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Cultural evolutionary theory as a theory of forces

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Abstract Cultural evolutionary theory has been alternatively compared to a theory of forces, such as Newtonian mechanics, or the kinetic theory of gases. In this article, I clarify the scope and significance of these metatheoretical characterisations. First, I discuss the kinetic analogy, which has been recently put forward by Tim Lewens. According to it, cultural evolutionary theory is grounded on a bottom-up methodology, which highlights the additive effects of social learning biases on the emergence of large-scale cultural phenomena. Lewens supports this claim by arguing that it is a consequence of cultural evolutionists' widespread commitment to population thinking. While I concur with Lewens that cultural evolutionists often actually conceive cultural change in aggregative terms, I think that the kinetic framework does not properly account for the explanatory import of population-level descriptions in cultural evolutionary theory. Starting from a criticism of Lewens' interpretation of population thinking, I argue that the explanatory role of such descriptions is best understood within a dynamical framework – that is, a framework according to which cultural evolutionary theory is a theory of forces. After having spelled out the main features of this alternative interpretation, I elucidate in which respects it helps to outline a more accurate characterisation of the overarching structure of cultural evolutionary theory.

Keywords Cultural Evolutionary Theory; Cultural Change; Kinetic Theory; Population Thinking; Evolutionary Forces; Dynamical Theory.

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1. Introduction

Pursuing a generalised explanatory framework for evolutionary change, biologists have repeatedly attempted, over the past 150 years, to ground evolutionary theory on a supposed analogy with physical theories, most notably Newtonian mechanics or the kinetic theory of gases. According to the Newtonian analogy – one version of which was arguably already defended by Darwin (Depew and Weber 1996) – evolutionary theory is a *theory of forces*. This is to say, roughly, that its explanatory import originates from the fact that it identifies, as possible causes of evolutionary change, a compact set of factors (selection, genetic drift, mutation, migration, recombination, etc.) perturbing the supposed "inertial state" of a population (which has been alternatively identified with the Malthusian growth model, the Hardy-Weinberg equilibrium, the tendency towards complexity, etc.). By contrast, the kinetic analogy – whose first formulation is sometimes attributed to Fisher (1930) – stresses the statistical features of evolutionary theory (or, more specifically, of its mathematical core, that is, population genetics). From this perspective, evolutionary change is nothing more than the by-product of a myriad of individual interactions – just like thermodynamic macro-phenomena, such as temperature or pressure changes – between organisms and between organisms and the environment. The explanatory import of evolutionary theory is in this case identified by its ability to predict the aggregative effects of these interactions.

Interestingly, both analogies have also made an appearance – albeit in a somehow different form – in the recent debate on the explanatory status of cultural evolutionary theory. On the one hand, Richerson and Boyd – among many others cultural evolutionists – have characterised cultural evolutionary theory as a theory of forces:

> We call the processes that cause the culture to change *forces* of cultural evolution. We divide the evolving system into two parts. One is the "inertial" part – the processes that tend to keep the population the same from one time period to the next. In this model cultural inertia comes from unbiased sampling and faithful copying of models. The other part consists of the forces – the processes that cause changes in the numbers of different types of cultural variants in the population. These processes overcome the inertia and generate evolutionary change (Richerson and Boyd 2005, p. 68; emphasis in the original).

On the other hand, Tim Lewens (2009, 2015) has argued that cultural evolutionary theory is best viewed as a kinetic theory. In practice, in his opinion, the explanatory pay-off of cultural evolutionary models rarely derives from the reference to some cultural equivalent of selection, drift or other evolutionary forces. Cultural evolutionary models instead interpret cultural change as the aggregative outcome of the interactions between social learners endowed by specific cognitive biases and preferences.

In this article, the scope and significance of these analogies for cultural evolutionary theory will be discussed. To put it boldly, I think that the main difference between the Newtonian – or *dynamical* – approach and the kinetic approach is that they rely on different interpretations of one of the basic tenets of cultural evolutionary theory, that is, *population thinking*. The kinetic framework puts emphasis on a bottom-up methodology, to highlight the additive effects of social learning biases on the emergence of large-scale cultural phenomena. The focus of the dynamical framework, on the contrary, is on populations of traits. Rather than trying to understand how social learners' cognitive biases add up, the dynamical perspective seeks to integrate information about social learning biases with information about other evolutionary factors, so as to provide a more general picture of the causes of cultural change. I believe that both approaches are defensible and provide important insights about cultural evolution and the strategies adopted in order to model it. Still, I shall argue that, ultimately, the Newtonian analogy offers a more comprehensive framework for cultural evolutionary theory.

In order to support this claim, I shall first show why the kinetic view defended by Lewens does not do justice to some aspects of cultural evolutionary theory. To this aim, in section 2, Lewens' position will be illustrated in some detail. In particular, I shall focus on Lewens' criticisms against the explanatory centrality of population-level descriptions in cultural evolutionary theory, stressing the link between Lewens' view and his specific interpretation of population thinking. In section 3, it will be argued that this is not the only available – nor the most largely supported – characterisation of population thinking. I will thus show how an alternative interpretation may shed a different light on population-level descriptions of cultural change. In section 4, I shall introduce the dynamical framework and, in section 5, I shall maintain that it plays a foundational role in cultural evolutionary theory. In the conclusion, I will briefly summarise and reinforce the main points argued throughout the article.

