

Complex Dynamical Systems and the Problem of Identity

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The philosophical problem of identity has a long history, dating back to ancient times of classical Greece. Quite early in the history of philosophy questions about the problem of identity arose in tandem with the recognition of change: If there is no change the problem of identity does not arise, since a static thing that undergoes no alterations is simply taken to be what it is—and can clearly be identified as such. Questions concerning sameness and difference arise, however, as soon as the thing in question changes. Is it *the same* thing (as before)?—an ontological question. By what criteria do we tell if it is or isn't?—an epistemological question. So questions of identity often suggest the presence of difference, and differences in time—that is, change—occasion the even more difficult philosophical question of time.

With the rise of modernity and its concern with the person, the question “Who am I?” became an even more pressing philosophical issue. Interested not so much in the issue of what makes my body the same as that of the baby I once was (which after all would be the problem of identity that arises with anything), the question “Who am I?” comes to be understood to mean “What makes me a *person*, indeed *this person*?” In turn, this question elicits other troubling ones such as “What is the relationship between me (*qua* person) and my body?” and “What is the relationship between me as a person and my circumstances, my history?”—along with related epistemological puzzles, such as “How do we identify and/or re-identify persons despite their psychological changes?” The moral implications of these questions are too numerous— and obvious—to mention.

A quick-and-dirty encapsulation of the history of the philosophical subject of identity might be summarized with the sentence: “Parmenides and Plato won; Heraclitus and Aristotle lost.” By that I mean that Parmenides’ answer to the question “What makes something *the same*?”—“Whatever persists unchanged throughout the changes”— became entrenched as western philosophy’s answer to the problem of identity. Heraclitus’ ontology of process seemed incapable of handling the problem of identity: Constant, relenting, pervasive change, as it seemed to imply no continuity whatsoever, was just too intractable.

As the *Encyclopedia of Philosophy* notes, there are in fact two distinct philosophical problems of identity. First, 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 problem of universals, and historically evolved into the problem of individuation.

Because complex dynamical systems are “structures of process” existing over time, both issues arise in any attempt to formulate criteria for their identity: how to identify a complex dynamical system as such, and how to identify a given dynamical system as the same one as before. With international corporations and web-based communities in effect decoupled from any particular spatial location, what identifies such organizations and associations as *that* corporation or community?

THE CONCEPT OF SUBSTANCE AS ESSENCE

As heir to Parmenides, western philosophy has for the most part explained change as a function of substance, a substrate that sustains and underlies change. For any given thing, its substance was not thought to change; only its superficial (accidental) attributes did.

By *substance* Aristotle meant primarily a concrete individual, but over the centuries the concept morphed into the concept of essence. A substance, in this view, is a nucleus of qualities that jointly embody the nature of the thing in question; a nucleus, moreover, capable of independent existence. At the end of this article we will explore whether the original Aristotelian concept of substance might be making a reappearance as a result of the new appreciation of what are now called complex dynamical systems, but in the meantime, just follow the logic of the notion of substance as a nucleus of qualities that jointly embody the nature of the thing they qualify: If the object’s essential attributes were to change, the thing would no longer be that “type” of thing, much less that particular thing.

So, the concept of substance as essence, a concept that can be traced to Plato's theory of universal forms or ideas, was successful because of its claim to be able to answer both problems of identity. Because it also presupposes stable and immutable qualities, this way of looking at substance and identity got a boost from an ontology derived from Newtonian science that emphasized intrinsic qualities such as the atom's mass. In this view only accidental qualities (such as temperature and color), which have to do with the object's relations to other things, are subject to change. Intrinsic qualities, permanent and immutable, are what confer identity on their bearer.

Such a worldview embodied the following presuppositions:

- A thing's essence is independent of its environment and/or its history, which do not affect that essence.
- The furniture of the world consists of isolated, immutable, and static things.
- Essential/defining attributes are intrinsic to any substance (such as atomic mass) and related internally by deduction.

