The Many Faces of Generalizing the Theory of Evolution[*]

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Abstract

[35] Ever since proposals for generalizing the theory of natural evolution have been put forward, the aims and ambitions of both proponents and critics have differed widely. Some consider such proposals as merely metaphors, some as analogies, some aim at a real generalization and unification, and some have even proposed to work out full reductions. In this paper it is argued that these different forms of generalizing the theory of evolution can be systematically re-framed as different approaches for transferring justification from the natural to the cultural realm, and that their differences are basically a matter of degree. With the help of such a classification it should be come clearer what to expect, but also what *not* to expect from the different approaches.

Keywords: cultural evolution, generalized Darwinism, indirect evidence, analogical reasoning, unification, reduction

1 Introduction

Classical mechanics provided an overarching and unificatory framework for modern physics. Likewise, the theory of evolution provided such a framework for modern biology. The changes in theory and model building, the rearrangement of knowledge, but also the restructuring of scientific institutions and curricula which came along with it are important causes of the fact that nowadays biology is one of the most advanced and leading branches of the natural sciences. Success attracts, for which reason quite early on influential social scientists aimed at embedding their research into a broader scope of evolutionary thinking:

> "Whether the adjective 'biological' be used or not, the principle of evolution is firmly established as applying to the world of living

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things. Here the social aspect of human life must be included. Such basic concepts of organic evolution as variation, selection, adaptation, differentiation, and integration belong at the centre of our concern, when appropriately adjusted to social and cultural subject matter." (Parsons 1966, p.2)

Success also increases confidence, for which reason biologists themselves popularized the idea of expanding the theory of evolution beyond the boundaries of biology: "Darwinism is too big a theory to be confined to the narrow context of the gene" (Dawkins 1976, p.191). Ever since proposals of generalizing the theory of natural evolution have been put forward, the motives, aims, and ambitions of both proponents and critics have differed widely. Some consider such proposals as nice-to-have metaphors (cf. Gould 1988), some as analogies (cf. Dawkins 1976), some aim at a real generalization and unification (cf. Mesoudi 2011), and some have even proposed to work out reductions (cf. Wilson 1975).

In this paper we provide a systematic classification of such diverse approaches to and [36] critiques of a generalized theory of evolution. For this purpose we propose a framework of classification which reduces the different background motives, aims, and ambitions to one single factor that is shared by all these forms of relating natural and cultural evolution, namely that of *transferring justification*.

According to our understanding, what is most relevant in the metaphor-, analogy-, generalization-, and reduction-talk is its different estimation regarding transferring justification. The idea is as follows: By such a talk a *source* system like natural evolution consisting of hypotheses, models, and theories H' and evidence E' is linked to a *target* system like cultural evolution consisting of the respective hypotheses, models, and theories H and evidence E. Theory building and unification within the source system was successful in justificatory terms. And so, by linking the target with the source system, proponents of such a linking hope for some transfer of success. Such a transfer is about properties of and relations between H', E' like the certainty of H', the degree of unification of H' or the confirmation of H' by help of E'. And since by such a transfer the certainty/unification/confirmation of H' in the light of E' is intended to be employed for increasing that of H in the light of E, it is natural to consider the problem of transferring justification as a problem of employing *indirect evidence* in the sense of using properties of H', E' as indirect evidence for properties of H, E.

The plan of our investigation is as follows: In section 2 we discuss different ways of employing indirect evidence by bringing together models of philosophy of science in a very selective way, which is intended to suit our later applications. As we will see, the differences in the metaphor-, analogy-, generalization-, and reduction-talk about transferring justification and employing indirect evidence is a matter of degree. Afterwards, in section 3 we will come to the application of our conceptual framework to the different approaches of extending evolutionary theory to the cultural domain and provide a systematic classification of different proposals for and critiques of generalizing the theory of evolution. We conclude in section 4.

2 Justification Transfer: Indirect Evidence

Typically, evidence is to be considered anything which can be used to confirm or disconfirm a hypothesis H. In this section we differentiate several further forms and grades of confirmation by indirect evidence which, as we will see afterwards, were more or less explicitly discussed as covering the relation between natural and cultural evolution.

