The Many Faces of Generalizing the Theory of Evolution

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- Baraghith, Karim and Feldbacher-Escamilla, Christian J. (2020-11-27/2020-11-28). *The Many Faces of Generalizing the Theory of Evolution*. Conference. Presentation (contributed). Science as a Public Good. Saint Petersburg State University: Russian Society for History and Philosophy of Science (RSHPS).

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- Baraghith, Karim, Feldbacher-Escamilla, Christian J., et al. (2018-01-31/2018-02-03). *The Generalized Theory of Evolution*. Conference. Organization. Facts: est. 70 participants; 6 invited: Daniel Dennett, Eva Jablonka, Ruth Mace, Alex Mesoudi, Thomas Reydon, Brian Skyrms. Conference report in the JGPS. Conference report in The Reasoner. Conference report in Kriterion - Journal of Philosophy. (Programme- and Local Organizing Committee). University of Düsseldorf. URL: http://dclps.phil.hhu.de/genevo/.

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- DFG funded research unit *Inductive Metaphysics* (FOR 2495); subprojects: *Creative Abductive Inference and its Role for Inductive Metaphysics in Comparison to Other Metaphysical Methods* and *Metaphysics of Evolution*.

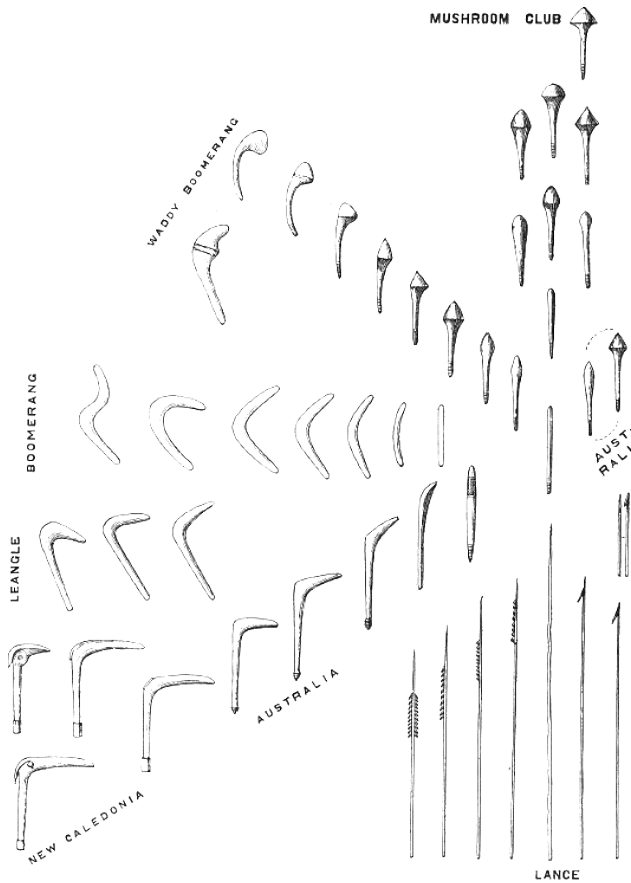
Introduction

Classical mechanics (or the Standard Model of particle physics) provide overarching and unificatory frameworks for modern physics.

Likewise, the theory of evolution (as spelled out in the modern synthesis) provides such a framework for modern biology.

Physicalism: E.g. physical explanation of regularities in chemistry (elements $\Rightarrow$ atomic structure)

"Biologization": E.g. biological explanation of sociological phenomena (family structure $\Rightarrow$ genetics of parental care)



Introduction

Evolutionary biologists popularized the idea of expanding the theory of evolution beyond the boundaries of biology already from the beginning on.

One of the first was, e.g., Herbert Spencer with his Social Darwinism.

Key for the contemporary debate is Richard Dawkins with his Memetics:

> *"Darwinism is too big a theory to be confined to the narrow context of the gene" (Dawkins 1976, p.191)*

Generalizing the theory of evolution had and still has many faces:

- metaphors — analogies
- unifications/generalizations — reductions

We will use 'indirect evidence' as an umbrella term for them.

Aim of this talk: Provide a landscape of different approaches of generalized evolution with regards to the role of indirect evidence.

Contents

Justification Transfer: Indirect Evidence

Evidence

That a proposition E is evidence means that E is evidence for or against some hypothesis H.

E is evidence for H, if E makes H more likely or, more generally:

- E is evidence for H iff E confirms H (and E is better accessible than H)
- E is evidence against H iff E disconfirms or undermines H

E can confirm H in different ways:

- If E is a logical consequence of H, then E directly confirms H.
- Otherwise (i.e. $H \nvdash E$) there are several further options: The states of affairs represented by E/H might be:
  - conceptually linked
  - linked by a constitutional relation
  - linked by a causal relation
  - linked by a explanatory relation

Evidence: Direct and Indirect

All confirmation relations cover logical relations, e.g.:

$$H \vdash E \quad \Rightarrow \quad E \textit{ confirms } H$$

But not all the other relations are covered by confirmation relations. E.g., conceptual links produce Goodman style problems for confirmation.

