The Gene-Meme-Analogy in Cultural Evolutionary Theory

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- Feldbacher-Escamilla, Christian J. (2013-06-11/2013-06-11). *What is a Meme? A Partial Characterization by Analogical Concept Formation*. Research Seminar. Presentation (contributed). Summer term 2013. University of Düsseldorf: Department of Philosophy, DCLPS.

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Introduction

Let us begin with an almost self-suggesting question:

- Gene theories allow us to explain diversity in nature.
- Meme theories aim at an explanation of diversity in culture.
- Some people think that memes are "the software of the brain".
- Other people think that memes are all kinds of information stored in brains, libraries, computers, states of affairs etc.
- How could meme theories explain diversity in culture, if there is so much diversity in the meanings of their vocabulary ('meme')?

Proposal: Concepts of cultural evolutionary theories are introduced by analogies allowing such a diversity

- without lack of precision,
- but at the cost of generality.

Contents

NE: Main Principles of Natural Evolution

General Conditions for NE

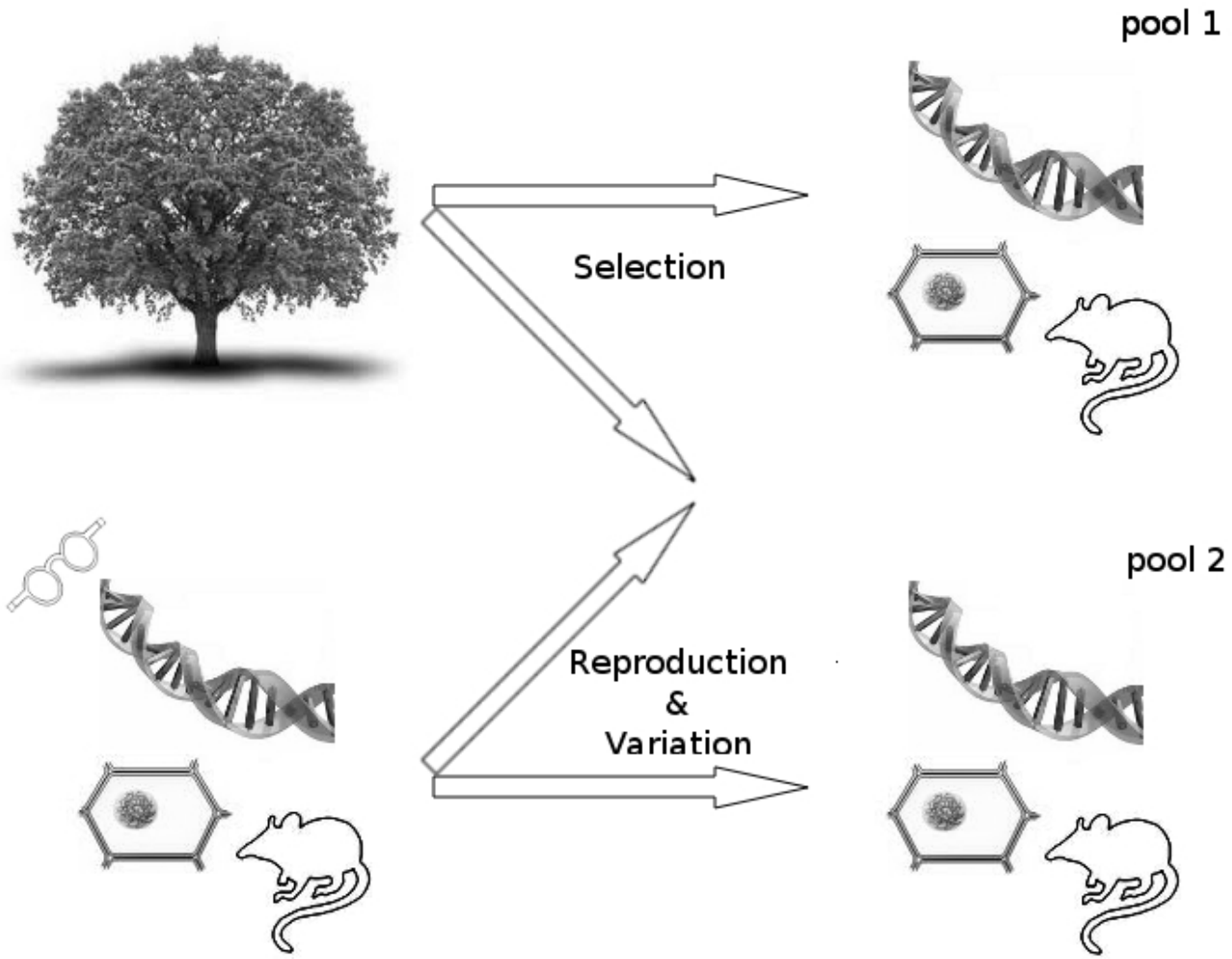
"Darwinian theory's [. . .] essential elements are simply replication, variation and selection. If these requirements are met then evolution seems bound to happen. If organisms reproduce, passing their characteristics almost (but not always quite) accurately on to the next generation, and if their environment does not supply them with unlimited resources for their survival, then they will evolve[.]" (cf. Distin 2005, p.2)

