1 Introduction

1.1 A Preview of the Trail

This Element is about change. Specifically, it is about the underlying mechanisms that cause changes to happen, both in nature and in culture; what types there are, how they work, where they can be found, and when they come into play. The ultimate aim is to shed light on two barbed issues. First, what kind of system of change is culture and, second, what kind of change in that system counts as creativity; that is, what are the properties and characteristics of the mechanisms of change when we humans explore unknown regions of the cultural realm.

The trail we will take up to get a good viewpoint from which to see these issues is strewn with difficulties because it requires, at several mileposts, that we strenuously exert our imagination. But I promise it will grow on you the longer you stay with it. We will arrive at a first stretch when we reach a small platform from which we can appreciate a new theoretical framework. This novel structure is based on the concept of a sightedness continuum and establishes a direct and straightforward relationship linking the three general mechanisms that cause gradual, adaptive, and cumulative of change: evolution, learning, and development. The theoretical framework provides a powerful vantage point from which to see not only how these mechanisms of change cause change but also where and when these changes occur. It will also serve as a base for an examination of what kind of system of change culture constitutes and our efforts to look for creativity in that system.

From the trailhead below up to this first platform, there are several sights to behold. Early on, we secure a prevalent but often overlooked consensus position on cultural evolution, so that we can all stay together as a group. This includes sticking with the overall term of cultural evolution until we get ourselves into a position to quibble about it. In a sentence, this consensus is that human creativity, and by extension cultural evolution, is best characterized as an evolutionary process that has some coupling between variation and selection, or degrees of sightedness of the selection criteria. Because confusions and errors abound on this topic, it is critical for this novel theoretical framework that we have an unclouded understanding of what, exactly, is involved in neo-Darwinian and Lamarckian evolutionary algorithms in terms of sightedness. This part is familiar terrain and should not be controversial.

Once we have identified the blind-sighted dimension as the key to understanding the character of the system of culture, we will survey the prediction paradigm of neuroscience to extract two critical insights. One is a neural mechanism of how the human brain manages to get some sightedness of the

fitness landscape when navigating what is supposedly an unknown problem space. In projecting hypothetical targets into that unknown topography, the brain's predictive computations put some sightedness into its thought trials, giving cultural evolutionary algorithms some unique properties, such as faster and more efficient heuristics and the ability to scaffold.

Second, we will also recast the process of learning from the sightedness perspective. Learning depends on prediction. It occurs in response to a prediction error, which, naturally, is a process that requires the existence of target information. Using these adaptive end points, the advances of the learner – the unit undergoing the change – is then instructed or directed. In other words, the changing unit has access, or visibility, to the selection criteria, making learning a fully sighted mechanism of change.

To render this insight clear and robust, learning – along with development and Lamarckian change later on – will be framed in terms of control systems engineering and Bayesian inferencing. Using the brain's motor control to work out the key computational principles, we will link sightedness to a control system in which the desired output is achieved by using a controller that directs the internal operations of the system. Since the opportunities to abandon the trail early are so numerous and the motivation to surrender to them is so strong, these cairns on the lower part of the trail will go a long way to block all the exists and stay the path.

Having equipped ourselves with sharper thinking tools, we now have a clear way forward. The novel theoretical framework invites the hiker to see the three kinds of mechanisms that cause change to come about – evolution, learning, and development – from a single dimension, the dimension of sightedness. In keeping all other complexities temporarily clamped, including interaction effects such as the Baldwin effect or evo-devo, the integration of all three algorithms of change into a unified axis can make visible links that can otherwise not be seen. For instance, when viewed in terms of sightedness, Lamarckian evolution should be reclassified as a learning process. Accordingly, Lamarckian evolution is a learning algorithm or, if you prefer, learning is a Lamarckian evolutionary algorithm. Throughout these lower parts of the trail however, we will refer to Lamarckian change as evolution until we can see the issue in the light of our novel theoretical framework.

Unlike in the blind, neo-Darwinian mechanism causing all the cumulative and creative changes in the biosphere, the fitness landscape in control systems is "visible" to the changing unit so that feedback from the selection criteria can instruct, or guide, the units undergoing the change. This visibility implies that these mechanisms of change can only work when the problem space is already known at the systems level. It also implies that they can use Bayesian predictive coding, among other computational tools, to bring about change.