If such a relation is also captured in a confirmation relation, then E also directly confirms H. In this case, E might be called 'direct evidence' for H.

Direct Evidence

E directly confirms H iff E confirms H and E and H stand in one of the following relations to each other: consequence, conceptual dependence, constitution, causality, explanation.

Evidence: Direct and Indirect

However, if there is no such relation, but, e.g., according to the underlying likelihood function E still increases the likelihood of H, then ...

Indirect Evidence

E indirectly confirms H iff E confirms H and E and H stand in none of the following relations to each other: consequence, conceptual dependence, constitution, causality, explanation.

Note that this distinction amounts to putting forward structural constraints for confirmation: E.g., not only probabilistic increase suffices for direct confirmation. Rather, also structural features (mentioned relations) matter.

This is in line with a general tendency in PoS (Feldbacher-Escamilla and Gebharter 2020, sect.4):

- E.g. Explanation: (Salmon 1984) vs. (Hempel 1965) ... causal relevance matters
- E.g. Causation: (Cartwright 1979) vs. *naïve* probabilistic theories ... correlation≠causation
- E.g. Decision theory: (Meek and Glymour 1994) vs. plain maximisation of expected utilities

Evidence: Direct and Indirect

Direct evidence plays an important role in deductive and inductive reasoning.

Indirect evidence is typically considered to be relevant, e.g., in analogical reasoning.

In the following, we spell out the mentioned four forms of generalization as different grades of confirmation by indirect evidence:

- metaphors
- analogies
- unifications/generalization (in the narrow sense)
- reductions

We will see afterwards, that these are more or less explicitly discussed as covering the relation between natural and cultural evolution.

Indirect Confirmation: Metaphor

A metaphor is a figure of speech. The role of metaphors consists in carrying over parts of the meaning of one expression into another context.

O.Greek *metaphorá*, English *transfer*; also: *metapherō* $\approx$ *to carry over*; from: *meta* $\approx$ *after* and *pherō* $\approx$ *bear/carry over*

E.g.: 'Achilles was a lion in the fight.' $\Rightarrow$ 'Achilles fought bravely.'

Part of the notion *lion* (*braveness*) is carried over and ascribed to Achilles.

It is important to note that metaphors in this loose sense of carrying over meaning provide no justification whatsoever (nothing in the *braveness of lions* speaks in favor of the *braveness of Achilles*).

Rather, metaphors are relevant mainly for *discovery* and didactic purposes.

As we will see soon, skeptics about a relation between natural and cultural evolution consider such a relation to be a very loose metaphor only.

Indirect Confirmation: Analogy

Sometimes analogies serve a similar skeptical aim about indirect evidence, particularly in case of so-called *programmatic analogies* (cf. Bartha 2020).

However, already in early approaches to confirmation one finds the idea of employing indirect evidence in form of analogies for confirming hypotheses (cf. Carnap 1950/1962, §110.D; and Hesse 1966).

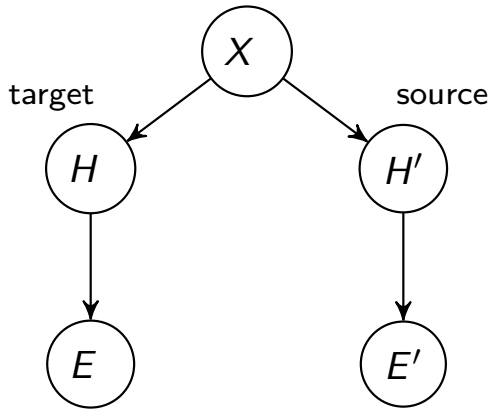
This approach was recently revived by models for *analogue simulation*.

The idea of analogue simulation: Study H about a target system where one lacks evidence E due to practical, theoretical, or ethical reasons by help of a source system, whose H' is structurally similar, and where E' is available.

Models of analogue simulation try to reconstruct how indirect evidence E' can be employed for indirectly confirming hypothesis H.

Indirect Confirmation: Analogy

Dardashti, Thébault, and Winsberg (2015) propose a common cause Bayes net model:



Such a structure allows for probability flow between E' and E: $P(E|E') > P(E)$.

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.

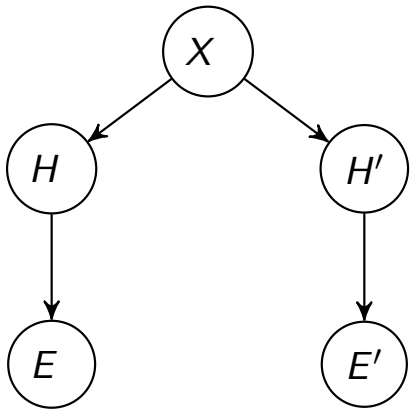
Upshot: Analogies might allow for indirect confirmation, however, such confirmation is very weak and based on many uncertainties (via X).

Indirect Confirmation: Unification

A simplified version of unification is as follows:

- Assume that data sets E and E' are to be explained or generalized.
- Assume that H/H' are models that explain E/E'.
- The task is to find some unifying model/theory X, which explains $E \cup E'$.