In short, the common thread that held this conceptual framework together was the belief that a thing's identity is given by its substance, substance is that which is capable of independent existence, and only that with intrinsic unchanging properties can exist independently. This cognitive framework has permeated most of our categories, including axiological ones, insisting as it did, for example, that the identity (and autonomy) of a nation state, a society, or a culture was to be found only in those unchanging, autochthonous features of the system in question. Anything absorbed from without was assumed uncritically to be a pollutant, a contaminant. The emphasis that existentialists such as Sartre placed on autonomy could be traced to this worldview, as could the theological understanding of God as eternal and immutable being (rather than the more eastern view of the path of becoming).

THE PROBLEM OF IDENTITY

Who am I? In Descartes's wake, this conceptual framework became the battleground between dualism and materialism in what came to be known as the problem of identity. Either I (a person) am my mind (defined/identified by its immaterial essential attribute, thought); or, I (a person) am my body (defined by its physical essential attribute, matter). In so far as the problem of identity as permanence is concerned, from Descartes to Kant an object's identity is thought to be given by its "selfsameness." In Leibniz's famous formulation of the principle of the identity of indiscernibles, "no two substances can be exactly alike except numerically." Unlike Newton's followers, Leibniz held that spatial relations were internal/essential attributes of substance, but with Ernest Nagel in the twentieth century, the very concept of internal versus external properties and relations was called into question—thereby making the notion of real essences and substance incoherent. The *coup de grace* to the traditional understanding of the concept of identity, however, was administered by Darwin. With the discovery of evolution, contemporary biology demonstrated that the notion of "essences" is illusory. There is simply no such thing as an organism's "invariable nature," unchanging immutable substance, or Platonic universal.

Now what? For those studying complex dynamical systems the problem of identity appears particularly acute because two moments of a dynamical process might be very different and yet (intuitively) be understood as moments of the same process. Since Heraclitus' process ontology has long been consigned to the dustbin, however, western philosophy is simply unable to account for the identity of complex adaptive processes.

In particular, it is difficult to pin down the identity of complex dynamical systems (CDS) because of their following properties:

- Because a CDS is open to its environment, sharp boundaries between the system and its environment are difficult, if not impossible, to draw.
- A CDS's external relations are as critical to it as its internal ones.
- A CDS's environment and history are as critical to it as its intrinsic attributes.
- Because a CDS adapts and evolves, the concept of essence as a nucleus of intrinsic and immutable qualities cannot handle a CDS's dynamical characteristic, particularly its embeddedness in time and space.

In order to identify a CDS:

- Do not ask: What is the substrate that changes?
- Do not ask: What universal Platonic substance or form does the CDS exemplify?
- Do not ask: What are the CDS's intrinsic and essential attributes?
- Do not ask: What is the bearer of those attributes?

In particular, do not inquire about the identity of the history or structure or essence of substance or universal, and so on, of phenomena... *in general*. The lesson of CDS's sensitive dependence on initial conditions is that there exist only particular, *individual—and increasingly individualized*—phenomena. When dealing with individuals that are structures of process, in other words, the problem of *identity as permanence* shares preeminence with the problem of *identity as unity*. On the one hand it is the concrete individual, not the species (much less the genus), that reappears as the primary locus of identity. But it is a processual individual, not a static, thing-like object that is in question. Moreover, it is one with the potential to qualitatively evolve, not just develop.

Aristotle, the first biologist, knew whereof he spoke. Whether animals, hurricanes, and so on, or organizations such as businesses, governments, organizations, and communities, complex dynamical systems are organismic phenomena. And living things are embedded in their environment and their history, both onto- and epigenetically. Autonomy and independence—the classical measures of identity—now suddenly come to be seen as values associated only with dead, isolated things. Living organisms and their creations must instead be judged by their degree of resilience and *flourishing*. Once again, Aristotle knew whereof he spoke: The primary ethical category for Aristotle was *eudaimonia*, usually and incorrectly translated as happiness, but more accurately as flourishing.