2. The kinetic approach to cultural evolutionary theory

In accordance with a largely shared view, the core of cultural evolutionary theory is constituted by the models that Boyd and Richerson and their collaborators (especially Joseph Henrich) built within the so-called dual-inheritance theory. According to dual-inheritance theory, culture is differential transmission and accumulation of learned information. The type of information that is transmitted and accumulated is largely dependent on our hard-wired preferences for certain kinds of behaviour. Biological evolution provided human beings with characteristic *social learning biases,* which have proven adaptive in relatively stable environments, wherein individual trial-and-error learning is unnecessarily costly.[1] The social learning biases include the disproportionate imitation/emulation of the most common type (conformism), the most successful type (model-based or prestige bias) – the former or, occasionally, both of these biases are also called context-based biases – and the most attractive, memorable or useful type, according to some psychological preference (content biases).[2]

Once a new cultural variant (an artefact, a belief, an item of knowledge, a word, a symbol, a skill, a norm, etc.) is generated – through a process that is somehow analogous to genetic mutation, but possibly more directed (directed variation) –, its subsequent distribution is influenced by its attractiveness (due to content biases) and the distribution of other cultural variants (due to context-based biases) *plus* migration, drift, and natural selection. Natural selection acts in cultural evolution by eliminating cultural variants that are too detrimental from a biological point of view. In spite of this, cultural evolutionary theory predicts a large degree of autonomy for cultural accumulation. Provided that social learning is less costly or more effective than individual trial-and-error, partially maladaptive cultural variants may be maintained within a population, evolve and even subvert "genetically-coded" behaviours.

According to the mainstream view in cultural evolution theory, cultural variants are not

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[1] This claim, as well as other dual-inheritance theorists' statements concerning the biological evolution of the cognitive and behavioural faculties, has been criticised from different standpoints. More research is surely needed in order to better understand which are the evolutionary and developmental factors that have had a major impact on originating and moulding cooperative and social psychology. I would like to stress, nonetheless, that the details on human evolution and the *origin* of social skills, although obviously fundamental for a more realistic picture of cultural change processes, do not automatically prove or undermine specific conceptions of the *dynamics* of cultural change. Although, if it was eventually found that cultural transmission is completely disanalogous to biological inheritance, there would good reason to dismiss dual-inheritance theory, other minor adjustments to the specific mechanisms involved in social learning may be easily tolerated and incorporated into it.

[2] This picture has been somehow complexified by recent research (see, for instance, Kendal et al. 2018). For simplicity, such developments are not taken into account.

autonomous replicators similar to genes (this conception – largely criticised – is usually associated with memetics; Dawkins 1976). Instead, they are usually considered to be a class of psychological or behavioural phenotypic traits – whose specificity is, precisely, that they are culturally transmitted – or, in the case of artefacts, written languages or symbols, objects carrying information potentially influencing phenotypic traits: they are sometimes conceived as making up a culturally constructed ecological niche (Odling-Smee et al. 2003). In spite of the differences between genes and cultural variants, cultural transmission is nonetheless usually considered faithful enough to guarantee a stable and efficient channel of inheritance for the latter.[3] This similarity between genetic inheritance and cultural transmission – along with the commonplace observation that in the cultural domain there is plenty of variation – led some authors (most notably Durham 1991; Mesoudi 2011) to explicitly characterise the action of content and/or context-based biases on the distributions of cultural variants as a process of "cultural selection".

Thus, there are two possible characterisations of cultural change: as the *product* of individual interactions between beings endowed with specific social learning biases or as an evolutionary *process* involving cultural variant distributions. Against the explanatory import of the latter characterisation, Lewens (2015, chap. 2) observes that biological evolutionary concepts have been traditionally translated to the cultural domain in a rather loose manner. More specifically, it is possible to maintain that, in the context of dual-inheritance theory, cultural evolutionary descriptions are either explanatorily *vacuous* or *redundant*.

Concerning the vacuity charge, Lewens' criticism – echoing Popper's tautology objections against Darwinian theory (Baravalle 2018) – is related to the difficulty of defining in a non-trivial or non-circular way the notion of "cultural fitness", which is supposedly crucial to make sense of cultural selection. The strength of this objection is questionable since, as recently argued by Ramsey and De Block (2017), the difficulties in formulating an operational definition of cultural fitness are likely not insurmountable. Moreover, Lewens himself seems to acknowledge that this problem is not as fatal as it would seem at first glance. More serious is, in his opinion, the redundancy charge. By analysing major works in cultural evolutionary theory – most notably, Henrich and Boyd (1998) on the effects of conformism in the diffusion of a cultural trait and Henrich and Boyd (2002) on the characteristics of cultural transmission – Lewens notices that their explanatory pay-off does not derive from the use of the notion of cultural selection, but rather from the fact that they

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[3] But see, against this view, Sperber (1996, 2001).

account for the aggregative effects of social learning (Lewens 2015, p. 38). This claim can be generalised, in Lewens' opinion, to most cultural evolutionary models built within the dual-inheritance tradition.

In order to theoretically ground this position, Lewens invokes bibliographic evidence, mainly drawn from Boyd and Richerson's work, stating that "they affiliate their approach to a Darwinian tradition in a manner that does not place selection in the foreground, but which instead stresses the importance of *population thinking*" (Lewens 2015, p. 16; emphasis in the original). As is well known, this concept was introduced by Ernst Mayr in order to highlight, from a historical point of view, the differences between the Darwinian notion of species and previous *typological* interpretations. Similarly, population thinking is employed by cultural evolutionists to highlight the contrast between cultural evolutionary theory and those conceptions of culture that postulate intrinsic tendencies in cultural change (Richerson and Boyd 2005, p. 58 ff.; Lewens 2009, 2015, pp. 35-6). Nineteenth-century social evolutionism is a good example of such non-populationist conceptions. Anthropologists such as Lewis Henry Morgan or Edward Tylor conceived cultural change as an unfolding of stages towards higher degrees of civilisation, and saw deviations with respect to the "ideal path" as accidents. Albeit with differences concerning what the essence of history is taken to be, some Freudian or Marxian approaches to the social sciences arguably still adopt this form of typological thinking (Rosenberg 2016, chap. 8). By contrast, for population thinking-based cultural evolutionism, there is no previous "plan" for cultural change; the diversity and variability of human cultures is primitive, and cannot be explained by invoking hidden tendencies.

