical problem of *identity* and *individuation*, permanence and change, being and nonbeing that dates back to antiquity. The characteristics typical of complex dynamical systems make this philosophical problem a particularly pressing one.

In the *Timaeus* Plato distinguishes “that which always is and has no becoming” from “that which is always becoming and never is.” In Book VI of his utopian work the *Republic*, Plato contrasts Knowledge proper, which he claims is achievable only because its subject matter is “that which always is and has no becoming,” with mere Opinion, the only available epistemological modality for things that change and “become” other than they are. No true science or knowledge of change, or of anything in constant change, is possible, according to Plato.

The difficulty of pinning down the identity of a constantly changing target is, of course, one reason Plato makes such an extreme claim. The problem of identity, however, because of its relation to the philosophical problem of change, did not begin with Plato.

Even before Plato, Parmenides of Elea held that for change even to be possible Being must somehow convert itself into NonBeing. For Being A to turn into Being B, that is, the former would have to transform itself into what it is not. Since there absolute nothingness does not exist, Zeno, Parmenides’s disciple, formulated the well-known paradoxes of motion (Achilles and the tortoise, the arrow, the stadium race, etc) in order to illustrate the impossibility of change.

As even Plato recognized, however, in light of the obviousness and ubiquity of change such a position is an intuitively difficult position to hold philosophically. For that reason other pre-Socratic philosophers such as Empedocles and Anaxagoras attempted to resolve the problem of change and identity by claiming the following. Ordinary things are composites made up of diverse and unchanging elements; visible change, then, simply consists in variations in the elements’ overall composition or configuration. Change is only change of position; *essentially, nothing changes*. And since objects are identified with their essence (later on called *substance*), the change they undergo is no *real* change at all. At this point in the history of philosophy, then, identity was not the problem; only change was.

An object's identity was given by its permanent and unchanging features.

Heraclitus of Ephesus, on the other hand, took the contrary view, famously expressed it in his dicta concerning the identity of rivers: Because "All things flow, [and] nothing abides," "You cannot step into the same river twice' (Fr 41). Given such relentless change, what gives the river its *identity*, according to Heraclitus, is a *balance or harmonia of opposites* that confers unity to the overall process of never-ending qualitative transformations. Clearly Heraclitus must have had in mind a concept of identity as "unity," identity in the sense of *continuity*, not *permanence*. I will suggest at the end of the paper that with complexity theory Heraclitus has made a spectacular comeback!

Like Heraclitus and unlike Parmenides Aristotle, regarded change as real. Like Heraclitus he conceptualized change as consisting in qualitative transformations, but unlike Parmenides and Zeno, Aristotle believed the two metaphysical elements participating in change were actuality and potentiality, not actuality (Being) and non-actuality (Non-Being). By introducing the concept of *possibility*, Aristotle opened the way for a conceptualization of an open, contingent future (Milic Capek, *Encyclopedia of Philosophy* vol 2 p 76). But not completely open, as David Depew has shown: for Aristotle, only *development* was possible; for him, change was the unfolding of possibilities or potentialities that were already latent inside the object to begin with. Development is therefore something like the unfurling of a rolled-up rug. The notion that completely new qualities could not only appear but also be passed on to offspring as we see occurring in *evolution*, was unthinkable for even Aristotle. This abhorrence of fundamental change was pervasive even in the Victorian era: one needs only to recall that for Herbert Spencer, who coined the term *evolution*, Darwin's ideas referred to the unfurling in time of already present traits. Darwin himself, one will also recall, believed that for that very reason, only *development* could be explained, not *evolution* proper.

Unfortunately for us students of complex dynamical systems, philosophical history shows that Parmenides won and Heraclitus lost this battle. In the end, especially after the rise of science in the XVIIth century, the concept of permanence as the locus of identity took preeminence over that of continuity: Being prevailed over Becoming, and so the problem of identity despite change remains a crucial and unresolved philosophical problem. Even in Hegel, the Absolute Idea is timeless; only the historical process exists in time.