General Conditions for NE

According to Darwin's theory of evolution (*The Origin of Species*, 1869) there are three conditions needed to be satisfied within a system in order to count as a system of evolution (cf. Schurz 2011, p.192):

1. **Reproduction**: There are subsystems or organisms which reproduce themselves with respect to some important properties. These properties are called 'reproduced or inherited properties' and every process of reproduction creates a new generation.
2. **Variation**: The reproduction leads to variation which is also inherited.
3. **Selection**: There is selection, because some variants are fitter under the given environmental circumstances than others, i.e.: They reproduce themselves faster than others. By this some other variants are eliminated in the long run. The selecting parameters of the environment are called '*selection parameters*'.

. . . Symbolized



. . . Preservation of Favoured Races in the Struggle for Life

In order to establish some complexity and regularities in an evolutionary system, a further condition is needed:

4. **Stability**: For directed evolution also a fourth condition, the condition of stability of the selecting forces is needed. This means that the changing rate of the selecting forces is little with respect to the generation rate. (cf. Schurz 2011, p.192)

CE: Expansion to a Framework of Cultural Evolution

CE: Expansion

Richard Dawkins' main idea in *The Selfish Gene* was to ground the investigations of the conditions for NE systems at the level of genes. Reproduction, variation, and selection (especially fitness) is not only considered with respect to whole organisms, but with respect to genes.

So, in Dawkins' theory the replicators are of main importance. Organisms are their "devised survival machines".

A typical way of expanding a successful theory is to expand its domain: "Darwinism is too big a theory to be confined to the narrow context of the gene." (Dawkins 1976)

CE: Expansion

In order to illustrate a universal and substrate-neutral replicator-centered theory of evolution, Dawkins introduced in 1976 the expression ‘meme’.

$$D = \textit{Set of genes} \Rightarrow D = \textit{Set of genes and memes}$$

Important figures:

- Richard Dawkins (cf. Dawkins 1976)
- Daniel Daniel C. Dennett (cf. Dennett 1992)
- Susan Susan J. Blackmore (cf. Blackmore 1999)
- Robert Robert Aunger (cf. Aunger 2000)
- Gerhard Gerhard Schurz (cf. Schurz 2011)

An Alternative Expansion: Sociobiology

Alternatively it was tried to cope with cultural evolution within sociobiology (founding father: Edward Wilson).

Main idea: Try to find genetic patterns whose "extended phenotype" are cultural properties.