Here is a schema for how this might work:



Take the same structure from before.

Assume strict dependencies: $H \dashv X \vdash H'$, $H \vdash E$, $H' \vdash E'$

Now, notice that H' is confirmed by E'; X, in turn, is confirmed by H'.

But then, also H is increasingly confirmed by X.

So, finally, indirect evidence E' has confirmatorial impact on H via H'.

Indirect Confirmation: Unification

One might worry that our reasoning seems to presuppose two problematic principles of confirmation:

Converse Consequence Condition: If A entails B and C confirms B, then C also confirms A (seemingly applied via $X \vdash H' \vdash E'$)

Special Consequence Condition: If A entails B and C confirms A, then C also confirms B (seemingly applied via $X \vdash H$).

These conditions are discussed by Hempel (1965, pp.31f) and trivialize the notion of *confirmation* (everything confirms everything).

Although we use a similar "mechanism" of probability flow, the structural conditions prevent trivialization.

Although structurally similar, in unification the "paths of the probability flow" are much stronger than in case of an analogy.

Another important difference is that unification aims at a carefully spelled out background theory, whereas analogies lack such a theory.

Indirect Confirmation: Reduction

We focus here on classical *theory reduction* only.

This is the case where a hypothesis or theory H is reduced to another hypothesis or theory H', if H' logically or analytically entails H (e.g. a biological theory reduces to a physical one; for a general overview of reductionism in biology see Brigandt and Love 2017; Rosenberg 2006).

Given the DN-account of explanation (Hempel 1965), theory reduction is a particular instance of explanation. In particular, H' logically or analytically (by help of "bridge laws") entails and explains the laws of H.

Performing a reduction is to employ the strongest form of "indirect" evidence.

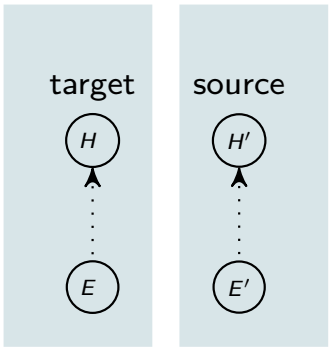
Indirect Confirmation: Reduction

Here is how it works:

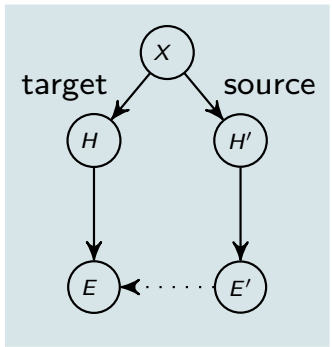
- As in the case of unification, we assume that evidence and hypotheses are strictly related via deduction: $H' \vdash E$ and $H' \vdash E'$.
- However, now we know furthermore that, given some bridge laws or *coordinating definitions* B', H can be strictly reduced to H', i.e.: $\{H', B'\} \vdash H$.
- Given the coordinating definitions are analytic, the schema amounts to that of unification, but now with $X = H'$, i.e.: $E \longleftarrow H \longleftarrow H' \longrightarrow E'$.
- Since the arrows are all aligned in one direction from H' to E and from H' to E', evidence is no longer indirect, but direct.
- The special case of elimination results from this picture if H is skipped.

Since all evidence is direct now, reduction allows for even stronger confirmation than unification does.

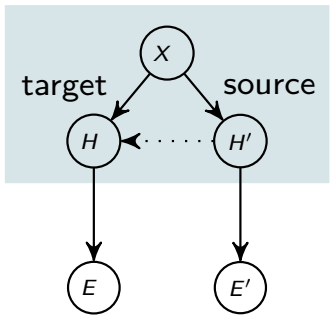
Indirect Confirmation: An Overview



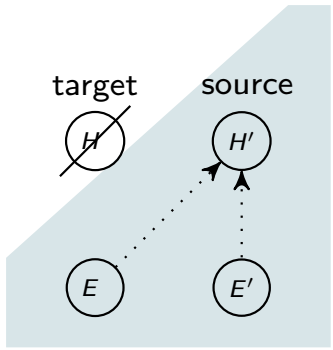
1. metaphor



2. analogy



3. unification/gen.



4. reduction/elimination

Indirect Justification in Generalized Evolution

Indirect Justification in Cultural Evolution

Theories of cultural evolution, dual inheritance theory, universal or generalized Darwinism:

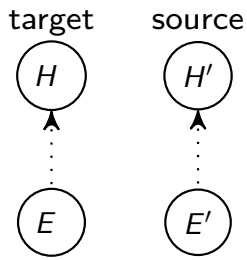
- evolutionary biology,
- archaeology,
- anthropology,
- linguistics,
- economics,
- the social sciences,
- cognitive science,
- philosophy

} different conceptual frameworks

Unlike in physics, transfer of (indirect) evidence challenging to establish in the field of generalized Darwinism, since cultural and biological evolution *differ* in many empirical aspects.

- E.g. Blending inheritance, horizontal transmission, guided variation etc.