I take all of this as uncontroversial. However – Lewens keeps arguing – there is another, in his opinion more significant, sense in which population thinking influences the explanatory strategy of cultural evolutionary modellers. It is in virtue of this second sense that cultural evolutionary theory can be assimilated to a kinetic theory. In a frequently cited passage, Mayr states that population thinking is the claim that:

> All organisms and organic phenomena are composed by unique features and can be described collectively only in statistical terms. Individuals, or any kind of organic entities, form populations of which we can determine the arithmetic mean and the statistics of variation. Averages are mere statistical abstractions; only the individuals of which the populations are composed have reality (1959 [2006], p. 326).

Accordingly, for Lewens, cultural evolutionists' commitment to population thinking involves crediting "only individuals with 'reality' and hints at least at a scepticism regarding the explanatory importance of population-level properties" (Lewens 2009, p. 248), such as the distribution of a cultural variant. This is why cultural evolutionists would see cultural change as similar to thermodynamic macro-phenomena; both are best explained in terms of the interactions between smaller components, such that "by adding up these interactions in statistically sophisticated ways we can understand the behaviour of the aggregate" (Lewens 2015, p. 17). More specifically, cultural change would be explained – at least in most cases – by adding up instances of learning, in turn characterised in accordance with the peculiar preferences supposedly at work in the human group being studied. Contrarily, descriptions of cultural change offered in terms of cultural evolutionary pressures acting on distributions of cultural variants would be merely statistical abstractions. Since it would be impossible to track all instances of learning occurring in a population at a certain time, such descriptions are often valuable, but are not identifying a "real" (i.e., causal) process in its own right.

Lewens (2015, chap. 7) admits that the kinetic approach, as presented above, might not be entirely satisfactory in accounting for certain cultural phenomena in which, apparently, the distribution of cultural variants is not a direct function of individuals' preferences. This is the case for phenomena of cultural change occurring in populations with a complex demic structure and/or in populations in which powerful or institutional actors play important roles. However, even in these cases, Lewens believes that cultural evolutionists typically attempt to understand the behaviour of the whole population by decomposing it into interacting similar parts (groups, structured networks of powerful people, etc.) in a way that, again, is reminiscent of the *modus operandi* of the kinetic theory of gases.[4]

3. Population thinking and distribution explanations

As aforementioned, two of the most well-known models cited by Lewens supporting his kinetic view are Henrich and Boyd (1998) and Henrich and Boyd (2002).[5] Their shared goal is to defend dual-inheritance theory by showing that the characterisation of social learning

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[4] Notice, by the way, that Lewens is not arguing that this is the *right* way to explain cultural change, but just that cultural evolutionists typically explain it in these terms.

[5] Other models discussed by Lewens are, for instance, Henrich (2001) and Salganik et al. (2006). I assume that the considerations here developed with regard to the two Henrich and Boyd's models apply equally well to these other models.

features that this theory proposes (as described in section 2) accounts for observed large-scale phenomena (the evolution of conformism and the emergence of between-group differences in the case of Henrich and Boyd 1998, and the stability of cultural information through cultural transmission processes in Henrich and Boyd 2002). In order to accomplish this, both sets of models explain how the cognitive abilities or biases that characterise cultural transmission in human beings have been naturally selected in virtue of the fact that the dynamics that they implement are globally adaptive. The explanations that these models provide are indeed plausibly aggregative, as held by Lewens, because the overall adaptiveness of the cognitive biases is actually a consequence of the fact that humans individually interact in a certain way.

Both Henrich and Boyd's models provide *origin explanations* of cultural dynamics. According to Peter Godfrey-Smith, this kind of explanation is typically "directed on the fact that a population has come to contain individuals or a particular kind *at all*" (Godfrey-Smith 2009, p. 42; emphasis in the original) – in this case, individuals able to implement certain types of social interactions. Arguably, not all cultural evolutionary models have this goal. Frequently "we assume the existence of a set of variants in a population, and explain why they have the distribution they do or why their distribution has changed" (Godfrey-Smith 2009, p. 42). This is what Godfrey-Smith calls a *distribution explanation*. Henrich and Boyd's models account for the overall conditions (i.e., the presence of individuals able to socially interact in a certain way) that allow for certain cultural dynamics to emerge. They however do not say very much about how – once such dynamics have emerged and, as a consequence, a certain amount of cultural variation becomes available – subsequent changes in the distribution of cultural variants occur. Although Lewens may be right that origin explanations are typically provided in kinetic terms, this conclusion cannot be automatically extended to distribution explanations (see also footnote 1).

While the influence of individual psychologies and the importance of aggregation in cultural evolutionary dynamics are uncontroversial, I do not think that the explanations provided in terms of cultural evolutionary pressures are secondary, or merely accessory, in distribution explanations. On the contrary, I believe that they are indispensable in order to detect causes of cultural evolution that are not directly resulting from aggregation or, at least, whose explanatory import is not reducible to the fact that they are resulting from an aggregation.

In order to introduce my point, I would like to question Lewens' understanding of the role of population thinking in cultural evolutionary theory. As Lewens (2015, p. 16) himself acknowledges, Mayr's is but one possible interpretation of population thinking. It is also not the most widely endorsed. As a matter of fact, many of Mayr's commenters (Sober 1980; Morrison 2004; Hey 2011) have noticed that the reference to population-level properties as abstractions is problematic, since in biology it is generally accepted that populations are not collections of individuals arbitrarily taken, but instead are "real" interbreeding communities. After all, Mayr was a realist concerning species, and this metaphysical position is arguably at odds with the deflationist view that he apparently defends in the passage cited above.

Although there is, of course, a sense in which the Darwinian populational perspective implies a focus on individual idiosyncrasies and differences (contrary to typological thinking), there is another sense in which "population thinking involves *ignoring individuals*" (Sober 1980, p. 370; emphasis in the original). While, in fact, on the one hand "the typologist formulates a causal hypothesis about the forces at work on each individual within a population … the populationist, on the other hand, tries to identify invariances by ascending to a different level of organisation". The invariant property that is at stake in population thinking "is the amount of variability, and this is a property *of populations*" (p. 370; emphasis in the original). According to Sober, the difference between non-population and population thinking is thus, in a way, the opposite of that suggested by Lewens. While "essentialism pursued an individualistic (organismic) methodology … the populationist point of view made possible by evolutionary theory made such reductionistic demands unnecessary" (p. 381). This is because Darwinian population thinking allowed biologists to see that "populations and their properties … have their own causal efficiency" (p. 381).