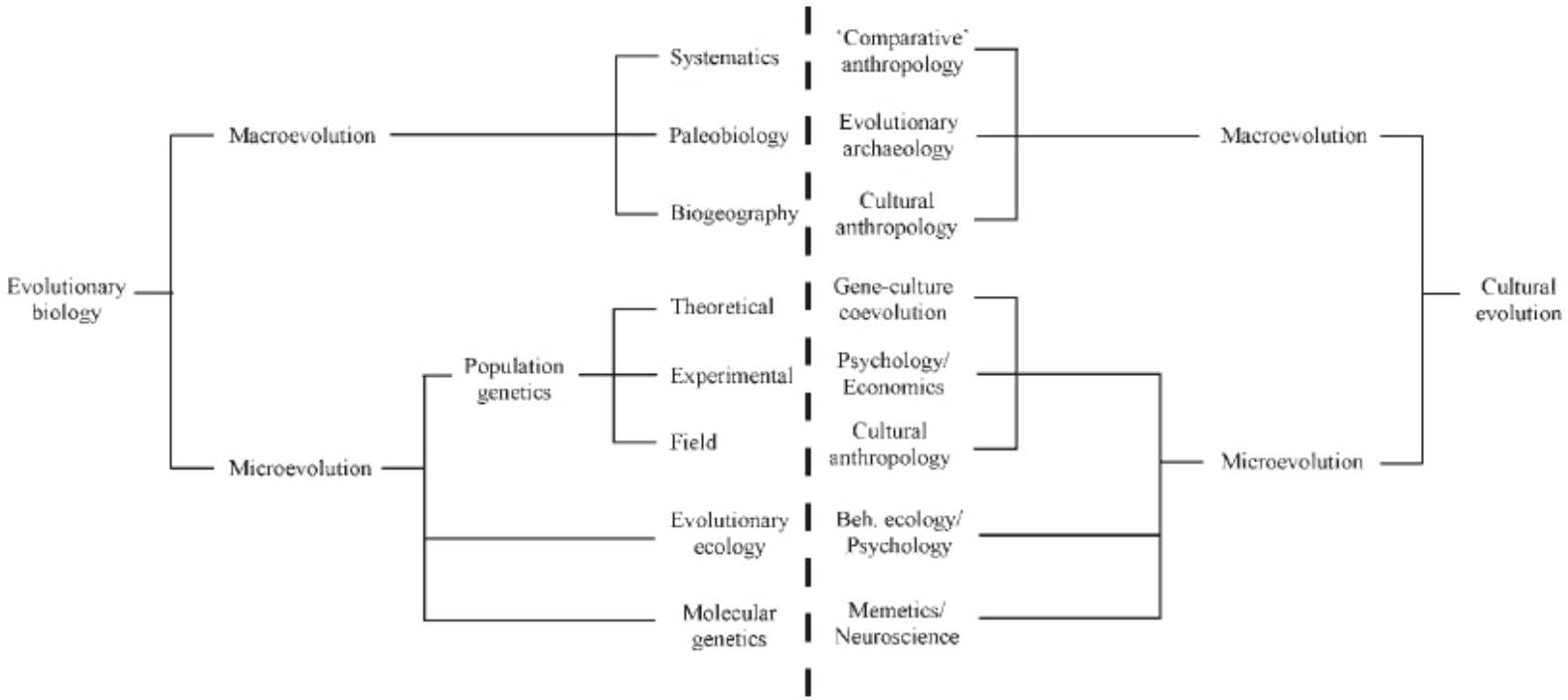
Difference:

- Sociobiology: Phenotypes at the neuronal level; replicators = genes
- Memetics: Phenotypes at the cultural level; replicators = memes

Problems (amongst others):

- Shortage of material: Genetically there are too less combinations possible to cope with electrochemical states of multiple neurons by base pairs.
- Speed: CE is too fast in order to become manifest in NE (cf. Distin 2005, p.15)

Disciplines of Cultural Evolution



Major subdivisions within evolutionary biology and corresponding disciplines of cultural evolution (Mesoudi, Whiten, and Laland 2006, p.331)

Diversity of an Understanding of 'meme' I

- **Imitable entities**: Memes are all things that are capable of being imitated. (cf. Dawkins 1976) and (cf. Blackmore 1999):
  "We need a name for the new replicator, a noun that conveys the idea of a unit of cultural transmission, or a unit of imitation. 'Mimeme' comes from a suitable Greek root, but I want a monosyllable that sounds a bit like 'gene'. I hope my classicist friends will forgive me if I abbreviate mimeme to meme. [...] It should be pronounced to rhyme with 'cream'. Examples of memes are tunes, ideas, catch-phrases, clothes fashions, ways of making pots or of building arches." (cf. Dawkins 1976, p.192)