Ad Metaphor



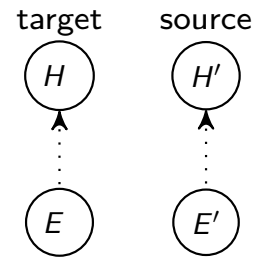
Thomas Hobbes ideal absolutistic state "Leviathan" (1651)

- metaphorical allusion on a giant biblical-mythological creature

In the same line are linguistic notions like:

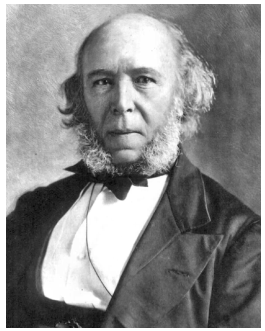
- "capital" (Latin: "caput" = head)
- "arm of the law" (executive force in a state)
- "Volkskörper" (society; old German concept, negative connotation)

Ad Metaphor



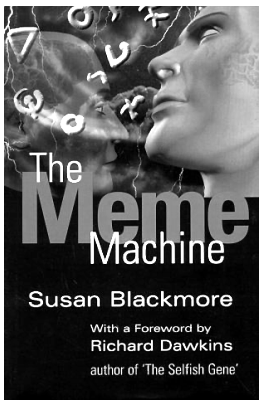
Social Darwinism: Herbert Spencer: "The Social Organism" (1892)

- 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".

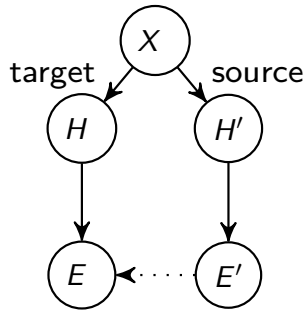


Metaphors in Memetics: Susan Blackmore: "The Meme Machine" (1999)

- Memes "jumping" from head to head
- Meme = virus of the mind

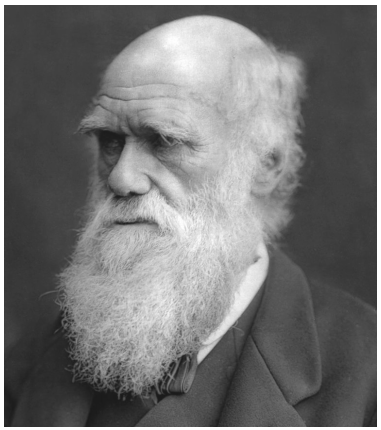


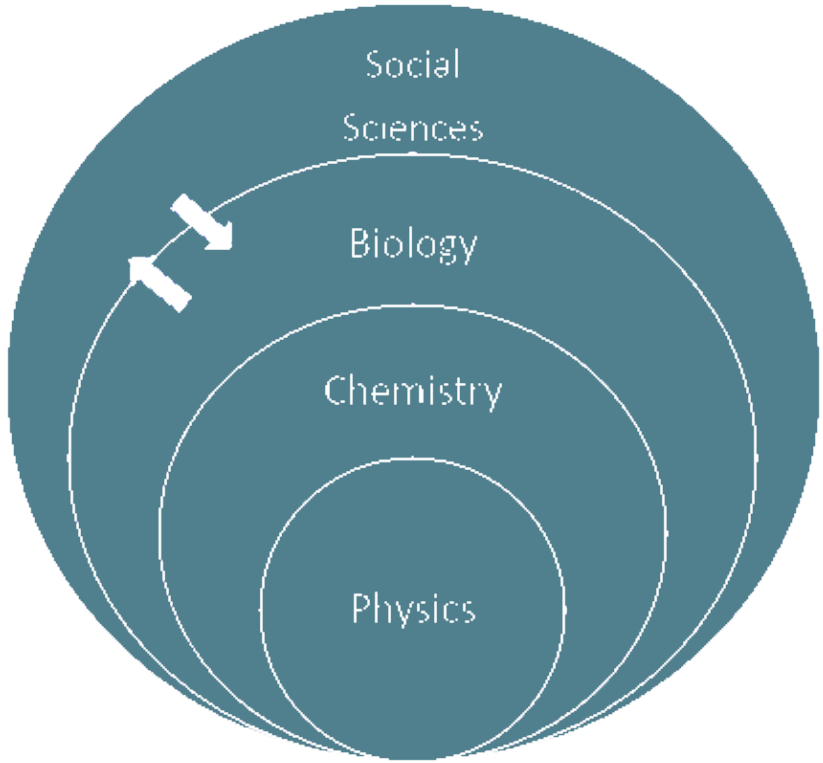
Ad Analogy



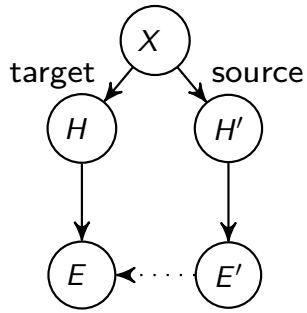
Charles Darwin: "On the Origin of Species" (1859)

- Darwin introduced his main hypothesis analogous to Thomas Malthus' theory of economical and population growth, to increase justification. He came upon his theory of selection while reading Malthus' Essay on Population.
- "[. . .] that 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."