Adopting the sightedness and control systems perspective brings out several other features and effects of the three mechanisms of change. One involves the location, acquisition, and transfer of controllers and what that means for problem spaces and sightedness values. Another involves different types of control systems. Depending on the feedback path, these are open loop control systems and closed loop control systems, which map well on to the processes of development and learning, respectively.

The new framework will become our guide for the higher sections of the trail. The joy of being high above the tree line is, of course, the panoramic view. This is just what we need for the next leg of our route, a systematic survey of the mechanisms of change in both nature and culture, as they appear from our novel theoretical structure. Once we understand how the crank mechanisms work, it is easier to tell where they can be found and when they come into play. For this task, we must distinguish in both systems of change – nature and culture – the problem spaces in which the topography is known, at least in principle, from those in which they are fundamentally unknown. The difference lies in the most general sense in the changing unit's "visibility" or "sightedness" of the fitness criteria, which, in turn, determines the type of algorithms of change that can be used to generate any change. Thinking through the resulting 2×2 matrix – system of change (nature versus culture) and problem space (known versus unknown) – is a task that requires discipline and vigor and that yields a satisfactory – and satisfying – account of the mechanisms and dynamics that cause gradual, adaptive, and cumulative change.

We now approach the summit of the trail and we can address our two barbed issues, which we will engage in reverse order. First, we will look for creativity. This search quickly becomes complicated for the simple reason that the brain's predictive processes generate partial sightedness even when the problem space is supposedly totally novel. To complicate things even further, there are also plenty of opportunities for creativity in principally known problem spaces, something that one might not suspect. To help clarify this, we will allot some space to the dual role played by prediction in known problem spaces.

From a few examples of how we humans discover, innovate, design, and create, we arrive at a general deduction about the mechanism of creative change. That is, there is a reciprocal causal interaction between sightedness, knowledge, and prediction. This reciprocal interaction implies that the creative process changes the mechanism of the creative process itself.

Finally, we can attend to the first barbed issue – what kind of system of change is culture? There are endless complexities attached to mechanisms of change that feature varying degrees of sightedness. And they make culture a system of change that is stranger and more fascinating than thought.

Anyone who has made it this far up the trail can now do more than just enjoy the conclusions arrived at after reaching the summit. The hiker can now also appreciate the details that get us there.

1.2 Directions to the Trailhead

If decades of fascinating discussions are any guide, most people who fail to make it to the summit do not give up along the way; rather, they do not make it to the trailhead in the first place. Heeding Woody Allen's observation that "eighty percent of success is just showing up," we must first acknowledge and clarify a number of undercurrents of resistance that shackle our imagination and thus prevent a general application of a neuroscientific, evolutionary, and algorithmic analysis of culturally changing systems. They must be identified and disarmed before we can comfortably start the journey.

The general aim of this preparatory work is to keep a lid on the anxieties that such a reductionist perspective induces and prevent them from depriving the hiker of the unfettered view that one has standing on the summit. We briefly touch on four of these recurrent misunderstandings.

One rather surprising form is resistance against neuroscience in general and involves the vague notion that the brain is not the only source of change in culture, creative change included. Accordingly, we must also consider social dynamics or the cultural context. What about creative ideas that emerge from people interacting during brainstorming sessions, for example? And what about embodied cognition, the idea that the body and its interaction with the physical environment also needs to be taken into account?

There is no need, however, to labor under this sort of neurophobia. As Henrich and colleagues (2008, p. 119) put it: "Culture can be understood in the most general sense as information stored in human brains." Social processes and cultural phenomena might very well be best explained by references to social processes and cultural phenomena. Nevertheless, they emanate from brains. In a brainstorming session, for instance, when people express their ideas, the creative change does not occur to the information in mid-flight between two people. Irrespective of how information gets into a brain – by way of genes, cultural environment, social learning, random events, and so on – changing the information into a novel combination occurs in the brain. To be altered, information still has to be represented in a computational system.

A second, closely related source of resistance is based on the lack of communication between those in the field of creativity and those in cultural evolution. A few exceptions aside, they do not talk to one another. In biology, there is no equivalent disciplinary boundary between the world of biological

artifacts and the sources – genes – that generate, to a first approximation, all the artifacts of that system, including the mechanism of neo-Darwinian evolution that puts the information into those genes. In other words, geneticists and evolutionary biologists take from one another.