  Blackmore:

Diversity of an Understanding of 'meme' II

"Memes are not best understood as semantic information stored in brains, but rather, as whatever is imitated or copied in culture." (Susan Blackmore in her comment "Why we need memetics" to Mesoudi, Whiten, and Laland 2006, p.349)

and: memes are independent of brain activity etc. because they are also "selfish":

"Memetic evolution constructed human brains and is now building better, higher fidelity meme machines, including computers, the Internet, and digital media. For the moment we humans are essential to the further evolution of the memosphere, but there are already many memes created that never have contact with a human being, and there will be more." (Susan Blackmore in her comment "Why we need memetics" to Mesoudi, Whiten, and Laland 2006, p.350)

Diversity of an Understanding of 'meme' III

- **Information:** Memes are acquired information, also storable outside of the brain, as, e.g., in books and computers (cf. Dennett 1992) *"Equivalent to the genotype-phenotype (or replicator-interactor) distinction in culture [...] we can speak of culturally acquired semantic information stored in brains as replicators and the expression of that information in behaviour or artefacts as their interactors." (cf. Mesoudi, Whiten, and Laland 2006, p.344)*

  Contra: Meme-phenotype-distinction becomes vague.
- **Brain dispositions:** Memes are dispositions of the brain to store (represent) information and cause behaviour (cf. Schurz 2011, p.213).
  Contra: Incoherent meme-histories:

Diversity of an Understanding of 'meme' IV

"if there were only minds and no external RS [(Representation System)] in which information could more permanently be stored, then memetic replication would lose much of its present stability." (cf. Distin 2005, p.90)

- **Brain software:** Memes are software parts of the brain (cf. Dawkins 1982, p.109)
  Contra: Too early stage of neuroscience
- **Neuromemes:** Memes are electrochemical states of multiple neurons, so-called 'neuromemes', i.e. configurations in one node of a neuronal network that is able to induce the replication of its state in other nodes (cf. Aunger 2000)

Diversity of an Understanding of 'meme' V

"Aunger (2002) has recently attempted to integrate memetics with neuroscience, arguing that a robust conceptualisation of the 'meme' must specify its material basis in the brain. He proposes that memes should be seen as electrochemical states of multiple neurons, and offers a definition of a 'neuromeme' as 'a configuration in one node of a neuronal network that is able to induce the replication of its state in other nodes'." (cf. Mesoudi, Whiten, and Laland 2006, p.343)

Contra: Too early stage of neuroscience

Main Properties of the Meme Concepts

Although there is such a diversity, proponents of cultural evolution agree in the following desiderata for memes:

- **Reproducibility:** They must be reproducible (not only syntactically understood, which would be mechanistically: replicatable, but also semantically): E.g. by imitation, but more generally by social learning activities (teaching etc.) (cf. Distin 2005, chpt.4)
  Dawkins: fecundity
- **A not too high variation rate:** Their variation rate must not be too high. Cf. Dawkins' test: An order—e.g., in a drawing—must be recognizable (cf. Distin 2005, p.104)
  Dawkins: copying fidelity
- **A not too low variation rate**: If the variation rate is too low, e.g. in almost perfect information copy machines as computers, then evolution comes to a standstill.