Robust resilience, which in large measure is a function of connectivity and interdependence, plays a significant role in the dynamic integrity and flourishing of communities, organizations, and associations. With the advent of complex dynamical systems, therefore, the importance of interdependence replaces the former emphasis on autonomy—which now comes to be equated with isolation; and the importance of robust resilience replaces that of independence—which now comes to be associated with stasis and stagnation.

Elsewhere (Juarrero-Roque, 1991) I have examined the difference between stability and resilience in the context of dynamical systems. Stability, which consists of “low fluctuation around specific states” (Holling, 1976: 83), can be contrasted with resilience, the system’s ability to absorb perturbations and evolve into a metastable level of organization. Complex dynamical systems theory teaches that survival and extinction are a function of resilience, not stability. A system that is very resilient can have very low stability—that is, it may fluctuate greatly—but survive. Conversely, a system with high stability may lack resilience such that any change or disturbance simply destroys the system. Ecosystems, furthermore, teach us that “the more homogeneous the environment in space and time, the more likely is the system to have low fluctuations and low resilience” (Holling, 1976). We also learn that the more interconnected a system (both internally and externally), the more robust and resilient it will be. The integrity and identity of a complex system are therefore fundamentally related to its dynamical connectivity.

Dynamical systems theory includes in its toolbox a notion somewhat similar to that used by Parmenidean ontology. I have in mind the concept of “invariance,” which purports to identify a *dynamical* set of relations that remain the same despite undergoing certain transformation. The difference between the concept of invariance and the traditional concept of identity is not only in the concept of invariance’s focus on *relations*, but in particular in its inclusion of *external* as well as *internal* relations, which are conceptualized as dynamic, not merely static, links.

The concept of dynamical invariance might serve as dynamical systems theory’s preliminary answer to the problem of identity as unity. Thinking of Coca-Cola or Toyota in terms of dynamic, invariant relations of a self-organizing web of production and distribution processes becomes a more natural and fruitful way to confer identity on these organizations than trying to spatially localize or identify their internal components. The same can be said in relation to, for instance, the “Vietnamese” identity: Instead of worrying about trying to identify a set of unchanging, autochthonous characteristics—which only leads to the question: “Are Vietnamese living in Los Angeles (really) ‘Vietnamese’?”—it might be best when attempting to formulate criteria of the identity of complex systems to think in terms of the number and quality of dynamical relations.

Just as Aristotle employed one sense of the concept of substance to suggest that the more qualities an object displays the more substantial it is, so too students of dynamical systems might begin by exploring whether the more numerous (and more diverse) qualities a process displays the more uniquely individuated it is; whether, in other words, the richer its internal and external relations both, the more individual and individuated—and the more resilient and robust—the process. Given the static connotation of the concept of “qualities,” however, perhaps that term is not quite the right descriptor that we need to identify CDS. As mentioned, dynamical systems not only *develop* in a regular and predictable way, they also evolve in unpredictable directions. The real puzzle thus becomes: “How can we identify them in light of their *evolutionary* capacity?” In light of the fact that a CDS’s identity must include both its dynamic etiology and its potential, how are we to address the problem of identity as permanence with respect to complex dynamical systems?

BOUNDARIES OF DYNAMICAL SYSTEMS

In this volume Paul Cilliers differentiates between boundaries and limits. Whereas limits are rigid barriers that separate—and beyond which one cannot transgress—boundaries, as exemplified in the eardrum, Cilliers notes, are permeable. *Indeed, it is their very permeability that makes possible many of qualities of the system in question* Without the presence of the eardrum, for example, as Cilliers points out, sound is impossible. Instead of functioning as what logicians call an exclusive disjunction (either/or, but not both) the way the traditional concept of identity did (inside or outside, but not both), the permeable boundaries of dynamical systems are fuzzy, *active sites* where qualitatively new phenomena emerge. As such, boundaries of dynamical systems are best conceptualized as sites of phase changes, sites where a different phase portrait can suddenly appear. The paradoxical characteristics of permeable membranes—which both exclude some potential inputs (thereby maintaining system integrity) at the same time as they include others (thereby allowing for the possibility of dynamic transformation)—are thus ultimately responsible for both a system’s actual identity as well as its potential and actual evolution.