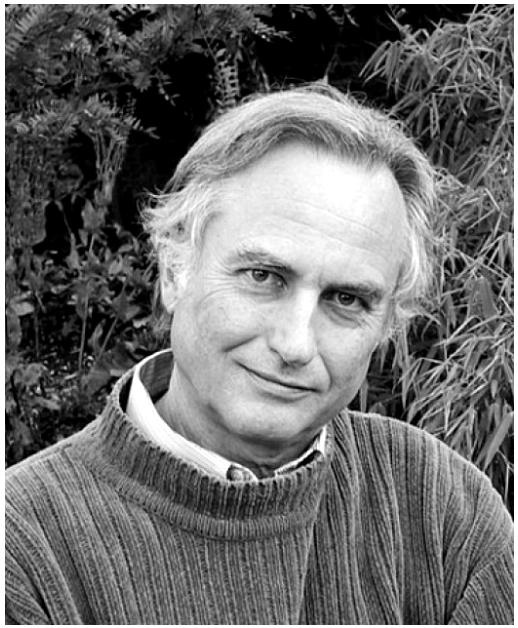


Ad Analogy



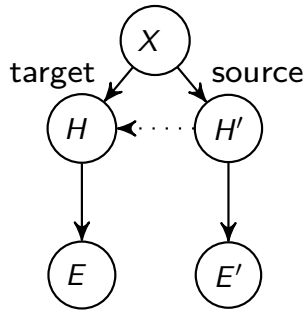
Richard Dawkins: "The Selfish Gene" (1976)

> *"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?"*



- Dawkins is fully aware of the distinction between "analogy" and "metaphor" and their different amount of justification.
- 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').

Ad Generalization

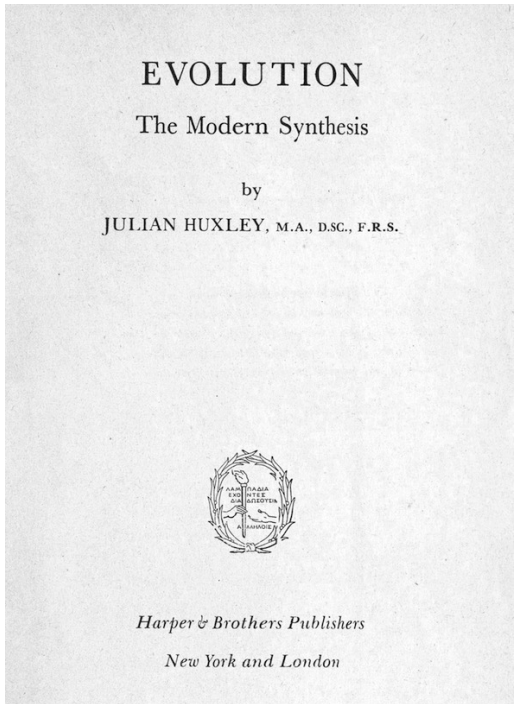


Generalization: a mathematical model or framework integrating both, the source as well as the target domain.

Successful scientific generalizations or "unifications" often major steps in scientific development.

Example: Modern Synthesis (Huxley 1942)

- continuous phenotypic variation (eye colour) arise from the recombination of multiple discrete genetic alleles
- Confirmation of Mendel's experiments
- T. Dobzhansky, E. Mayr or J. Huxley, the results of population genetics were used to *reestablish* Darwinian selectionist evolution
- Result: 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


EVOLUTION

The Modern Synthesis

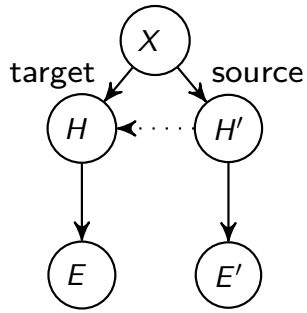
by

JULIAN HUXLEY, M.A., D.SC., F.R.S.

Harper & Brothers Publishers

New York and London

Ad Generalization



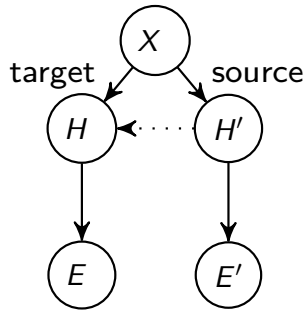
Natural selection explains observations of patterns of genetic differences in recent populations (adaptations).

These genetic changes in turn explain the theory of evolution by natural selection.

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.

In a sense, this is a win-win situation for both theories.

Ad Generalization

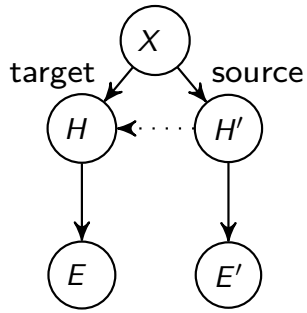


Likewise, generalizing Darwinian principles to the cultural domain requires a carefully spelled out background theory.