Criticism I

Criticism (cf. Mesoudi, Whiten, and Laland 2006, p.343):

- **Discernibility:** Culture cannot be divided into discrete units (cf., e.g., Maurice Bloch)
  Contra:
  "However, the same putative 'criticism' could equally be levelled at modern concepts of the gene. [...] The concept of the gene has undergone significant changes through the past 150 years. The classical view, held from the time of Mendel (1866) until the 1930s, [also] saw the gene as an indivisible unit of transmission, recombination, mutation, and function." (cf. Mesoudi, Whiten, and Laland 2006, p.343)

  And:

Criticism II

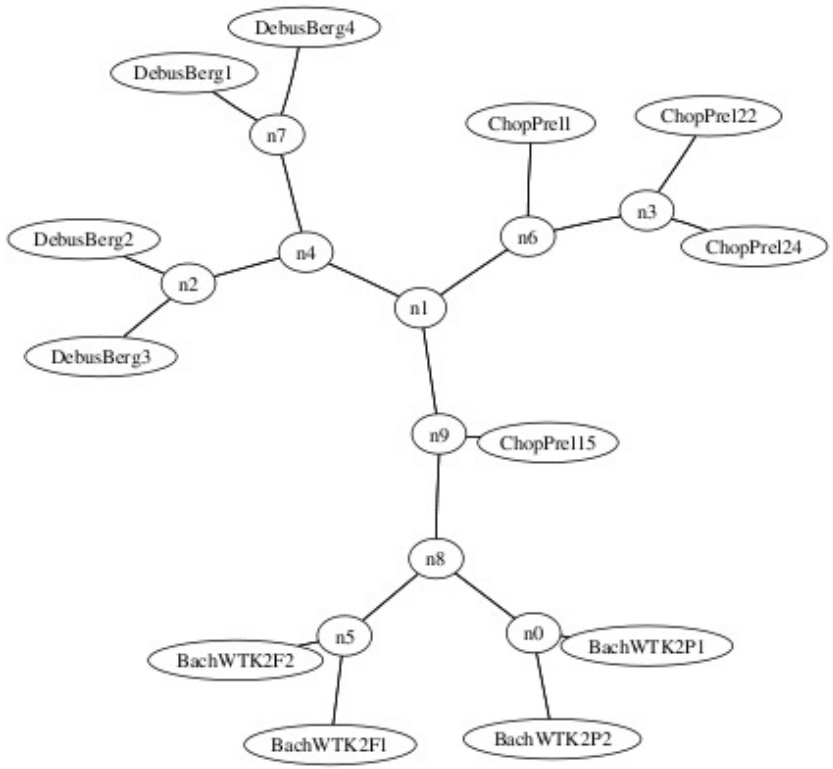
"Already, one can perceive the beginnings of what has been called a 'social cognitive neuroscience' that aims to integrate all the required levels of analysis." (Mesoudi, Whiten, and Laland 2006, p.343)

- **Dissimilarities:** They outweigh similarities to a very high degree.
- **Generality:** Similarities are too general in order to be fruitful.
- **Terminology doubling:** Meme-talking is redundant. What we need is only to talk about the "phenotypes" as usual.

Criticism III

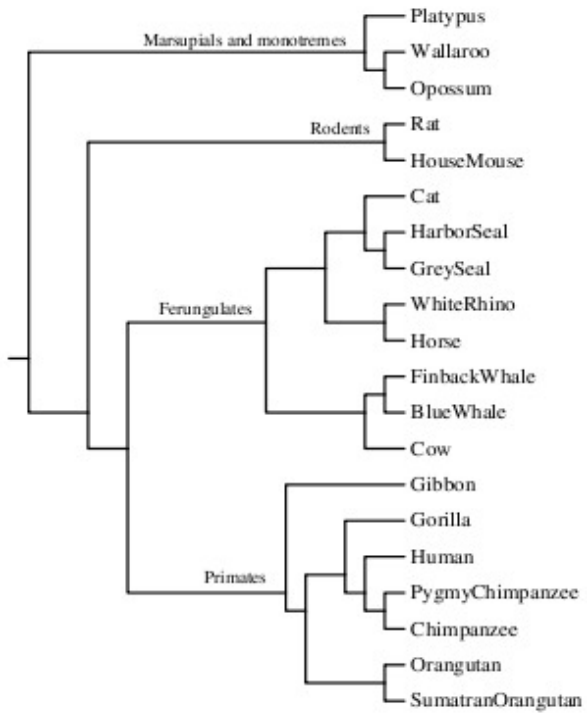
- **Inadequate Framework**:
  "Mathematical models are potentially as useful for culture as for evolution, but cultural models must have different designs from genetic models. Social sciences must borrow from biology the idea of modelling, rather than the structure of models, because copying the product is fundamentally different from copying the design." (Bruce Bridgeman in his comment "It is not evolutionary models, but models in general that social science needs" to Mesoudi, Whiten, and Laland 2006, p.351)