2.1 Metaphor

A metaphor is a figure of speech. Very roughly and selectively speaking, the role of metaphors basically consists in carrying over parts of the meaning of one expression into another context. In conveying abstract ideas and for purposes of exploration, metaphors have always played a role in biology. So, e.g., the "tree of life" is obviously not a real tree. In general, the field of genetics is full of metaphorical elements (Leslie 2012). One actual example would be that the information contained in the DNA is "read" by the polymerase enzyme during the process of cell copying. One could provide many other examples, like the four DNA nucleotides (A, T, C, G), often referred to as "letters" or "genetic alphabet" or the protein-synthesizing parts of the genome of an organism being a "code" for the phenotype.

For our purposes it is important to stress that metaphors in this loose sense of carrying over meaning are thought to provide no justification whatsoever for the target context. Rather, metaphors can be seen as a step of discovery in the process of *understanding* the world.

To put it in more general terms: according to this skeptical stance regarding indirect [37] evidence, such "evidence" might be instructive for the context of discovery and exploration, but it does not allow for transferring justification from a source context to a target context and, hence, there is no indirect evidence.

2.2 Analogy

Sometimes analogies are also used to make skeptical claims about indirect evidence. This is particularly the case when analogies are described as so-called *programmatic analogies* which serve only as a heuristics for the context of discovery (cf. the discussion in Bartha 2020). However, already in early approaches to confirmation one finds the idea of employing indirect evidence in the form of analogies for confirming hypotheses (cf. Carnap 1950/1962, §110.D; Hesse 1966). This approach to confirmation by analogy was recently revived by models for so-called *analogue simulation* which one finds in natural science and engineering. The idea of analogue simulation is to study hypotheses H about a target system where one lacks evidence E due to practical, theoretical, or ethical reasons by help of a source system, whose hypotheses H' are known to be at least partially structurally similar, and where evidence E' is available. Models of analogue simulation try to reconstruct how indirect evidence E' of a source system can be employed for (indirectly) confirming hypothesis H of the target system. For this purpose, Dardashti, Thébault, and Winsberg (2015) propose a Bayes net model of analogue simulation by using a common cause structure as depicted in figure 1, where the variable X should stand for a claim about the relevance of structural similarity of H and H'. They argue that if analogue sim-

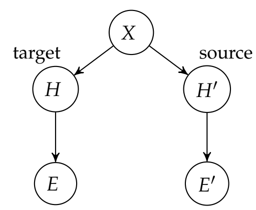

Figure 1: Bayes net model underlying several forms of indirect confirmation: H and E are random variables about possible states of a target system (representing hypotheses and evidence). The same holds for H' and E' with respect to a source system. X is a random variable linking both systems. The arrows allow for representing important probabilistic independencies like screening off (Spirtes, Glymour, and Scheines 2000).

ulation can be embedded in a Bayesian network like this and if further plausible conditions hold, then there is probability flow between E' and H which can be employed for indirectly confirming H by help of E': $P(H|E') > P(H)$. In this sense, analogies might be used not only as heuristics for discovering relevant H and E, but also for confirming some hypothesis of the target domain by means of evidence in the source domain.

Clearly, whether one gets such models to work for a particular case depends a lot on whether one can argue for the relevant features of X. However, we think that, firstly, if analogies are used not only for making justified predictions, but also for rationally reconstructing in fact established scientific confirmatory practice, then such a model might be a handy tool for a rational reconstruction. Secondly, this model might be expanded to a more complex model which might allow rational reconstruction of other well-established practices in which scientists consider a hypothesis about a target system to be confirmed by or via indirect evidence (cf. the different types of analogies covered by such a model in Feldbacher-Escamilla and Gebharter 2020).

As an upshot of our short discussion we think that establishing relations of analogy allows for transferring justification from the source to the target. But this remains a very weak form of confirmation, with many uncertainties (via X). [38]

2.3 Generalization or Unification

Since in the debate of cultural evolution the terms ‘unification’ and ‘generalization’ are used in a very similar manner, we follow this implicit convention and use them interchangeably. Typically, unification is related not to indirect evidence, but to direct evidence. However, one can also introduce the idea of employing indirect evidence in generalization and unification as follows. Assume a structure similar to the Bayes net in figure 1, but this time read the arrows not only as relations of probabilistic dependence, but as strict deductive relations connected with accompanying probabilistic dependencies. So, we assume that X is a strictly unifying theory, which means that $X \vdash H$ as well as $X \vdash H'$. Then, given the structure of the Bayes net with the implied independencies and the non-extremity of our probabilistic estimation of the unified theory X, there is probability flow between H and H'. This probability flow can be used for indirectly (via X) confirming H by help of H' and the other way round, i.e. for establishing mutual confirmation between H of the target and H' of the source system. The reasoning is as follows: H' is confirmed by E'. This allows for confirming X based on the confirmational impact of E' on H' and this in turn can be used for confirming H on the basis of the confirmational impact of E' on X. Hence, in the end E' as well as H' has confirmational impact on H, as well as E, only that the latter is direct evidence.