> *"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. [. . .] Generalization in science starts from [. . .] different phenomena and processes, without giving analytical priority to any of them over others. Where possible, scientists adduce shared principles. Given that the entities and processes involved are very different, these common principles will be highly abstract [. . .]." (Aldrich et al. 2008, pp.579)*

Do not compare similarities of "phenomena" (analogy), but instead create an abstract formal model, that can serve as explanandum for both domains of inquiry.

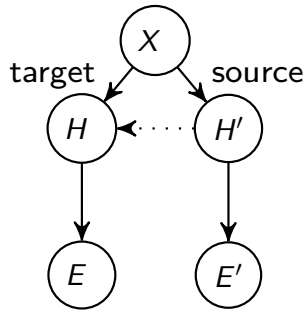
Ad Generalization



Ten (out of many) positions of the different versions of generalized evolutionary theory:

1. Geneticists Jablonka and Lamb (2000), four dimensions of developmental processes: (i) genetic, (ii) epigenetic, (iii) behavioural and (iv) *symbolic* inheritance
2. Proponents of the "extended evolutionary synthesis", Pigliucci and Müller (2010): larger conceptual framework that should extend the scope of the "modern synthesis", also integrating developmental and environmental features
3. Hodgson and Knudsen (2006) or Aldrich et al. (2008): try to implement generalized Darwinian thinking in economics and organizational sciences.
4. Mace and Holden (2005) or Tehrani and Collard (2013): apply *phylogentic methods* in their empirical studies on languages, customs, and archeology, focusing on transmission mechanisms of material culture in different societies.

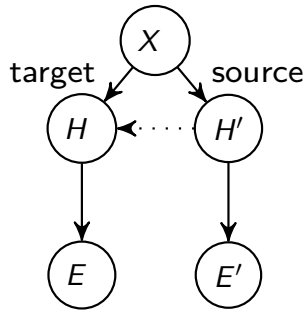
Ad Generalization



Different versions of generalized evolutionary theory Continued:

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.
6. Classical proponents of cultural evolution, like Boyd and Richerson (1988) and Cavalli-Sforza and Feldman (1981): "California School":
   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: "Paris School":
   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.

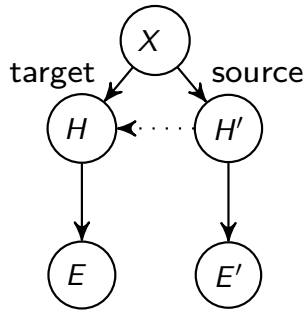
Ad Generalization



Different versions of generalized evolutionary theory Continued:

8. Distin (2011):
   subsumes cultural and biological evolution under a framework with even larger scope, namely "information theory".
9. Skyrms (2004; 2010), Huttegger (2007):
   model the evolution of human altruism, moral norms, the "social contract" or the evolution of meaning and semantics within evolutionary game theory.
10. Schurz (2011, 2019):
    argues 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.

Ad Generalization

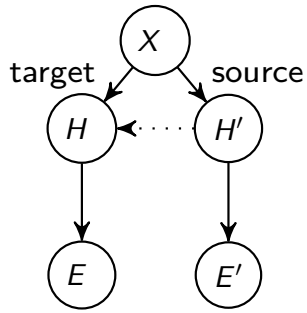


- X_a The first family is "evolutionary game theory" (9, 10).
- X_b The second can be labeled "population dynamics" (3, 5, 6, 10).
- X_c The third family are "phylogenetic models" (4, 5).
- X_d The fourth family consist of "developmental approaches" (1, 2, 7).
- X_e The fifth can be called "evolutionary information theory" (8, 9).

Depending on the single X_i (X_a,...,X_d), 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.

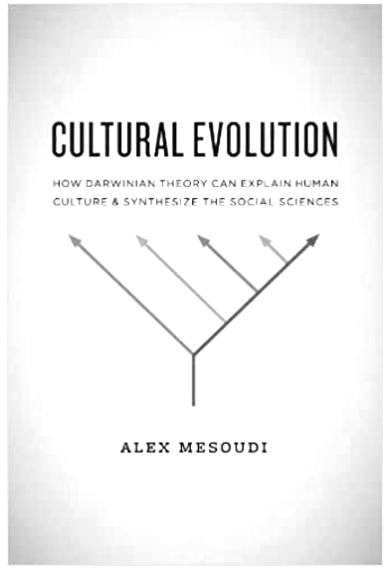
Ad Generalization: An Example



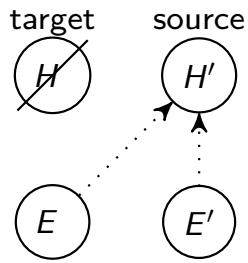
Assumption: The social sciences are currently fractionated, such that different disciplines speak different languages and hold mutually incompatible theoretical assumptions.