Consider the (unintentional) permeability of the Rio Grande border between the United States and Mexico, a fascinating active site of great sociological interest currently under construction, a dynamical site that would not be so were it not for the simultaneously (supposedly) impermeable but *de facto* permeable border. Although in one sense it is easy to determine whether one is on the Mexican or US side of the border, there is another sense in which it is not so easy: Laredo, Texas, and Nuevo Laredo, Mexico, are more one regional “dynamical system” with its own identity than is the conjunction of Laredo and Minneapolis, for example. If recent articles in the popular media can be trusted, events taking place at the country’s edges are responsible for the United States’ current robustness. Even more interestingly, however, those same articles have noted—but have had a hard time characterizing—the appearance of a completely new “border” phenomenon that, precisely because it straddles both sides, is creating something entirely new and exciting. If so, then one can say that these border active sites are also responsible for the country’s resilience. Since any real individual is embedded in numerous dynamic attractors, the multiplicity of identities that this implies makes individuals more diffuse than heretofore assumed.

Although the Rio Grande example rests heavily on the role that a shared physical space can play in identifying a system, spatiality is not the only way in which such permeable, dynamical boundaries can appear. Imagining that all boundaries are like the eardrum or the Rio Grande is therefore misleading; these are too physically localizable. More and more one hears of European regionalism not merely described in terms, for example, of the Catalan or Basque communities, which straddle physical frontiers, but even more interestingly in terms of a newfound identification between citizens of Ireland and the Spanish province of Galicia. What do these two groups have in common? A Celtic heritage, for one— a permeable, temporally based, dynamic boundary, in this case—an active site that is creating a dynamic community of fans involved in, among many other activities, international festivals devoted to Celtic music, folklore, tradition, and so on.

Similar dynamics are emerging among members of the Chinese, Vietnamese, South Asian, or Mexican “diaspora” and their compatriots in the homeland. Whether it is an interest in trade or culture that binds each side to the other, at any dynamic (not spatial!) boundary there exists the potential to create a newly emergent phenomenon. As complex dynamical systems theory would have predicted, this creative potential was absent during earlier periods of immigration when immigrants lost all contact with the friends and relatives they left behind.

It might be useful to expand Cilliers’ views on boundaries by comparing the boundaries of dynamical systems to, for example, proteins— proteins *qua* active sites that emerge at the intersection of folded-up amino acid sections. If what we mean by calling these sites *active* (whether an eardrum or a protein) is that they are the (not spatial but dynamical) locus of emergent properties, boundaries would constitute functional entities responsible for a system’s evolutionary change. As active sites, boundaries are creative because they are the locus of evolutionary potential. Whereas the essentially unchanging furniture of the old conceptual framework was stagnant, the dynamic processes of the new framework are characterized by the potential to evolve into qualitatively new forms—not just develop into larger (but more of the same) systems. At a given point in time, any CDS’s identity will therefore encompass not only what it currently is (given by its invariant relations) but also what it has the potential to become. Since openness to the environment (via feedback and feedforward) is crucial to evolutionary processes, the degree of permeability of a given CDS’s boundary—even as that same dynamical membrane or information closure confers the requisite robustness to maintain the system’s integrity—will be a central aspect of its identity as permanence.