Via Complexity and Information to Semantic Closeness



(Vitányi et al. 2008, p.53)

Via Complexity and Information to Semantic Closeness



(Vitányi et al. 2008, p.51)

Analysis of the Analogy

A Detailed Characterization of Analogies

A reminder – cf. my talk: Research Seminar, Düsseldorf, June 19, 2012

Comparison of water in a pipe with current in a conductor:

Shortened analogical description:
'Electric current in a conductor is like water in a pipe.'

Take, e.g., the law of Hagen-Poiseulle and Ohm's law:

- L1 $p_1 - p_2 = \frac{V}{c}$ (V . . . volume of fluid, c . . . speed, p_i . . . pressure)
- L2 $v_1 - v_2 = \frac{I}{k}$ (I . . . amperage, k . . . conductance, v_i . . . potential)

A Detailed Characterization of Analogies

It is well known that c varies indirect proportional with the length of the pipe:

- L3 $c \sim \frac{1}{l_1}$ (l_1 . . . length of the pipe)

Analogical to this fact it holds that k varies indirect proportional with the length of the conductor:

- L4 $k \sim \frac{1}{l_2}$ (l_2 . . . length of the conductor)

Furthermore it holds that:

- L5 $V \sim r_1^4$ (r_1 . . . radius of the pipe)

But it holds (not similarly) that:

- L6 $I \sim r_2^2$ (r_2 . . . radius of the conductor)

A Detailed Characterization of Analogies

Analogical usage of language about two different domains (e.g., physics of liquids and electromagnetism) is given here in the sense that some descriptions of regularities are syntactically isomorph, i.e.: $V \mapsto I$,... and vi.ve.

The main problem of analogical usage of language is easily expressed:

Which descriptions of regularities within one domain of investigation are adequately adoptable for descriptions of regularities within another domain of investigation?

The simplest solution to the problem would be a restrictive definition (cf. Hempel 1970, p.434):

Instead of defining 'x is analogue to y' one just defines 'x is analogue to y with respect to L_i'.

According to this solution it holds: I is analogue to V with respect to L1 and L2, but not with respect to L5 and L6.

A Detailed Characterization of Analogies

Let *is* be a (partial) mapping (on the vocabulary of both theories):

- $is(I) = V$
- $is(v_i) = p_i$
- $is(k) = c$
- $is(l_2) = l_1$

Then one may generalize *is* inductively:

- For all ...: $is(P^n(t_1, \ldots, t_n)) = is(P^n)(is(t_1), \ldots, is(t_n))$
- For all terms t_1, t_2: $is(t_1 \equiv t_2) = is(t_1) \equiv is(t_2)$
- For all formulas A: $is(\neg A) = \neg is(A)$
- For all formulas A, B: $is(A \& B) = is(A) \& is(B)$
- For all formulas A and variables x: $is(\forall x A) = \forall x is(A)$

And describe the analogical relations by: L1$\Rightarrow$ *is*(L1), L3$\Rightarrow$ *is*(L3)

Concept Formation by Analogies

What does it mean that by these analogical relations current (I) and conductance k are in some way characterized?

The analogical relations can be restated logically equivalent as:

- L1$\Rightarrow$ (is(L1) $\Leftrightarrow$L1)
- L3$\Rightarrow$ (is(L3) $\Leftrightarrow$L3)

Which may be seen as conditionalized contextual definitions of:
I, k, v_i and I_2

By such restatements one can make some sense of 'concept formation by analogies'.