Employing H' of the source system for indirectly confirming a hypothesis H of the target system via unification as described here allows for better justification transfer than doing so by help of analogical reasoning. This is the case since the “paths of the probability flow” are much stronger in the former than in the latter case. It is easy to see that, all else being equal, the higher the conditional probabilities along the paths are (i.e. $P(X|H), P(X|H')$), the higher the confirmational impact of H' on H will be. Whereas in the case of analogical reasoning X and its relevance for H and H' is quite uncertain, in the case of unification as described here the relevance of X for H and H' is clear: H and H' are simply consequences of the more general X.

2.4 Reductionism

In philosophy of science, reductionism has a long tradition and has been characterized in many different ways. For reasons of simplicity in our typology, we focus here on classical *theory reduction* only, where a hypothesis or theory H is reduced to another hypothesis or theory H', if H' logically or analytically entails H (e.g. biological theory reduces to physical theory). Given a deductive-nomological account of explanation (Hempel 1965), theory reduction as deduction from theoretical principles is an instance of explanation. In particular, in case of reduction, H' logically or analytically entails and explains the laws of H.

Reduction also provides the strongest form of employing indirect evidence. Due to the reduction the hypothesizing-part of the target is eliminated or at least its independent role vanishes. Here is how it works: Assume, again, the two domains, one of the target system and one of the source system. As in the case of confirmation by unification we assume that evidence and hypotheses are strictly related via deduction: $H \vdash E$ and $H \vdash E'$. However, now we know furthermore that, given some bridge principles or so-called *coordinating definitions* B', H can be strictly reduced to H', i.e.: $\{H', B'\} \vdash H$. Given the coordinating definitions are analytic, the schema amounts to that of unification (figure 1) with $X = H'$, i.e.: $E \longleftarrow H \longleftarrow H' \longrightarrow E'$. Now, since the arrows are all aligned in one direction from H' to E and from H' to E', both cases of evidence are now direct. The special case of elimination results from this picture if H is skipped.

By reducing the target to the source, there is no need of introducing a more general theory X. Rather, all that is necessary for linking the [39] target to the source is provided already by H' (and analytic coordinating definitions). In comparison to unification, all evidence (E, E') is direct evidence and hence allows for even more confirmation. For a general overview of reductionism in biology see Brigandt and Love (2017) and Rosenberg (2006).

2.5 Intermediary Summary

Let us briefly sum up the framework we want to employ for discussing the different approaches to justification in cultural evolutionary theory: the problem is about relating evidence, hypotheses, models, and theories about a target system to evidence, hypotheses, models, and theories about a source system. The most skeptical stance claims that this relation does not exceed metaphorical parlance, which brings no transfer of justification from the source to the target with it. According to this stance, there is no indirect evidence, or such evidence cannot be employed. The position that there are analogies between target and source is stronger, allowing for at least some transfer of justification. Quite advanced is the approach of finding a unified theory or framework, which includes greater transfer of justification not only at the very particular, but also at a much more abstract and general theoretical level. And finally, there is the very difficult program of reductionism which aims at the strongest form of justification transfer by strengthening and enriching the source in order to incorporate seemingly indirect evidence as direct evidence. Figure 2 provides an overview of the relevant confirmational or justificatorial relations.

In the next section we use this framework to provide a systematic typology of current debates in cultural evolution.

3 Indirect Justification in Cultural Evolution

Theories of cultural evolution, dual inheritance theory, universal or generalized Darwinism have been discussed in the sciences (in evolutionary biology, archaeology, anthropology, linguistics, economics, the social and the cognitive sciences) and philosophy (of science or of the mind) for decades, with an overwhelming body of literature from various domains and subdomains.