A somehow intermediate position between Mayr's and Sober's is defended, in the context of cultural evolutionary theory, by McElreath and Henrich (2007). According to these authors, population thinking does not entail a reduction of population-level dynamics to individual-level interactions (this would be more characteristic of *methodological individualism* in social sciences), nor a reduction of individual-level interactions to population-level dynamics (this would be tantamount to adopt a sort of *holism*). Instead, it entails an interplay between the two levels. Given a certain demic structure, individuals interact with neighbours and with the environment, thus determining the composition of the population in terms of cultural variants. However, the other way around, cultural variants influence, in virtue of their distribution and functional properties, the demic structure and, therefore, individuals' behaviours and interactions.

A similar conception was already defended by Boyd and Richerson (1985):

> … it may seem that we must side with the reductionists because we attempt to discover the

> causes of the large-scale and long-term patterns of society in terms of events in the lives of individuals. This is a misperception. In our models the two levels are reciprocally linked; large-scale processes affect small-scale phenomena, and vice versa. We take the group (or population) of individuals as our fundamental unit. A group can be characterised by the number of individuals who exhibit each different cultural variant. We refer to this as the "distribution of cultural variants" (or phenotypes) within the group. To understand why a group is characterised by a particular distribution of cultural variants, we must understand the forces of cultural evolution that act on members of the group. Some of these forces have their origin in the psychology of individuals … Other forces are the result of larger-scale social processes (Boyd and Richerson 1985, pp. 23-4).

I have cited this excerpt integrally because it displays two aspects of cultural evolutionary theory that are, in my opinion, underestimated by Lewens.

The first aspect is that, as also noted by McElreath and Henrich, cultural evolutionary theory does not support any reductionism as the one implicit in Lewens' interpretation of population thinking. In order to explain cultural change, it is not enough to decompose the phenomenon into its basic elements, but it is also necessary to take into account the characteristics of the population as a whole. The second aspect neglected by Lewens – directly related to the first – is that in order to provide a complete picture of cultural change, populations must be represented as "distributions of cultural variants". This is not simply a useful description of something that can also be expressed otherwise (i.e., in terms of additive individual interactions); it denotes a standalone feature of the processes being modelled.

This point is very well expressed by O'Brien, Lyman, Mesoudi and VanPool (2010), who argue for taking cultural variants as units of analysis in evolutionary approaches to archaeology. One of the main claims of these authors is that a satisfactory explanation of the different distributions of specific cultural variants in a population requires a focus on their functional features. Of course, this involves the consideration of individuals' goals and preferences. Nonetheless, individuals should not be conceived of as the protagonist of cultural evolution, as "cultural traits are part of human phenotypes, but the traits themselves are populational. They can be traded at an individual level across time and space, but trait evolution is observed at the level of the changing membership of a population …" (O'Brien et al., 2010, p. 3803). Lycett and von Cramon-Taubadel (2015) further develop this population-focused conception, observing that: "As in biological quantitative genetics, the 'trait' of evolutionary interest within this framework is not … the value derived from an individual specimen, but the pattern of variation exhibited by a population of those individuals compared against that of (an)other population(s)" (p. 659).

Quantitative geneticists and, more generally, evolutionary biologists typically adopt this population-focused view because otherwise they could not properly detect selective pressures – or the action of other evolutionary factors – in the population under study. Although phenotypic features obviously belong to individuals, evolutionary biologists do not build up the explanation of the phenotypic change by simply adding up in a statistically sophisticated way individuals' births, lives and deaths. A distribution of traits is, in fact, usually compatible with more than one hypothesis about the evolutionary factors (selection, drift, mutation, migration, etc.) that have actually produced it (Endler 1986). In order to distinguish between these hypotheses, evolutionary biologists have to identify what genetic, biotic or environmental conditions have acted *systematically* and *differentiall*y on the population, so as to increase the frequency of a trait instead of another in some characteristic way over generations (Millstein 2006). Note that it is precisely for this distributed and intrinsically relational nature of evolutionary pressures that the evolutionary process is usually considered – in accordance with Sober's conception of population thinking – a population-level process (Shapiro and Sober 2007).

Analogously, by adopting this population-level approach, cultural evolutionists aim to integrate knowledge about social learning biases within a broader evolutionary picture. By focusing on cultural variants instead of on individuals, the models providing distribution explanations employ, so to speak, the same currency as biological evolutionary models. By considering cultural variants as a class of phenotypic traits and social learning biases as peculiar selective processes, these models permit simultaneous comparison of the action of cultural, genetic and environmental factors on cultural change, without assuming a privileged level of causation.

An example of this approach is the analysis proposed by Rogers and Ehrlich (2008). Rogers and Ehrlich's goal is to account for different rates of change of biologically adaptive and neutral cultural variants. The evolution of the techniques of canoe building in Polynesian populations is used as a case study. The authors distinguish between two types of cultural variants related to these techniques: functional design elements and symbolic design elements. Functional design elements have direct effects on the fitness of the individuals who are able to implement them (since the occupants of well-designed boats clearly have better chances of survival than the occupants of poorly-designed boats), while symbolic design elements are adaptively neutral. Rogers and Ehrlich's study reveals that while the former cultural variants usually undergo negative (purifying) natural selection and possibly cultural selection, thus changing at a slow rate, the latter change more quickly and display greater inter-group variation.