Thinking of a dynamical entity’s boundaries in this way, for example, would mean drawing both the Turkish community in

Hamburg, Germany and the in-country Turks back home on “one side” of the boundary, with the non-Turkish German community on the other. However, even phrasing it this way is misleading, because non-Turk Germans trading with Turks would also fall on the “Turkish” side of this “boundary.” We are so accustomed to spatial, reified categories that thinking of identity in terms of dynamical processes becomes very difficult. We must try hard to do so, however, because problems such as those mentioned in this volume that arise with globalization often come ready formatted by spatial, static categories. For example, when referring to global organizations or enterprises, the very labels “international” and “transnational” presuppose that the physical boundaries of a nation state (and the concomitant place of registry of a business) are what confer identity. That might have been true at one time, but it is no longer so.

In contrast, an autopoietic web, as Ulanowicz in this volume and elsewhere points out, is informationally decoupled from its material components; it also has the ability to add and delete nodes while maintaining its identity and integrity. If General Motors stops purchasing parts from a supplier in Lansing and begins to purchase them from a supplier in Hamilton, Ontario, is the Cadillac it makes with those parts still an American car? *Mutatis mutandi*, the same question can be asked of Honda Accords, for example. (Several acquaintances of mine, American citizens all, who for patriotic reasons insist on “buying American,” in recent conversations have expressed their dismay at not even being able to identify a particular make as American!) Or think of General Electric (GE): There is certainly nothing in that company that would qualify as “a nucleus of qualities that have gone unchanged” since its inception; nor could GE survive as that company without its extensive external relations with suppliers, foreign government agencies, and so on.

Since dynamical systems are describable by networks and graphs, it might be fruitful to look there for metaphors and descriptors of identity. As active sites, boundaries can—from one perspective—be viewed as *nodes* in a network. From another, however, permeable boundaries can appear as *weak links* between nodes, somewhat along the lines suggested by Mark Granovetter’s now classic 1973 work on “weak ties.” Just as Wittgenstein undermined the concept of Platonic essences with his work on “family resemblances,” so the concept of dynamical “clustering” of nodes and links might take the place of that of identity and its much more static connotations.

In this reconceptualization, whereas *strong* dynamical links among components (characterized as nodes) result in a “strong cluster,” weak links between strong clusters give rise to a community or a world. Since any given node can simultaneously belong both to a strong cluster and to a larger networked community, society, or world, boundaries become diffuse, but also dynamic and creative. Complex dynamical systems thus begin to look a lot more like bramble bushes in a thicket than like stones. And it is extremely difficult, as any outdoorsman will tell you, to determine precisely where a particular bramble bush ends and the rest of the thicket begins. As referenced by Albert-Laszlo Barabasi in his new book, *Linked* (2002: 171), Flake *et al.* suggest that “documents belong to the same community if they have more links to each other than to documents outside of the community” (my emphasis).

We must think in terms of concepts such as “active sites,” “linked clusters,” “robust resilience,” and the like if we are to make any sense of the concept of identity in reference to complex dynamical systems.

References

1. Barabasi, A-L. (2002) *Linked: The New Science of Networks*, Cambridge, MA: Perseus.
2. Cilliers, P (2002) “Why we cannot know complex things completely,” *Emergence*, 4(1/2): 77-84.
3. Flake, G. W., Lawrence, S. & Giles, C. L. (2000) “Efficient identification of web communities,” *Proceedings of the Sixth International Conference on Knowledge Discovery and Data Mining*, Boston: ACM Special Interest Group on Knowledge Discovery in Data and Data Mining: 156-60.
4. Granovetter, M. (1973) “The strength of weak ties,” *American Journal of Sociology*, 78: 1360-80.
5. Holling, E. (1976) “Resilience and stability in ecosystems,” in E. Jantsch & C. Waddington (eds), *Evolution and Consciousness*, Reading, MA: Addison Wesley.
6. Juarrero-Roque, A. (1991) “Fail-safe versus safe-fail: Suggestions towards an evolutionary model of justice,” *Texas Law Review*, 69(7): 1745-77.
7. Ulanowicz, R. (2002) “Ecology, a dialog between the quick and the dead,” *Emergence*, 4(1/2): 34-52.