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Life as a Natural Kind

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ABSTRACT. Artificial life consists in modeling in silico living systems. I argue that these models actually belong to the same kind of the traditional living systems that they purport to represent. Therefore, they are a sui generis way of modeling. Although Dennett (1991) made an analogous remark about artificial intelligence, I will develop this idea within a framework that retains the notion of a natural kind.

1. Introduction

In the following work, I argue that living systems form a natural kind. Every populations of reproducing entities subject to natural selection belong to this kind, be they flesh and blood animals or pieces of software competing for virtual resources. *In silico* models of life are informative about more orthodox living organisms because they share with the latter a cluster of interesting properties. Thus artificial life is – at least in one respect – a *sui generis* science: models and *phenomena* normally belongs to different sorts of object whilst populations of electronic bugs and populations of ordinary bugs are both the same kind of stuff, namely living systems. There is of course a trick beyond this peculiarity of artificial life, one that is indeed not too hard to spot: the best characterization of the notion of a living system that we have is rather *abstract*, in the Lockean sense of lacking concrete details. Lewontin's criteria

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of reproduction, inheritance and selection (or refinements thereof) are in fact quite general – more precisely, they are multiple realizable by all sorts of things (Fodor 1974). Therefore, it doesn't come as a surprise the fact that *in silico* models and the phenomena that they purport to represent actually belong to the same kind. I will develop these remarks by (1) telling apart several conceptions of natural kinds that have surfaced in the philosophical literature; (2) distinguishing some ways in which objects share clusters of properties; (3) categorizing living systems in the framework developed in (1) and (2) and commenting upon the so-called "biology's first law" described by McShea and Brandon (2010) in a recent work.

2. Natural kinds play a role in realism, induction, and laws of nature

"Natural kind" is actually a label for many conceptual tools that were brought up in the philosophical debate for quite different reasons (Bird 2008). I will tell apart three of these tools, without implying that my list is exhaustive. I will dub them "minimal", "projectible" and "nomological" natural kinds. The relation between these items is the following: being a minimal natural kind is necessary to be projectible, which in turn is necessary to be robust (and they are distinct). As for the notion of a kind, I will let aside the debate about essences and pick up the suggestions of Boyd (1999b), who argues that kinds are just sets of objects which share a cluster of properties.

Minimal natural kinds are involved in some formulations of scientific realism: scientific knowledge tracks the joints of nature, that is, tells apart sets of objects that instantiate a *significant* cluster of properties. Each member of any set of objects, of course, shares at least some properties with all its fellows, though these properties need not be *significant*. Skeptical about kinds argue that the choice of a set is entirely subjective or always driven by our interests (Kitcher 2001): in other word, that there is no way to make sense of *significance* that is independent from our concerns. This proposition may well be coherent with a realist position – as it is the case for Kitcher. Certainly, its denial is a form of scientific realism, even though one of a rather weak kind, for we certainly need a constraint on the set of *significant* properties to render it more substantial.

A second issue that was tackled with reference to natural kinds was the new riddle of induction that had been proposed by Nelson Goodman (1978). Briefly, he showed that any set of observations of the form "x is A and P" could support (by induction) conclusions of the form "All As till 2050 and non-A afterward are Ps", which are of course infinitely many. What seems to go wrong in this further version of the under-determination thesis is, of course, that the set of objects upon which we induce (As till 2050, not-A afterward) is somehow *non-natural*. Only natural kinds ground inductions. They are in fact that categories that occur in our best inductions: these are projectible kinds, after Goodman usage of this adjective.

The obvious *ad hoc* nature of the solution above is even more apparent in the definitions of laws of nature that mention natural kinds. According to these conceptions, laws of nature are just generalization in which natural kinds (as opposed to contingent kinds) occur. An independent characterization of the latter would at this point save the analysis, but nothing worth has been provided as yet. One tentative conclusion might be the following: the relation between the notion of a natural kind and that of a law of nature is not analyzable any further. They are *somehow* the same concept. These kinds are nomological, for obvious reasons.

I will argue in the paragraph (3) that there are interesting laws involving living systems as defined by Lewontin, although probably these laws are quite different from what we normally label "law of nature". Therefore, life is a nomological kind. Given the relations between the kinds of natural kind that I have mentioned above, life is also a projectible kind (and a minimal kind, of course). This feature is of special importance for our underlying concern: the use of artificial life as a model for generic living systems.

3. Cluster of properties can be contingent, nomological or analytic

Let us assume that a set of objects share a cluster of properties. Why is it the case? In some instances, this state of affairs is wholly contingent, as for the properties "being on my table" and "weighing less than 5 kg". Sometimes, instead, the explanation seems to be more robust, as in the case of the co-instantiation of property "having the atomic number X" and the various physical and chemical properties associated with that atomic number. Let us make these sketchy remarks more systematic.