Solution: Synthesis of the Social Sciences:

> *"[. . .] if culture does indeed evolve [. . .], then a similar 'evolutionary synthesis' might be possible for the social sciences. That is, large-scale trends or patterns of cultural macroevolution (H), as studied by archaeologists, historians, historical linguists, sociologists, and anthropologists, might be explained in terms of small-scale microevolutionary cultural processes (H′), as studied by psychologists and other behavioral scientists. We can see the emergence of a unified science of culture, [. . .] unified around a Darwinian evolutionary framework (X). Valuable findings [E, E′] are [. . .] transferred across traditional disciplinary boundaries to stimulate work in [. . .] explaining culture scientifically." (cf. Mesoudi 2011, p.xii)*

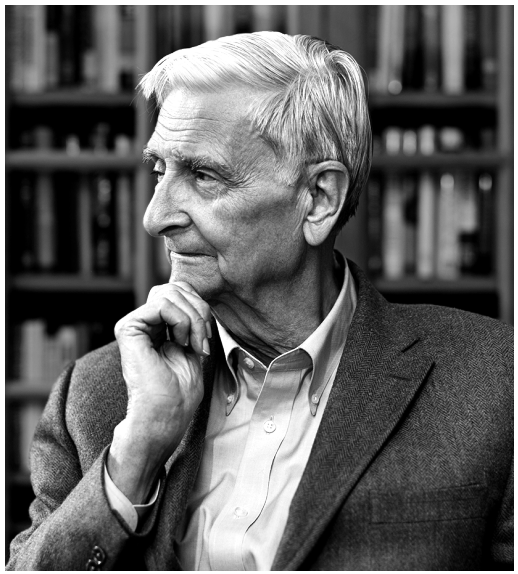


Ad Reduction



Sociobiology of E.O. Wilson (1975)

- Argues for culture as being determined by genetic features, ultimately.
- Genetic dispositions construct a limited space of possibilities, in which all cultural evolution takes place and can never extend it.
- If true, this would open up a genetic determinism, explanatory reducing culture to biology.



Evolutionary Psychology (Cosmides and Tooby 1997):

- culture as thin veneer spread upon genetically selected, innate, human-specific, psychological mechanisms, so-called "mental modules"
- 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

Idea: All social (E) and biological (E') phenomena are ultimately explained by

A Landscape of Generalized Evolutionary Research

Theoretical Framing of the Landscape

Recall: Differences in the metaphor-, analogy-, unification-, and reduction-approach to generalized evolution are a matter of degree.

They differ in transfering justification and employing indirect evidence.

Metaphorical linking ascribes zero weight to indirect evidence.

Analogical reasoning stresses functional features, but without a background theory. It might allow for some justificatory impact of indirect evidence.

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.

A Landscape

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.

We have mentioned Malthus' influence on Darwin in this respect.

More generally, in conveying abstract ideas and for purposes of exploration, e.g. metaphors have always played an important role in biology.

Examples: The "tree of life" is obviously not a real tree. Also the field of genetics is full of metaphorical elements (cf., e.g., Leslie 2012), as e.g., the polymerase enzymes' reading of the DNA, the "genetic alphabet" or the "coding" of the phenotype.

A Landscape

For our purpose of classification more important is the reverse direction: 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*	Herbert Spencer, Gould, Blackmore
analogy	gene	meme	+	Dawkins, Dennett, Blackmore
unification/ generalization	genetic information	cultural information	++	Aldrich, Hodgson & Knudsen, Boyd & Richerson, Cavalli-Sforza & Feldman, Distin, Jablonka & Lamb, Mace & Holden, Mesoudi, Schurz, Sperber, Skyrms et al.
reduction/ elimination	gene	culture	+++	Wilson, Plotkin

Summary

- We have outlined how analogical, unificatory, and reductive transmission of justification might work.
- We think that this conceptual framework allows for a fruitful classification of the many approaches to generalizing the theory of evolution.
- It is important to stress 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.

Blackmore (1999, p.9):

> *"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."*

References I

Aldrich, Howard E., Hodgson, Geoffrey M., Hull, David L., Knudsen, Thorbjørn, Mokyr, Joel, and Vanberg, Viktor J. (2008-10). "In Defence of Generalized Darwinism". In: *Journal of Evolutionary Economics* 18.5, pp. 577–596. DOI: 10.1007/s00191-008-0110-z.

Baraghith, Karim and Feldbacher-Escamilla, Christian J. (2021b). "The Many Faces of Generalizing the Theory of Evolution". In: *American Philosophical Quarterly* 58.1, pp. 35–50. DOI: 10.2307/48600684.

Bartha, Paul (2020). "Analogy and Analogical Reasoning". In: *The Stanford Encyclopedia of Philosophy (Spring 2020 Edition)*. Ed. by Zalta, Edward N. Stanford University: Metaphysics Research Lab.

Blackmore, Susan J. (1999). *The Meme Machine*. Oxford: Oxford University Press.

Boyd, Robert and Richerson, Peter J. (1988). *Culture and the Evolutionary Process*. Chicago: The University of Chicago Press.

Brigandt, Ingo and Love, Alan (2017). "Reductionism in Biology". In: *The Stanford Encyclopedia of Philosophy (Spring 2020 Edition)*. Ed. by Zalta, Edward N. Stanford University: Metaphysics Research Lab.

Carnap, Rudolf (1950/1962). *Logical Foundations of Probability*. London: Routledge and Kegan Paul.

Cartwright, Nancy (1979). "Causal Laws and Effective Strategies". In: *Noûs* 13.4, pp. 419–437. DOI: 10.2307/2215337.