Even admitting that the term “cultural selection” ultimately denotes, in Rogers and Ehrlich’s model, nothing more than an aggregate of individuals interacting in a way that leads them to adopt one design element instead of another, this does not mean that the explanatory pay-off of the model results from “the surprising nature of aggregation” (Lewens 2015, p. 38). The model does not talk at all of individuals interacting. The model is explanatory rather because it clarifies how distinct factors – some having origin in the psychologies of individuals, others in the environment, still others in the structural characteristics of the populations – concur in order to produce a certain pattern of variation. Instead of pursuing a bottom-up methodology as that postulated by the kinetic interpretation, Rogers and Ehrlich aim, in their own words, to “untangle the relationship between cultural change and the different *forces* that might act on it systematically” (Rogers and Ehrlich 2008, p. 3418; emphasis added).

Having introduced this alternative, non-aggregative, way to explain evolutionary change, the Newtonian analogy that supposedly grounds it will now be explored.

4. The dynamical theory of cultural evolution

Hitherto, it has been argued – against Lewens’ scepticism – that there is a consistent tradition, within cultural evolutionary theory, which conceives and models cultural change as a population-level phenomenon of phenotypic evolution. Lewens labels this tradition simply as “selectionist” (2015, p. 11 ff.), though he acknowledges that, according to this tradition, population-level dynamics of cultural change are not necessarily due to causes analogous to natural selection, but also to drift, migration and other evolutionary factors. In this section, it is argued that a more accurate way of characterising this conception of cultural change – and its explanatory value – is by representing cultural evolutionary theory as a dynamical theory.

As it is possible to appreciate from the previous discussion, many cultural evolutionists characterise the causes of evolution as “forces”. Nonetheless, few have attempted to make this conception more rigorous. Part of this resistance is likely due to the fact that, in spite of having being widely adopted in evolutionary biology, the notion of “evolutionary force” has frequently been held as metaphorical (if not completely misleading; e.g., Endler 1986). Yet, as anticipated in the introduction of this article, Darwin himself arguably conceived his theory in analogy with Newton’s, and recently many philosophers have made use of this analogy in order to clarify metatheoretical aspects of evolutionary theory.

According to Sober (1984), who popularised a contemporary version of the Newtonian analogy, a theory of force is composed of three main elements: a *zero-force law*, a set of *consequences laws* and a set of *source laws*. In genetic evolutionary theory, the zero-force law – the “inertial part” of the theory, in Richerson and Boyd’s passage in the introduction – is commonly identified with the Hardy-Weinberg principle (albeit other characterisations are possible; see, for instance, McShea and Brandon 2010). The consequence laws are the equations of population genetics, which describe the direction, the magnitude and the outcome of specific evolutionary factors, such as selection, drift, mutation and migration. Rather than “laws” (the term is still sometimes used in order to refer to “universal” or “unrestricted” generalisations, although there is no need to conceive them in this way; see, for instance, Lorenzano 2006), the consequence laws of a theory can be a set of mathematical models, accounting for the *effects* of the different factors acting on the system under study.

While the zero-force law and the consequence laws constitute together, so to speak, the formal part of the theory, the source laws constitute its empirical element. The source laws explain *why* the inertial state has been perturbed by pointing out the causes of the change.

On this latter point, it might seem that Sober considered the analogy between Newtonian mechanics and biological evolutionary theory to be stronger than what is effectively the case. In Newtonian mechanics, we have a limited set of source laws – like Archimedes’ principle, or the law of gravitation – which describe causal characteristics of the process under study that are shared by each instance of it. Archimedes’ principle, for instance, univocally identifies the causal component of buoyancy with the weight of the fluid displaced by a submerged body, the law of gravitation identifies the causal components of gravitation with the mass and the distance of the gravitating bodies, etc. Conversely, with the possible exceptions of mutation and migration (Hitchcock and Velasco 2014), the causal characterisation of evolutionary forces is dependent on the specific ecology in which the changing population is found. Natural selection is, possibly, the most striking example of this: in a certain circumstance selective pressures are identified with a cold climate favouring a long fur, in another one with a hot climate favouring a morphology that allows to dissipate heat, still in another with the presence of specific predators favouring mimicry, etc.

Because this context-sensitivity, it could be argued that evolutionary regularities are not general enough to be considered, properly speaking, laws. Such an argument would, however, miss the point. In a theory of forces, source laws play an explanatory role not because their generality, but because they allow to identify patterns of counterfactual dependence. Once this is realised, the difference between Newtonian mechanics and evolutionary theory appears more a matter of degree than of kind. Archimedes' principle supports, *ceteris paribus*, counterfactuals concerning any body submerged in a fluid. On the contrary, a regularity denoting the relation between a cold climate and long fur does not say anything about another evolutionary scenario connecting, to say, predators and mimicry – in spite of the fact that both are causal instantiations of selective processes.[6] Still, all this does not take away that, notwithstanding its more limited scope of application, the regularity connecting cold climate and long fur supports a certain range of counterfactual claims concerning analogous ecologies. More in general, once certain traits are found that have evolved under specific ecological circumstances, we are justified to say that, *ceteris paribus*, similar traits will evolve under similar circumstances. This is enough to guarantee to the causal characterisations of evolutionary forces an explanatory role at least analogous to that of source laws in Newtonian mechanics (Caponi 2014).

Within this framework, the notion of force is neither mysterious nor metaphorical. The zero-force law defines the *principle of stasis* of the domain under study, that is, the "normal" condition of the system, where nothing is happening. A force is nothing more than a cause instantiating a source law, whose effects are formally depicted by its corresponding consequence law as a perturbation of the inertial state (Maudlin 2004; Luque 2016). Note that, within this framework, "cause" is any factor potentially perturbing the inertial state; the theory is agnostic about metaphysical claims concerning a supposed privileged (i.e., more basic) level of causation.