But ideas in science, particular those concerning evolution and thermodynamics, and more recently, those of complexity and chaos, have caused the problem of identity to come to the fore once again. Even contemporary particle physics has been forced to confront the same problem: by the late XXth century atoms were no longer envisioned as miniature solar systems: minuscule billiard ball-like masses (the nuclei) circled by other minuscule billiard ball-like masses (the electrons). We now speak of "clouds" of electrons, which under certain circumstances behave more like waves than particles. For such entities, their identity is much harder to pin down.

"If space and time cease to be immutable containers of motion, and matter ceases to be its substantial vehicle, the whole classical concept of motion as displacement of a *substantia* entity in static space yields to a more comprehensive and less intuitive notion of change that has some affinities with the Heraclitean concept of irreversible change without vehicle and without container." (Capek, p78) But how is one to "synthesize conceptually the continuity of becoming and the individuality of events"? (Capek 79)

_____ writing on Identity in the *Encyclopedia of Philosophy* notes that there are in fact two distinct philosophical Problems of Identity: one, the problem of Identity as Permanence, is captured by the question "What makes something *the same thing as it was before?*" The second, the problem of Identity as Unity

(amidst diversity), is captured by the question, “What makes those two things *the same kind of thing*?” The first question involves the philosophical problems of change and permanence, which in turn evolved into two other philosophical problems, those of substance and personal identity. The second question, which can arise independently of the observation of change, gave rise to the philosophical problems of universals and formal cause, and historically evolved into the problem of individuation.

How did this play out historically?

As mentioned earlier, the standard philosophical reply to the question “What makes something *the same thing* as it was before?” used to be, “Its immutable and eternal essence (or substance), which remains unchanged throughout any superficial change,” a reply which coincided nicely with Newtonian science’s emphasis on the mass of atomic particles. Newtonian science’s answer to the problem of identity, in short, was for the most part the same as that of Anaxagoras and Empedocles: only accidental properties change; essential ones don’t. Even within philosophy, this answer came under suspicion after Wittgenstein and Putnam’s attacks on the concepts of essential properties in the mid XXth century.

Newtonian science’s answer to the other question, “What makes this particular thing *the same kind of thing* as that other particular thing?” was similar to that given to the first: “They both have the same essence or substance.” In Newtonian science, of course, atomic mass played both roles. If they both are the same *kind of* thing, however, “What makes two distinct objects that are the same kind of object different *individuals*?” The classical answer to the problem of *individuation*, a philosophical question quite different from that of *identity*, was “Location in space and time, and configuration of superficial or accidental characteristics.” Leibniz’s well-known principle of the identity of indiscernibles articulates this position.

However, neither one of these two answers will work for complex adaptive systems, which possess no essential properties in the sense of unchanging eternal ones. So what makes a given

CDS *the same* CDS as earlier? And what makes *this particular* CDS under examination now *the same kind of CDS* as that other particular CDS over there?

We can turn to Heraclitus for a first pass at an answer to the second question: if they both embody or exemplify the same dynamical pattern over time, then they are the same *kind* of CDS. To be more precise, we might say that both processes embody or illustrate the same “dynamical attractor.” Despite individual differences, we easily identify spatio-temporally distinct phenomena as both being, say, “Benard cells,” or “B-Z reactions,” or “zebras,” or “hurricanes,” or “human beings,” or “NGO’s.” We never confuse Benard cells with NGO’s. The concept of dynamical attractor plays a role similar to that of formal cause. Insofar as one can associate a particular attractor with a function, then identity in the sense of “kind” or “type” can be established in terms of function as well.

Stephen Wolfram no doubt would say, “They both embody the same rule.” Time and again in his book Wolfram refers to the “sameness” of the “overall properties” of the various runs of a rule – which he then takes great pains to contrast with “the level of [its] details” where he admits great difference and variation exist. Keeping track of the level one is referring to is half the battle in dealing with the problem of identity – although not the easier half, perhaps the most crucial half.