References II

Cavalli-Sforza, Luigi L. and Feldman, Marcus (1981). *Cultural Transmission and Evolution: A quantitative approach*. Princeton: Princeton University Press.

Cosmides, Leda and Tooby, John (1997). "Evolutionary Psychology: A primer". URL: http://www.psych.ucsb.edu/research/cep/primer.html.

Dardashti, Radin, Thébault, Karim P. Y., and Winsberg, Eric (2015-05). "Confirmation via Analogue Simulation: What Dumb Holes Could Tell Us about Gravity". In: *The British Journal for the Philosophy of Science* 68.1, pp. 55–89. DOI: 10.1093/bjps/axv010.

Dawkins, Richard (1976). *The Selfish Gene*. Oxford: Oxford University Press.

Distin, Kate (2011). *Cultural Evolution*. Cambridge: Cambridge University Press.

Feldbacher-Escamilla, Christian J. and Gebharter, Alexander (2020). "Confirmation Based on Analogical Inference. Bayes meets Jeffrey". In: *Canadian Journal of Philosophy* 50.2, pp. 174–194. DOI: 10.1017/can.2019.18.

Hempel, Carl G. (1965). *Aspects of Scientific Explanation and Other Essays in the Philosophy of Science*. New York: Free Press.

Hesse, Mary B. (1966). *Models and Analogies in Science*. Notre Dame: University of Notre Dame Press.

Hodgson, Geoffrey M. and Knudsen, Thorbjorn (2006). "Why we Need a Generalized Darwinism, and Why Generalized Darwinism is Not Enough". In: *Journal of Economic Behavior and Organization* 61.1, pp. 1–19. DOI: 10.1016/j.jebo.2005.01.004.

References III

Huttegger, Simon M. (2007). "Evolution and the Explanation of Meaning". In: *Philosophy of Science* 74.1, pp. 1–27. DOI: 10.1086/519477.

Jablonka, Eva and Lamb, Marion J. (2000). *Evolution in Four Dimensions. Genetic, Epigenetic, Behavioral, and Symbolic Variation in the History of Life*. Cambridge: MIT Press.

Leslie, Carolyn E. (2012). "Metaphor, Narrative and Reality in the Life Sciences". In: *Via Panorâmica: Revista Electrónica de Estudos Anglo-Americanos*, pp. 113–131.

Mace, Ruth and Holden, Clare J. (2005). "A Phylogenetic Approach to Cultural Evolution". In: *Trends in Ecology & Evolution* 20.3, pp. 116–121. DOI: 10.1016/j.tree.2004.12.002.

Meek, Christopher and Glymour, Clark (1994). "Conditioning and Intervening". In: *The British Journal for the Philosophy of Science* 45.4, pp. 1001–1021. DOI: 10.1093/bjps/45.4.1001.

Mesoudi, Alex (2011). *Cultural Evolution: How Darwinian Theory Can Explain Human Culture and Synthesize the Social Sciences*. Chicago: University of Chicago Press.

Pigliucci, Massimo and Müller, Gerd B., eds. (2010). *Evolution: The extended synthesis*. Cambridge, MA: MIT Press.

Rosenberg, Alex (2006). *Darwinian Reductionism: Or, how to stop worrying and love molecular biology*. Chicago: University of Chicago Press.

Salmon, Wesley (1984). *Scientific Explanation and the Causal Structure of the World*. Princeton: Princeton University Press.

References IV

Schurz, Gerhard (2011). *Evolution in Natur und Kultur. Eine Einführung in die verallgemeinerte Evolutionstheorie*. Heidelberg: Spektrum Akademischer Verlag. DOI: 10.1007/978-3-8274-2666-6.

Skyrms, Brian (2004). *The Stag Hunt and the Evolution of Social Structure*. Cambridge: Cambridge University Press.

— (2010). *Signals. Evolution, Learning, and Information*. Oxford: Oxford University Press.

Spencer, Herbert (1892). "The Social Organism". In: *Essays: Scientific, Political and Speculative. Volume I*. Ed. by Spencer, Herbert. London: Williams and Norgate, pp. 265–307.

Sperber, Dan (1996). *Explaining Culture: A naturalistic approach*. Oxford: Blackwell Publishing.

Tehrani, Jamshid J. and Collard, Mark (2013). "Do Transmission Isolating Mechanisms (TRIMS) influence cultural evolution? Evidence from patterns of textile diversity within and between Iranian tribal groups.". In: *Understanding Cultural Transmission in Anthropology: A critical synthesis*. Ed. by Ellen, Roy, Lycett, Stephen J., and Johns, Sarah E. Methodology & History in Anthropology. New York: Berghahn Books, pp. 148–164. URL: http://dro.dur.ac.uk/12227/.

Wilson, Edward O. (1975). *Sociobiology: The New Synthesis*. Cambridge, MA: Harvard University Press.

Zalta, Edward N., ed. (2020). *The Stanford Encyclopedia of Philosophy (Spring 2020 Edition)*. Stanford University: Metaphysics Research Lab.