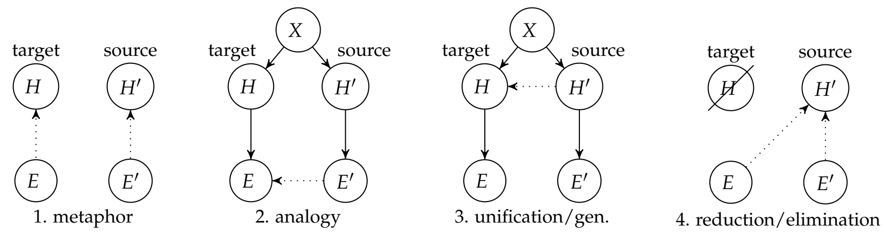

Figure 2: Different approaches to confirmation by help of indirect evidence: The solid arrows represent probabilistic information as described in figure 1. The dotted arrows represent confirmational/justificational relations. In case of a metaphor, indirect evidence (e.g., E' for H) has no confirmational force. In case of an analogy there is indirect confirmation, but it is on a lower level only and weak due to a loose relation between target and source. In the case of unification, the relation of indirect evidence is much stronger and possible also at a more abstract level. Finally, in case of reduction or elimination, indirect evidence turns to direct evidence.

Obviously, this paper cannot address them all and provide a full encyclopedic classification of all positions (or critiques) of the many-faceted debate(s). The conceptual frameworks are often different, as is the identification of the central phenomena to be explained, but in the last years, some excellent overviews have been published (Henrich 2016; Mesoudi 2011; Schurz 2011).

[40] Since we do not want to take a stance in this paper concerning the scientific or philosophical value of the different approaches that we are going to present, the reader will not find a recommendation as to which of them should be favored and for what reasons. Unlike in physical theories, for example, transfer of (indirect) evidence is especially challenging to establish in the field of generalized Darwinism, since cultural and biological evolution differ in many empirical aspects. Gene-based properties do not change during the life of an organism for example, while cultural evolution tends to be rapidly changing and fluctuating. Cultural traits are not for the most part instantiated in discrete information packages like genes in DNA, and guided variation and blending inheritance rarely occur in biological evolution while they seem to be the standard case in cultural evolution. Biological lineages of descent tend to form “trees”, where the “branches” rarely reunite, while horizontal transmission between cultural populations is one of the strongest forces in complex modern societies. Fetzer (2005) documents further essentials concerning the differences between genetic and biological evolution.

In what follows, we will try to identify and describe some important or classical approaches against the background of our typology of metaphor, analogy, unification/generalization and reduction. It might be used to investigate and classify those many positions within past debates which we were unable to address here.

3.1 Metaphor: The society as an "organism"

Thomas Hobbes named his ideal absolutistic state "*Leviathan*" (1651), a metaphorical allusion to a giant biblical-mythological creature, but the "state/society as (super-) organism" metaphor can be found in various (scientific or popular) domains since ancient times. Even classical notions of "culture" in anthropology like that of Kroeber (1952) build on the "superorganic" picture. Our everyday language use is full of such semantic elements. We call the city in which the government has its seat "capital" (from Latin: "caput" = head), or the executive power the "arm of the law". An old German concept for *society* that has a negative connotation today is "Volkskörper" (German: "Volk" = people, "Körper" = body), which brings us closer to the framework of *Social Darwinism*. This dubious, desultory "body" of theories with proponents such as Herbert Spencer or Ernst Haeckel from the late 19th and early 20th century "embodies" this metaphor. A book by Spencer is entitled "The Social Organism" (1892). For him, evolution revolves around the process of aggregating matter inherently driven towards complexity and perfection—in the case of society, populations of human beings and the structures that organize people as "superorganic phenomena" (cf. Turner, Beeghley, and Powers 2002). Even though Spencer proposed many specific propositions and guidelines for a science of society, his concepts are just metaphors, because they do not transfer real justification from theories of the biological organism to theories of society and vice versa. Spencer did not know much about biology and some of his interpretations of Charles Darwin were not correct (e.g. that evolution naturally leads to more perfection). Furthermore, Social Darwinism is under the strong suspicion of committing naturalistic fallacies.

In a different context, we also find many metaphors in *memetics* (the "science" of *memes*). Some passages in Blackmore (1999) but also the idea of a meme (a cultural unit of transmission) as a "virus of the mind" used by Dennett (1995, pp.342) are clearly metaphorical, which the authors play with suggestively. A clear investigation on memes by Gatherer (1998) bears the title: "*Why the Thought Contagion* Metaphor *is Retarding the Progress of Memetics*" (our italics). [41] However, there are also cases in the cultural evolutionary literature where memes are used as an analogy, as the next subsection will show.