Some clusters of properties are contingent. There is no explanation of the co-instantiation that uses any scientific theory or laws of nature. The case of the objects on my desk belongs to this category.

More substantial clusters are those explained by historical facts, no matter how contingent: properties that are shared by members of each biological phylogenetic-based *taxa* are of this kind. Notice that the difference with the first instance is a matter of degree: the next object on my desk could well weigh ten kilos (even though not ten tons), whereas the next mammal is very unlikely to be cold blooded. I will call these clusters "historical" after Boyd (1999a, see also Millikan 1999).

The following situation is even less unlikely: that the next atom with the atomic number X that we encounter has a different electric charge of its fellows. This is unlikely because the cluster is grounded in some law of nature. I will dub these clusters "nomological", with an obvious relation to nomological *kinds*.

Other co-instantiations are more trivial: some properties are instantiated together as a matter of logical necessity. There are two relevant cases here: if some objects share the property P, then they also share the property "P or G". Furthermore, if some objects share the property P, then they also share whatever is contained in that property as a matter of meaning. These clusters are "analytic".

A more complicated case, which I list among the analytic clusters, would be one where some objects share a property P and we have a proof that, if an object instantiates P, then it must instantiate also G. This is of course the case for the logical necessity from "P" to "P or G", although these cases are not the most interesting ones.

We could also try to compare systematically the various natural kinds tools of the paragraph (1) with this taxonomy of clusters. This is of some interest but I will instead focus on another issue, that of living systems. I will argue that biology's first law (McShea and Brandon 2010) is analytic and that, therefore, the cluster of properties shared by living systems is of the latter kind.

4. Life is an Abstract Kind

McShea and Brandon describe a law that is true for all living systems and that it will be indeed true for all future living systems or would be true for any possible living system. The last proposition should suggest that there should be some kind of proof of the law. In other word, it must be the case that the cluster of properties that are shared by all possible living systems is analytic. Let us go through they argument to understand whether this is the case.

Two phenomena are widespread in the tree of life: the increase in diversity and the increase in complexity of organisms. The two processes are actually one and the same in the work of Brandon and McShea, since they claim that life is hierarchically organized and that diversity at the level n is just complexity at the level n+1. In fact, members of the upper levels are made of (former) members of the lower levels and complexity is defined as the number of kinds of parts (McShea 2001). Instances of these increases in complexity-diversity are events such as post-extinction radiations or the increase of diversity of appendixes in arthropods since their appearance on the earth.

Traditionally, all these processes required an explanation, probably a local one, that is, a different explanation for each of them. However, if McShea and Brandon are right, these outcomes are expected by default. It is decrease or stasis in diversity and complexity that call for a local explanation force.

Their argument is a rather simple one. Consider a bi-dimensional space: one axis represents time whereas the other represents a phenotypic measure. Assume that at time 0, there is a population of organisms spread on the phenotypic space and that the average value of their phenotype is 0 (these latter assumption may be dropped). At each time point (the time dimension is discrete), each organism *reproduces*. That is, there is an organism at the time n+1 for each organism at time n. The position of the offspring in the phenotypic space depends on that of the parent (*inheritance*) plus a chance that it will move in one direction (*variation*) with probability 0,5 or in the other with probability 0,5 (absence of selection).

There is a simple proof of the proposition that, repeating the experiment several times, the typical outcome is an increase of the variance of the phenotypic score of the organisms and a stasis to 0 of the average (there is 0,5 probability at each time step that variance will increase). Since variance is a measure of diversity, we have a proof that reproduction, variation and inheritance are sufficient for diversity to increase. Since reproduction, variation and inheritance are defining feature of life according common definitions, then we have a proof for a law that holds for all living systems. Diversity (and complexity) must increase in living systems (if nothing contrasts this drift).

As I had announced, the co-instantiation of the properties that define life and of the property "showing increasing diversity/complexity" is a matter of necessity, indeed I just sketched a (informal) proof of this proposition. Interestingly, despite its necessity, the law seems to be cognitively interesting: according to Brandon and McShea, it is expected to move the focus of research from change to stasis, certainly a big deal in some fields as paleontology.

I would like however to make another kind of point. The procedure that they used to prove their law is inspired by some famous basic models of living systems: random walks. It is because some of these models share with living systems important features (indeed defining features) that they could be used to prove a law that is true everywhere and in every time. In fact, Brandon and McShea work belongs to the tradition of artificial life, although their book does not refer to any *in silico* model.

The simplicity of their example, however, is precious to make an important point: *in silico* models of life and living systems do resemble each other because they belong to the same kind. An *in silico* model of an earthquake is not an earthquake whereas an *in silico* model of living systems is alive. Notice, however, that this is not to be taken as an important truth about artificial life. It rather tells us something important of kinds that are defined abstractly, that is, in a multiple realizable way. If we define intelligence functionally, is really important to remark that human thinking and artificial models of thinking are both instance of intelligence?

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