Studying a certain domain of phenomena according to this dynamical framework involves three main steps. First, the researcher notices that the system under study is not behaving according to what is predicted by the zero-force law and calculates the divergence from the expected value. This, in Newtonian mechanics, amounts to identifying the *net force* acting upon an object. Second, the researcher elaborates hypotheses about which forces might have produced the change in the system by decomposing the net force into a set of consequential laws. Finally, the researcher considers the phenomenon empirically and tests the hypotheses by identifying source laws possibly responsible for the change in the system.[7] In the rest of

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[6] In addition, it may be said that the regularity connecting cold climate and long fur admits more exceptions than Archimedes' principle. Note, nevertheless, that also physical source laws must satisfy background conditions in order to support counterfactuals (in the case of Archimedes' principle, for instance, the submerged object must not touch the bottom of the vessel in which it is submerged in, the fluid must not be a complex fluid, etc.).

[7] This is, of course, a conceptual – and not necessarily temporal – sequence of steps.

this section I shall first identify the formal components of cultural evolutionary theory as a theory of forces. It will then be shown that, as a matter of fact, cultural evolutionists often adopt the explanatory strategy just described in order to offer distribution explanations of real-world cases of cultural change.

The zero-force law of cultural evolutionary theory has been identified by Boyd and Richerson (1985, p. 60 ff.) with the constant repetition of the same frequencies of cultural variants. However, other authors have proposed alternative zero-force laws. Most notably, Bentley, Hahn and Shennan (2004) have put forward a "neutralist" zero-force law, where the inertial state of cultural evolution is a "drift plus mutation" process. Although the choice of a zero-force law is partly conventional, this is not to say that it is arbitrary; it should reflect some very general and uncontroversial fact about the domain under study. Moreover, it should be mathematically simple, in order to avoid unnecessary complexity when acting forces are taken into account. Both Boyd and Richerson and Bentley and colleagues consider that cultural inertia is a condition in which social learning is somehow unbiased, although they disagree on the implications of this assumption. In order to simplify the characterisation of cultural evolutionary forces below, I shall adopt Boyd and Richerson's classic conception without any further discussion. The question of which is the zero-force law of cultural evolution is nonetheless still open and, since – by establishing what is the cultural "stasis" – the zero-force law determines the subsequent causal assumptions of the theory, it is a fundamental one.

The consequence laws of cultural evolutionary theory have been initially formulated, though in a somehow different form, by Cavalli-Sforza and Feldman (1981) and Boyd and Richerson (1985). Rogers and Ehrlich (2008), El Mouden et al. (2014) and Aguilar and Akçay (2018) can be considered as attempts to improve the formal characterisation of the forces of cultural evolution. A tentative taxonomy of cultural evolutionary forces according to measurable effects can be provided as follows:

- *Selective forces*: natural selection, cultural selection due to content and context-based biases
- *Transformational forces*: guided variation and random mutation
- *Random forces*: genetic and cultural drift
- *Migration:* demic diffusion and cultural diffusion
- *Recombinational forces*: blending transmission

Selective forces increase or decrease the frequency of a cultural variant depending on its genetic fitness value (natural selection), its cultural fitness value (cultural selection due to content biases – that is, selection favouring a variant due to its psychological attractiveness or its specific usefulness) and its previous distribution (cultural selection due to context-based biases).[8] Cultural selection due to context-based biases can be further sub-classified into:

a. Frequency-dependent cultural selection (due to conformist preferences), and
b. Cultural selection dependent on structural features of the population (due to prestige biases).

Transformational forces introduce variation in the process of cultural evolution. Cultural variation may be introduced by changing the features of a cultural variant in a way that it makes it expectedly – but not necessarily – fitter, either genetically or culturally (or both). The processes responsible for this kind of directed variation are sometimes referred to as "decision-making" forces, to distinguish them from processes changing features of cultural variants "blindly" – that is, in a way decoupled from the increase of genetic or cultural fitness.

Both genetic and cultural drift produce chancy fluctuations in the frequencies of cultural variants, but this phenomenon has arguably different causes in the two cases. Genetic drift has an impact on the distribution of a cultural variant because it stochastically changes the number of potential transmitters of the variant. Cultural drift is the effect of the transmission of cultural variants with equal genetic or cultural fitness (that is, selectively neutral).

An analogous difference subsists between demic diffusion and cultural diffusion, which are the two forms of migration that can affect the distributions of cultural variants. Demic diffusion increments the frequency of a cultural variant because more potential transmitters are physically introduced into the population under study. Cultural diffusion is generally due to the presence of technologies (radio, press, tv, internet, etc.) that allow the cultural variant to spread quickly within the population in spite of no physical displacement via individuals.

Finally, recombinational forces, along with transformational forces, are the other important engine of novelty generation. Blending transmission, however, does not create a new variant nor does it simply modify an existing one, but rather it merges two (or more) existing variants

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[8] See Aguilar and Akçay (2018) for a rigorous definition of cultural fitness. In accordance with my remarks in section 2, I shall here simply assume that such notion can be adequately formulated.

into a new one. This process – as the name of the force that produces it suggests – may be considered as analogous to recombination in genetics.

This taxonomy (drawn, with some important differences, from Mesoudi 2011) is tentative and can certainly be improved on in many ways. From the dynamical approach, it must be stressed that the formal representation of evolutionary forces are tools that allow for the source laws of cultural change to be found. It is precisely in the discovery of such laws that the explanatory power of many distribution explanations resides. As anticipated, the source laws are, in the context of an evolutionary theory, "laws" to the limited extent that identify a pattern of counterfactual dependence between a dynamic of distribution of phenotypic traits and the factors that are responsible for it. Within cultural evolutionary theory, some of these laws connect the diffusion of a cultural variant with psychological preferences, but others – differently from what a purely kinetic picture of cultural evolution would suggest – identify the causes of cultural change with other non-aggregative factors. These factors may include the natural environment, population structure, the presence of powerful actors or institutions, or the functional features of the cultural variants under study.

A straightforward example of the implementation of the dynamical approach is MacCallum, Mauch, Burt and Leroi (2012). In this work, the authors employ a simulation, the DarwinTunes, in order to understand the evolution of music. They assume the action of two forces – that is, recombination and mutation – throughout the entire evolutionary process. After a certain number or generations in which musical variants are subjected, in addition, to cultural selection due to content biases, the researchers observed a slowdown of the evolutionary process.