3.2 Analogy: Genes and memes as replicators

Darwin himself—as one of the pioneers of evolutionary thinking—builds heavily on analogies to human societies in his work, often to make his ideas more vivid to the reader (cf. Millman and Smith 1997), but also to increase justification. He compares biological species with human languages, for example (Darwin 1871/2003, p.90):

> "The formation of different languages and of distinct species, and the proofs that both have been developed through a gradual process, are curiously parallel [...]. The survival or preservation of

> certain favoured words in the struggle for existence is natural selection."

In fact, Darwin introduced his main hypothesis as analogous to Thomas Malthus' theory of economical and population growth, according to which human population growth will eventually outpace agricultural production, leading to famine and starvation—the "Malthusian catastrophe"—unless some kind of birth control will be established. Darwin came upon his theory of selection while reading Malthus' *Essay on Population*. According to his reasoning and observations, "struggle for existence" appears equivalently in both domains, leading to a selection of the best fitted variants. He summarized the crucial steps in his thought in a letter to Wallace, emphasizing the great importance of Malthus' theory (Young 1971, p.454):

> "[...] I came to the conclusion that selection was the principle of change from the study of domesticated productions; and then, reading Malthus, I saw at once how to apply this principle."

So much for employing an analogy for transferring justification from the social (source) to the biological (target) realm. What is more important for us, is reasoning of this sort the other way round: Zoologist Richard Dawkins coined the term "meme" as an analogy to "gene", emphasizing that both are *replicators* (opposed to "vehicles" such as bodies). He writes (Dawkins 1976, p.191):

> "I think Darwinism is too big a theory to be confined to the narrow context of the gene. The gene will enter my thesis as an analogy, nothing more. What, after all, is so special about genes? The answer is that they are replicators."

The replicator-vehicle or replicator-interactor view on evolution (Hull 1988) goes beyond metaphor, because *if* replicators are real existing objects that can be studied scientifically, at least some (small) amount of justification can be transferred from genetic to memetic evolution and vice versa, namely the statement that both are driven by replicators and that evolution can be found in different domains. Since Dawkins was indeed the founding father of the term "meme" (a concept which proved to be a good meme itself), let us quote him a second time. That Dawkins is fully aware of the difference between *metaphor* and *analogy* is revealed in this passage, where he uses both terms next to each other (Dawkins 1976, p.196, our italics):

> "Let us pursue the *analogy* between memes and genes further. [...] Just as we have found it convenient to think of genes as active agents, working purposefully for their own survival, perhaps it might be convenient to think of memes in the same way. [...] In both cases the idea of purpose is *only a metaphor* [...]. We have even used words like 'selfish' and 'ruthless' of genes, knowing full well it is only a figure of speech. Can we, in exactly the same spirit, look for selfish or ruthless memes?"

Perhaps looking in this direction was not Dawkins best idea, because it entails a very replicator-centred view on evolution, which—at least in the case of cultural evolution—might be totally misleading. As Henrich, Boyd, and Richerson (2008, pp.124) show, the idea that replicators are necessary for cumulative adaptive evolution is simply wrong [42], although it has been echoed by scholars such as Aunger (2002), Blackmore (1999), and Dennett (1995), leading to much confusion in the field. After all, no discrete mental representations are transmitted during cultural evolution but cumulative evolution still occurs, for example through "success-biased blending mechanisms," argued with vivid examples and models in (Henrich, Boyd, and Richerson 2008, p.125; Feldbacher-Escamilla and Baraghith 2020).

Replicators are sufficient but not necessary for cultural evolution. The gene-meme analogy can be considered to transfer justification in a loose sense, because it has to be shown in which cultural domains exactly we have replicator-driven evolution and in which we do not. Furthermore, disputes have raged concerning the nature of a meme—is it an idea, behavior, artifact, neuronal pattern, unit of information or all at once? Up to now, no consensus has emerged.

In a nutshell: Dawkins produces the concept of a meme (E) as a kind of replicator (X) in cultural evolution (H) and *supports* it with genetic (E') background knowledge from biological evolution (H').

3.3 Unification/Generalization: A variety of approaches

In a generalization one often provides a mathematical model or framework integrating both the source as well as the target domain. Successful scientific generalizations or "unifications" were often major steps in scientific development.