Those who study brains and those who study culture do not share in the same way. Neuroscientists working on creativity have nearly universally ignored the basic variation-selection rationale in setting up empirical protocols (Dietrich & Haider, 2017). All psychometric 'tests of creativity' collapse the two fundamental elements of the creative process, and it is hard to imagine useful neuroimaging data from studies blending variation with selection, given that both likely engage different cognitive processes and different brain areas (Dietrich, 2015). The same holds for those working on cultural evolution. There is a remarkable disconnect between the way we study the system of culture on the one hand and the underlying brain mechanisms that generate all the goodies of that system on the other. In this Element, we make a concerted effort to try to join the two.

The blanket rejection of an evolutionary approach to the study of culture, in any form, is perhaps still the strongest of all the recurrent misunderstandings. Therefore, it receives its own section, the next.

1.3 Basic Thinking Tools

Whenever cultural evolution is the topic, the temperature rises. Amidst the bruising rhetoric of ridicule and contempt on all sides, debates on how far Darwinism extends upward into culture typically generates more heat than light. Champions of Darwinism in culture like to describe their opponents as mushy humanists and soft-headed poets who, having overdosed on postmodernism, are prone to panic attacks whenever they hear the rattling of the saber of science. This being academia, it does not end there. Opponents heap scorn on the entire enterprise of Darwinizing the social sciences and humanities and like to depict their rivals as overzealous scientists and pigheaded technophiles who, having overdosed on reductionism, erratically swing the club of Darwinism at everything in sight.

There are some signs that the pugnacious hyperbole is subsiding a bit. Of course, there are those who regularly go into orbit denouncing Darwin outright – creationists, believers in intelligent design, and so on – but those people must be taken up elsewhere. We will focus here on neutralizing a third source of resistance, which is perhaps best called residual dualism. Apart from the study of consciousness, this residual dualism can be observed quite often when the topic turns to creativity and, by extension, cultural evolution. This resistance must be

broached head-on, because any lack of clarity here is prone to lead to Cartesian danglers once we push for sound mechanistic explanations later on.

We all grow up with the warm blanket of dualism, the combination of instinctive truthiness and spiritual comfort that can only come from leaving your intuitions unexamined. Residual dualism fuels a tacit and deep-seated motivation to keep evolutionary and algorithmic thinking, in any form, out of culture and away from the mind. Efforts to protect the mind – and culture as its derivative product – from being a full member of the canon of science are nothing new. The irony is that residual dualists waste no time telling you that they have no qualms with Darwinism in biology. But after they cede the mind to be the outcome of evolutionary processes, they make a stance there and reject as absurd the application of the same principles to the mind. This is perhaps because they can dimly see that if the tug-of-war is lost here, at this line, there is nothing that protects our creativity, consciousness, and agency from a bad case of existential vertigo. Exactly where a residual dualist draws the line can differ greatly from one to the next but, eventually, if one presses hard enough, there is a line.

Residual dualists part ways, not to retreat into the walled enclave of vague Cartesian dualism, but because they misunderstand key terms and concepts. Common stumbles include conflating neo-Darwinism and Darwinism, being unclear about what is actually involved in a Lamarckian algorithm, the foresight fallacy, the argument from intention and purpose, or confusing ultimate (evolutionary) explanations that answer *why* questions with proximate (neural or cognitive) explanations that address *how* questions, all in the hope that Darwinism somehow goes away. Some confusions hit the same spot but from a different angle, and we will address some of them in the pages to come.

You can run but you can't hide, as they say. The snag with such motivated reasoning is, of course, that this defense requires, beyond said line, a miraculous force to make it all work. It is powerful proof that it is one thing to commit yourself to a view, it is quite another to accept all the logical consequences that go along with it.

Unfortunately, the most typical response to clarifying these issues is intellectual stonewalling. It is a disarming reflection of the determination to keep the Darwinian grenade from detonating inside the well-protected pocket in which we hold the mind and the cultural world it creates. Therefore, we make one more effort to address this form of resistance and offer in Figure 1 a simple sketch of why evolutionary thinking, for human creativity and cultural evolution, is a form of TINA (There Is No Alternative).