I want to claim that, even when he is referring to the randomness and differences the *rule* itself produces, Wolfram’s book is fundamentally concerned with the former – the overall pattern — not the latter — the diverse details. If I am correct, Wolfram’s book should be read as an exploration of (and an alleged answer to) the second formulation of the problem of identity: “What makes two things the *same kind of* thing?” Wolfram’s radical thesis, of course, is his claim that some rules, so-called class 4 rules, because they behave like Turing machines, might be responsible for everything. Wolfram appears to be claiming, in short, that everything in the universe is “the same” – by which he means the sense of identity that holds that everything is “*the same kind of*” thing — insofar as everything is (probably) due to the “same kind of” thing: a class 4 rule.

Let us now turn to the first question of identity: With respect to CAS's, "What makes this particular thing we see now *the same* thing it was before?" At the level of the details (and Wolfram does often seem to forget that the devil is in the details), "What makes a process at time T4 the same thing as it was at time T1 (when its characteristics were different)?"

If there are no essential and unchanging properties, then the whole approach to Identity as Permanence must be discarded. Once one does so, then, the lesson of Complex Dynamical Systems theory is that *dynamical continuity* is all there is to establish the Identity on these systems; Identity now as *Continuity*, of course, not *Permanence*. Since what we're dealing with here is the variant of the problem of identity called the *Problem of Individuation*, one needs to keep in mind that at this level there are only individuals as such, no individuals-*in-general* and, whether or not it is so in principle, in fact, each individual is a historical, contextual individual embedded in space and time in such a way as to make its trajectory unique. (N.B. The individual *is* its trajectory; it does not *possess* a trajectory.)

So with regards to complex adaptive systems, the identity of individuals is given by their unique trajectory. What determines whether two moments of a process are (part of) the same process, then; whether they are the same *individual*? The answer, I submit, is to be found in the possibility of retrospectively tracking, or tracing, so to speak, the later moment back to the earlier. What gives Hurricane Andrew its identity is its trajectory's continuity.

Whether in reference to developmental or evolutionary change, however, the problem of individuation is not that easily resolvable. Take autopoietic webs, for example. As Ulanowicz notes, one characteristic of self-organizing webs or networks of interactions is that they have a tendency to prune and/or alter inputs so as to maximize efficiency. Thus, network ABCD might develop into ABED, which in turn might develop into AFED, and so on until not only none of the original components are present. Indeed, the dynamics themselves might be sufficiently altered

so that it's difficult to tell whether one should call it the "same" dynamics or not. So is it?

And that's not the only problem. If individual trajectories owe their unique characteristics to their embeddedness in time and space, then abstracting individuals from their environment turns out to be quite difficult. Elsewhere (forthcoming double issue of *Emergence*) I have attempted to elaborate on Paul Cilliers' distinction between *boundaries* and *limits*. The latter are rigid termini that cannot be transgressed; not so the former, Cilliers emphasizes. Because CDS's are open to their environment, their "borders" (how trapped we are by spatiality!) are therefore best conceptualized as *boundaries*, permeable membranes through which they receive inputs and expel wastes. Evidence indicates that continual communication and feedback with the external environment in fact causes these systems to extend themselves further and further into that environment. For purposes of their identification, this inevitable expansion makes their boundaries fuzzier and fuzzier.

The problem of individuation becomes even more difficult to resolve across phase changes. Consider the transition from caterpillar to pupa to moth. At each qualitative phase change there occurs the equivalent of a catastrophe, on the other side of which one finds an entirely different – qualitatively, not just quantitatively different – dynamics, configured along qualitatively different dimensions. Because the transformations are discontinuous is involved, there is a sense in which no retrospective tracking or tracing can be smooth. This gappiness raises the question, "Is this moth or butterfly *the same* as the earlier caterpillar?" (Clearly it is not the same *kind* of thing, which is why the traditional answer to both questions concerning identity — "its essence provides both its identity as permanence and as unity – does not work for complex dynamical systems.) It is telling that descriptions of such processes in ordinary language often imperceptibly switches to the verb "turns into," a verb which suggests that in fact one became something entirely different. Another equally common linguistic description, on the other hand, calls the caterpillar one "phase" of an overall process – the moth would be a "different" phase of the "same" process.

Since the transitions across phase changes are not smooth and continuous, I submit that in order to capture its identity, one needs to describe its phase portrait across bifurcations.