A crucial scientific event of that kind was the "modern evolutionary synthesis" in the first part of the 20th century (Huxley 1942/2010). Historically, it was triggered by early proponents of population genetics, such as Ronald Fisher. He showed mathematically that continuous phenotypic variation, such as height or eye color, could arise from the recombination of multiple discrete genetic alleles. This confirmed Gregor Mendel's experimental demonstration that biological inheritance is particulate. In a series of textbooks published by evolutionary biologists such as Theodosius Dobzhansky, Ernst Mayr and Julian Huxley, the results of population genetics were used to reestablish Darwinian selectionist evolution (which faced a severe crisis in the late 19th century, due to Darwin's incorrect understanding of the biological inheritance mechanism, which he thought of as "blending inheritance"). The result was a scientific generalization of the term "evolution", integrating and unifying Darwin's idea of natural selection and Mendel's ideas on heredity within a joint mathematical framework.

A unified approach like the modern synthesis transfers confirmation from one domain to another by providing a new unified theory, which entails both as outlined in section 2.3. Given the modern synthesis, natural selection explains observations of patterns of genetic differences in recent populations (adaptations) and these genetic changes in turn explain the theory of evolution by natural selection. It is a win-win situation for both theories because genetics (H'), which explains the biological micro-level of allelic variations (E') and the theory of speciation by natural selection (H) which explains the macro-level of biological species (E) are now unified in the modern synthesis (X) that can explain E and E'. Via X, H and H' mutually confirm each other. Speciation by natural selection, once considered a hopeless and unverifiable speculation about biological history, became predictable and testable in light of the modern synthesis.

Likewise, generalizing Darwinian principles to the cultural domain requires a carefully spelled out background theory and precise models, which allow us to create genuine new knowledge, describe and predict the systems under study, and provide a better understanding of both domains—biological and cultural evolution. [43] Proponents (and critics) of "generalized Darwinism" have long agreed that analogies are too weak to fulfill the tasks listed above. For instance, Aldrich et al. (2008, pp.579) write:

> "What is the difference between *analogy* and *generalization*? With an analogy, phenomena and processes in one domain are taken as the reference point for the study of similar phenomena or processes in another domain. Differences are regarded as dis-analogies. On this basis, for example, social evolution is clearly dis-analogous to genetic evolution, because of the very different entities and mechanisms of replication. [...] Generalization in science starts from a deliberately copious array of different phenomena and processes, without giving analytical priority to any of them over others. Where possible, scientists adduce shared principles."

For proponents of (this kind of) generalized Darwinism, one ought not compare similarities of "phenomena" (analogy), but instead create an abstract formal model that can serve as explanandum for both domains of inquiry. Even if one totally agrees with this claim, it seems that Aldrich et al. (2008) fail to give a precise instruction on how to realize that exactly. The problem is that even if one has a background model or theory in mind, re-specifying it in different domains actually *forces* one to compare phenomena again. Otherwise, there is no way to justify the choice of one's model over others. The modern synthesis was successful, not because it was more abstract or more properly formalized mathematically, but because its assumptions and predictions matched with real-world data. For critics and skeptics in the field, like philosopher of biology Thomas Reydon (Reydon and Scholz 2014), generalized Darwinism has hitherto failed to do that. We do not think, that this is actually the case and that this skeptical approach falls short. In fact, there are (at least) five larger domains of inquiry, where generalized Darwinism (although sometimes not called by this very name), is already quite successful across a range of scientific disciplines and methodologies:

(X_a) evolutionary game theory

(X_b) population dynamical studies

(X_c) phylogenetic methods

(X_d) developmental approaches

(X_e) and information theory

For reasons of space, we can only provide a very sketchy overview here. We offer ten positions of different versions of generalized Darwinism, whose approaches differ slightly in nuances, models and concepts:

1. Geneticists Jablonka and Lamb (2000), strongly emphasize the causal role of *development* in evolution. They open up four dimensions of developmental processes in their book, that can fulfill the requirement of bearing the predicate "evolutionary". These four levels are (i) genetic, (ii) epigenetic, (iii) behavioral and (iv) *symbolic* inheritance, where (iv) explicitly addresses sociocultural phenomena in human cultural evolution, like languages and institutions.

2. Proponents of the "extended evolutionary synthesis."Pigliucci and Müller (2010) embed symbolic or cultural evolution (i.e. "inclusive inheritance") within a larger conceptual framework intended to extend the scope of the "modern synthesis", also integrating developmental and environmental features, which the modern synthesis failed to address.