MacCallum and his colleagues explicitly attempt to explain this phenomenon by, first, decomposing the net force into its component forces and, subsequently, pointing out the possible causes instantiating such forces. Concerning the first step of the test, a series of hypotheses is proposed. The conclusion is that the stagnation of the evolutionary process is due to strong transformational forces (called by the authors "transmissional forces") opposing cultural selection when an apparent adaptive peak is reached. MacCallum and his colleagues thus identify the causes underlying these forces with a kind of epistatic interaction between different components of the tunes' cultural fitness (that is, consonance, rhythm and melody).

The importance of this result is that – in accordance with the goals of the dynamical approach – it provides a source law of cultural evolution. It can be expected that in other cases in which the cultural fitness of a variant is dependent on a set of factors analogous to the ones intervening in the DarwinTunes, an analogous slowdown of the evolutionary process will be seen when an adaptive peak is reached. Moreover, it can be noticed that the causes of the populational dynamic are not identified with aggregative interactions but, rather, with a structural characteristic of the evolutionary process.

In other cases, the reference to the dynamical approach is less explicit; yet, it is quite natural to interpret the authors' commitments within this framework. Take, for instance, Watts et al. (2018). The aim of their article is to explain under which conditions Christianity (conceived of as a "pack" of cultural variants concerning Christian beliefs, rituals and behaviours) evolves, by comparing two alternative hypotheses. The first – supported by so-called top-down theories – explain the spread of Christianity as an effect of powerful actors (think about the role of the Roman emperor Constantine in the rise of Christianity in the ancient world). The second hypothesis – supported by bottom-up theories – conceives of the spread of Christianity as the effect of the appeal of its egalitarian doctrines for underclasses. Top-down theories may be interpreted as explaining the phenomenon under study as the effect of cultural selection due to prestige biases. Bottom-up theories explain the phenomenon as the effect of cultural selection due to content biases and subsequent frequency-dependent selection. Watts and colleagues test the two theories compatibly with this interpretation, finally arguing – based on the analysis of 70 Austronesian societies – that a political structure (and thus selection due to prestige biases) and a reduced population size (which, according to the authors, facilitates the action of frequency-dependent selection) are the crucial factors for a rapid spread of Christian beliefs.

Again, the ultimate explanatory import of this study is that it provides a source law of cultural evolution: we may expect that "packs" of cultural variants analogous to the ones involved in the spread of Christianity will evolve under similar conditions. The model is agnostic about the existence of a privileged level of causation: individual interactions, the functional properties of cultural variants, the structure of populations, and the presence of powerful actors and institutions all compete as possible causes of cultural change.

A final example is provided by Newson and Richerson (2009) on the demographic transition in modern times. The authors conceptualise the phenomenon as the result of conflicting forces acting for and against the maintenance of kin networks. Since they distribute the burden of offspring care, kin networks allow the members of pre-modern societies to raise large families, thus being favoured by natural selection. However, once a kin network-based social structure reaches equilibrium (and, therefore, its members *inertially* transmit certain variants related to the values and norms of such social structure), it becomes vulnerable to other cultural selective forces. This weakens individuals' kin ties and favours non-kin networks – which, in their turn, reduce birth rate. Newson and Richerson characterise these selective forces both from a theoretical and a causal point of view. The forces are mainly selective pressures due to prestige biases – instantiated by the emergence of state institutions – and due to content biases – instantiated by the decline in the social rewards associated with getting married and becoming a parent, and the relaxation of the social sanctions against promiscuity, adultery and divorce. As a test for corroborating the causal interpretation of the evolutionary dynamics, Newson and Richerson compare different societies at different stages of demographic transition and – as expected from a model assuming a dynamical framework – identify similar invariant factors (concerning religiosity, nationalism and gender norms).

5. The foundational role of the dynamical framework

In the last two sections, I have argued that it is not possible to supply distribution explanations of cultural evolution without taking into account population-level causal descriptions of cultural change. I have therefore argued that it is for this reason that cultural evolutionists find profitable to conceptualise cultural change within a dynamical framework. Yet, previously (section 3), I conceded to Lewens that many models concerning the evolutionary origins of cognitive biases – and, more in general, the conditions that allow for certain cultural dynamics to emerge – are provided in aggregative terms. How should we interpret these apparently divergent stances?

One simple answer may be that the dynamical and the kinetic approach provide two complementary strategies of model building, dealing with two different aspects of cultural evolution. Consequently, the choice between the two frameworks should be made on a case-by-case basis, depending on the specific aspect of cultural change to be modelled. In this perspective, if our goal is to clarify the relation between cultural evolution and our genetically evolved psychology, then we shall adopt (at least in principle) a kinetic approach. Otherwise, if we aim to understand the behaviour of the population as a whole and explain its changing composition through time, we will opt for a dynamical approach.

I do not see anything properly wrong with this kind of pluralist interpretation. It is, indeed, well supported by my previous discussion. Nevertheless, I think that it is somehow incomplete and dismissive. To start with, cultural evolutionary theory is not just a collection of separately constructed models. As many other theories, also cultural evolutionary theory arguably displays something like a characteristic *structure*. I do not mean to say that such a structure is, at present, neatly defined: after all – everybody agrees – cultural evolutionary theory is still a developing theory. Yet, cultural change is commonly treated, in cultural evolutionary literature (Cavalli-Sforza and Feldman 1981; Boyd and Richerson 1985; Durham 1991; Mesoudi 2011; Henrich 2016), as a unitary subject. This would suggest that models concerning different aspects of cultural evolution are in some way connected within the theory.