3. Hodgson and Knudsen (2006) and Aldrich et al. (2008) try to implement generalized Darwinian thinking in economics and organizational sciences.

4. Mace and Holden (2005), Tehrani and Collard (2013), and O'Brien and Lyman (2003) apply *phylogentic methods* in their empirical studies on languages, customs, and archeology, focusing on transmission mechanisms of material culture in different societies across the globe.

5. Mesoudi (2011) argues for the potential of generalized Darwinism and cultural evolution to provide a unified overarching framework and thereby "synthesize" the social sciences. [44] This approach must not be confused with the extended evolutionary synthesis, although both plan a "synthesis," since the first deals mainly with the social sciences, while the second mostly with biological phenomena. There are interesting intersections, such as "inclusive inheritance".

6. Classical proponents of cultural evolution, like Boyd and Richerson (1988), Cavalli-Sforza and Feldman (1981), and Creanza, Kolodny, and Feldman (2017), provide interpretations of cultural dynamics with population dynamical models from biology and also identify several specifics of cultural evolution such as *guided variation* or several kinds of *biased transmission*.

7. Sperber (1996) and his group argue for the use of *epidemiological models* instead of population dynamics. Their explanatory value is estimated to be higher as most cultural change is not really driven by replication, but (rational) reconstruction and interpretation.

8. Authors like Distin (2011) subsume cultural and biological evolution under a framework with even larger scope, namely "information theory".

9. Formal philosophers like Skyrms (2004; 2010), Huttegger (2007) and Huttegger et al. (2009) model the evolution of human altruism, moral norms, the "social contract" or the evolution of meaning and semantics within evolutionary game theory.

10. Philosophers of science like Schurz (2011) argue for a "generalized theory of evolution" as a powerful interdisciplinary framework, showing how theorems of population dynamics (6) and evolutionary game theory (9) can seamlessly be transferred into each other.

This list is far from complete, but we suggest grouping these ten versions of generalized Darwinism into five (not necessarily exclusive) types of generalization.

(X_a) The first family is "evolutionary game theory" (9, 10). This is a very well established field with many applications in biology, economics, and the social sciences. Tracing back to John Maynard Smith (1982), it models strategic interactions between two or more "players" against a background of selection, reproduction and strategy variation. The players can be genetic alleles, organisms or social groups, and the strategies can be any kind of behavior that can be transmitted and proliferate in a population.

(X_b) The second can be labeled "population dynamics" (3, 5, 6, 10). Population dynamics offer a mathematical framework from the time of the modern evolutionary synthesis. An introductory overview can be found in (Mesoudi 2011).

(X_c) The third family are "phylogenetic models" (4, 5). Here we mean lineage-based investigations that result in "trees" of cultures, where different phylogenies represent different probabilistic assumptions about past developments.

(X_d) The fourth family consist of "developmental approaches" (1, 2, 7). Here emphasis lies more on other biological domains than (population) genetics, such as cell-theory, ecology, epidemiology and developmental biology.

(X_e) The fifth can be called evolutionary "information theory" (8, 9). Although authors from almost all positions refer to "information", "cultural information", "information transmission" and so forth, they rarely define this concept or build their generalization on it explicitly. However, since information is a quantitative concept that can formally be modelled, this approach seems very promising.

Depending on the single X_i (X_a,..., X_e), each of these types of generalization or unification is intended to transfer justification between the respective particular cultural (H_i) and natural (H'_i) models. Although all of them are united by their generalizing/unifying methodology, they very much differ with respect to the details of spelling out X_i, H_i, H'_i. [45]

3.4 Reduction: Sociobiology and evolutionary psychology

Within a Darwinian framework, people can acquire information through genes, individual learning or social transmission, where the latter calls for cultural evolutionary theories. However, there have also been attempts to explain human sociocultural events not only in biological terms and models, but simply as *biological*. This nears a kind of reductionism, giving an almost exclusively gene-centered view of human heredity and evolution, one that minimizes the role of cultural construction and cultural evolution and abstracts away from their effects on the genetic evolution of human behavior.

There are two different domains of research that focus on explanations of human behavior in terms of genetically evolved adaptations. The first is classical sociobiology. The second is evolutionary psychology.

Dennett (1995, p.453) suggested that Hobbes was in fact the first sociobiologist because he explained the origins of morals in human society from an amoral sociobiological perspective in the *Leviathan*. However, the term "sociobiology" was popularized by Edward O. Wilson (1975) with his famous book *Sociobiology: The New Synthesis*. Note that we mention *four* completely different versions of an evolutionary "synthesis" in this paper: the modern synthesis, the vision of generalized Darwinism "synthesizing the social sciences" of Mesoudi (2011), the "extended evolutionary synthesis" of Pigliucci and Müller (2010), and the sociobiology of Wilson (1975). In the book, Wilson argues for culture as ultimately being more or less determined by genetic features. Genetic dispositions construct a limited space of possibilities, in which all cultural evolution takes place. If a strong version of sociobiology were true, this would open up a genetic determinism, explanatorily reducing culture to biology. This claim has been the object of a great deal of controversy within biology and between different disciplines and is very hard to defend (cf., e.g., Schurz 2011, pp.198).

Evolutionary psychology is related to this line of thinking. Researchers in this domain (Cosmides and Tooby 1997; Plotkin 1997) see culture as a colorful and thin veneer spread upon genetically selected, innate, human-specific, psychological mechanisms—so-called "mental modules" (cf. Jablonka and Lamb 2000, p.212). These modules evolved and were completely established in times of our early ancestors in the African savanna. Our uniquely human behavior is the product of Darwinian selection on mechanisms for their creation during brain-evolution. For nearly all cultural features (e.g. our passion for candy consumption and the whole economic industry pleasing this need), there is a more or less plausible evolutionary story like this (Jablonka and Lamb 2000, p.213):

> "[...] our sweet tooth was adaptive in our evolutionary past when high-energy food was in short supply; it is only in today's affluent societies that satisfying our cravings for sweet things has become self-damaging."

In the context of the evolution of cognition, there has also been a lively discussion about the evolutionary architecture of the human brain and even our capacity for logical reasoning as being the product of evolved domain-specific mental modules, while others claim that the human brain works like a "general-purpose mechanism" (cf. Davies, Fetzer, and Foster 1995).

To schematically illustrate this, in this line of thinking one assumes that all social (E) and biological (E') phenomena are ultimately explained by biological theories (H') alone, making social theories (H) more or less redundant. [46]

4 Conclusion

We argued that the differences in the metaphor-, analogy-, generalization-, and reduction- approach to generalized evolution are matters of degree regarding transfer of justification and employing indirect evidence. Metaphorical linking ascribes zero weight to indirect evidence and considers it to be relevant in a context of discovery, but not in a context of justification. Analogical reasoning stresses functional features, but cannot offer a background theory for linking target and source. It does allow for justificatory impact and usage of indirect evidence, although only in a very weak sense. Generalization or unification is based on a background theory linking target and source and has a focus on structural features. This brings real transfer of justification and systematic employment of indirect evidence with it. Finally, reduction transforms indirect evidence into direct evidence and, hence, allows for the strongest form of transferring justification and employing indirect evidence.

These different ways of using indirect evidence were and are still applied in biological theorizing. During the formation of evolutionary theory, in fact, indirect evidence was sometimes used for transferring justification from the cultural to the natural realm. What is more important for our purpose of classification is the reverse direction, namely the employment of indirect evidence from natural evolution for social sciences. The main result of our classification can be summarized as follows:

Type	E.g. Source	E.g. Target	Justification	Adherents
metaphor	organism	society	*none*	Spencer, Gould
analogy	gene	meme	+	Dawkins, Dennett, Blackmore
unification/ generalization	genetic information	cultural information	++	Aldrich et al., Boyd & Richerson, Cavalli-Sforza & Feldman, Distin, Hodgson & Knudsen, Jablonka & Lamb, Mace & Holden, Mesoudi, Schurz, Sperber, Skyrms et al.
reduction/ elimination	gene	culture	+++	Wilson, Plotkin

We have outlined how analogical, unificatory, and reductive transmission of justification might work and how they form a pattern increasing in strength. We think that this conceptual framework allows for a more fine-grained distinction regarding the many approaches to generalizing the theory of evolution. Note that our investigation has only been about classifying such approaches. Whether and which form of justificatory transfer and employment of indirect evidence will be successful is of course not tackled by this: "In the end, the success or failure of [generalizing the theory of evolution] will decide whether memes are just a meaningless metaphor or the grand new unifying theory we need to understand human nature" (Blackmore 1999, p.9). [47]

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