The pluralist interpretation sketched above presupposes that the aspects of cultural evolution that are accounted for by, respectively, the dynamical and the kinetic approach are equally fundamental. This is, in my opinion, not the case. As corroborated by most metatheoretical reconstructions in the semantic tradition – and, more specifically, in the context of metatheoretical structuralism (Balzer et al. 1987) – scientific theories are hierarchically organised entities. This does mean that, usually, some elements of the theory (a model, a law, a heuristic principle) play a more fundamental role with respect to other, more peripherical, elements. Now, if we look at the original formulations of cultural evolutionary theory – such as Cavalli-Sforza and Feldman (1981) and Boyd and Richerson (1985) – we can appreciate that this theory does not constitute an exception. Both expositions focus, from the outset, on the characterisation of culture as a coevolutive inheritance channel. By doing this, they put a special emphasis on the fact that culture is a *process* (see section 2). Take, for instance, the following excerpt: “The dynamics of the changes within a population of the relative frequencies of the forms of a cultural trait under defined cultural interactions is the subject of this book” (Cavalli-Sforza and Feldman 1981, p. 5). Analogously, Boyd and Richerson state: “First, the theory should predict the effects of different structures of cultural transmission on the evolutionary process” (Boyd and Richerson 1985, p. 2).

Consequently, both expositions of the theory proceed by listing the forces of cultural evolution and modelling their effects on different populations. Of course, this goal – which roughly corresponds to providing what we have called *distribution* explanations of cultural phenomena – cannot be fully attained without a detailed evolutionary understanding of how we humans think and interact – that is, without *origin* explanations of social behaviours. As a matter of fact, especially Boyd and Richerson (1985) cite substantial empirical evidence – supplied, mainly, by psychological studies – supporting the characterisation of the social learning biases postulated by the theory, and a great deal of effort has been devoted since then to the same goal. However, the expositive strategy followed by the seminal writings of Cavalli-Sforza, Feldman, Boyd and Richerson suggests that the analysis of social learning biases is subordinate and instrumental to the explanation of the evolutionary process involving changes in cultural variant distributions.[9]

This is, in an important sense, what makes cultural evolutionary theory different from other evolutionary theories of culture, such as evolutionary psychology, which conceives the evolution of our cognition as a goal in itself. Evolutionary psychologists maintain that cultural phenomena can be almost exhaustively accounted for in cognitivist terms, that is, by explaining the way in which our psychologies adapt themselves to the environment and to other's beliefs and behaviours. This is precisely what dual-inheritance theorists and mainstream cultural evolutionists challenge (Brown and Richerson 2014; Richerson 2017). Cultural evolutionary theory is not merely an extension of evolutionary psychology (as somewhat suggested by Lewens 2015, chap. 8). It is an attempt to embed our knowledge about our evolved psychology in a broader theoretical framework concerning culture as a dynamical phenomenon. The interpretation of culture as a dynamical process – supported by the Newtonian analogy – is not accessory to cultural evolutionary theory but, very much on the contrary, it is the constitutive principle that guides any development of the theory.[10]

By stressing the conceptual dependence, in cultural evolutionary theory, of the models providing origin explanations from the models providing distribution explanations, I absolutely do not intend to lessen the explanatory value of the former. Still, I think that – since origin explanations are typically supplied in kinetic terms, while distribution explanations are provided in dynamical terms – this conceptual dependence has a crucial consequence for the proper depiction of the relation between the dynamical and the kinetic approach in cultural evolutionary theory. We can express it as follows.

Cultural evolutionary theory offers, by adopting a Newtonian approach, a general framework in which the causes of cultural change can be accommodated together so as to provide a unified picture of cultural evolution. The models providing origin explanations enrich this picture by specifying how social learning biases have evolved in our species, and how individuals endowed by these biases interact in order to implement *some* of the characteristic dynamics of cultural change (i.e., those whose overall effects are dependent on the action of social learning biases). The information obtained from these kinetic models is incorporated

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[9] A similar conception arguably underlies Durham (1991) and Mesoudi (2011) as well.

[10] That is, it is something akin to what metatheoretical structuralists call a "guiding-principle" (Moulines 1984).

into dynamical models that, by taking into account other forces instantiated by non-aggregative factors (see section 4), allow to formulate distribution explanations of cultural change and specific source laws. From this point of view, the causal decomposition that the kinetic approach promotes is nothing more than an attempt to open the black box of a *subset* of the forces of cultural evolution. Differently from the Newtonian analogy, which plays a foundational role with respect to the whole cultural evolutionary theory, the kinetic analogy is just a strategy of model building with a specific domain of application.

6. Conclusion

In this article, I have discussed the significance and scope of two recurrent analogies in the literature on cultural evolutionary theory: the Newtonian analogy, which compares cultural evolutionary theory to a theory of forces, like Newtonian mechanics; and the kinetic analogy, which compares cultural change to a thermodynamic phenomenon, fully explainable as the result of myriad of interactions between its components. My starting point has been to deny that the kinetic framework is able to account for all cultural evolutionary models. By relying on Godfrey-Smith (2009), I have distinguished between two kinds of explanation in cultural evolutionary theory, that is, origin explanations and distribution explanations. They respectively aim to account for the emergence of cultural dynamics (with special emphasis on the cognitive conditions necessary for it) and for the change in cultural variant distributions. After having related the Newtonian (or dynamical) and the kinetic analogy to two different interpretations of population thinking, I have argued that only the dynamical framework can properly account for distribution explanations in cultural evolutionary theory.

Understanding the evolutionary roots of our social learning abilities is, of course, fundamental to the knowledge of how the dynamics of cultural change are implemented in the human species. Still, it is not enough to characterise cultural change as a whole, since – as argued – there are more than individual interactions in cultural change. In this sense, the dynamical interpretation is more general. It provides an explanatory scheme that can be completed by adding the details concerning the psychological processes underpinning cultural dynamics, as well as other potential causes of change. It does so without any prejudice concerning a privileged “level” of causation. Accordingly, it provides a sufficiently broad framework to further develop the project of a more comprehensive evolutionary synthesis for the social sciences, like the one advocated for by many cultural evolutionists.

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