Main problems:

- conditionalized multiple characterization of an expression
- difference between contextual definitions and non-definitional axioms

The Analysis of the main NE–CE–Analogy

Some Details: The Mendelian Basis

Mendel's starting point, modernized:

Phenotype > **Genome** > **Diploid chromosome set** >	**Genotype**
Brown-eyed	AA, Aa
Blue-eyed	aa

So A is dominant and a is recessive.

Since meiosis is randomly (independent frequencies) it holds: $p(AA) = p(A) \cdot p(A)$, $p(aa) = p(a) \cdot p(a)$ and $p(Aa) = 2 \cdot p(A) \cdot p(a)$

Now let's get some dynamics: The Hardy-Weinberg-law states, that if there is no selective pressure, then these frequencies retain (cf. Schurz 2011, chpt.12.4):

- $p_{n+1}(AA) = p_n(A)^2 = p_n(AA)$
- $p_{n+1}(Aa) = 2 \cdot p_n(A) \cdot p_n(a) = p_n(Aa)$
- $p_{n+1}(aa) = p_n(a)^2 = p_n(aa)$

That's within systems with reproduction and non-mutational variation, but neither selection nor mutation.

Some Details: Dynamics with Selection and Mutation

Selection may be introduced into the dynamics with a parameter for selection. Let's assume, e.g., a selection pressure s on blue-eyed people:

	Variation_1	Variation_2	Variation_3
Genotype (V_i)	AA	Aa	aa
Fitness (f)	1	1	$1-s$

Then the dynamics changes to (here $k = 3$; (cf. Schurz 2011, chpt.12.5)):

$$p_{n+1}(V_i) = p_n(V_i) \cdot \frac{f(V_i)}{\sum_{j=1}^{k} p_n(V_j) \cdot f(V_j)}$$

Implementation of mutation via m (frequency of V_i-mutations back or forth; (cf. Schurz 2011, chpt.13.1)):

$$p_{n+1}(V_i) = p_n(V_i) \cdot \frac{f(V_i)}{\sum_{j=1}^{k} p_n(V_j) \cdot f(V_j)} \cdot (1 - m(V_i))$$

Some Details: CE–Dynamics

Transformation by analogy:

$$\text{NE: } p_{n+1}(V_i) = p_n(V_i) \cdot \frac{f(V_i)}{\sum_{j=1}^{k} p_n(V_j) \cdot f(V_j)} \cdot (1 - m(V_i))$$

$$\Downarrow$$

$$\text{CE: } p_{n^*+1}(V_i^*) = p_{n^*}(V_i^*) \cdot \frac{f^*(V_i^*)}{\sum_{j=1}^{k} p_{n^*}(V_j^*) \cdot f^*(V_j^*)} \cdot (1 - m^*(V_i^*))$$

So $is(V_i) = V_i^*$, $is(n) = n^*$ etc. where:

- n: ancestor relation — n^*: generations/rounds
- m: mutation rate — m^*: variation rate of information etc.
- f: natural selection pressure — f^*: cultural selection pressure
- V_i: Genotypes — V_i^*: Memes

Why Don't Bother?

Most importantly we need to figure out: $m^*(V^*)$ and $f^*(V^*)$ and also be able to distinguish n^* from $n^* + 1 \ldots$.

As long as m^* and f^* are quite general, V^* or memes seem to serve the aims of cultural evolution.

Why Don't Bother?

This thesis is not new:

> *"[A] possibility is that such methods [that allow a clear characterization of memes] will reveal that certain aspects of cultural transmission are not [classical]. Even in this case, however, evolutionary models are still applicable [...]. Indeed, Darwin formulated his theory of evolution with little understand- ing of genes or Mendelian inheritance." (cf. Mesoudi, Whiten, and Laland 2006, p.344)*

And:

> *"Although the neuronal interpretation of the expression 'meme' seems to me plausible, the theory of culutural evolution doesn't hinge on it." (cf.: my translation of Schurz 2011, p.210)*

Fitness Properties of Memes I

Fitness properties of cultural evolution (f^*) that are quite general:

- Different kinds of fitness: "Natural selection occurs when organisms differ in their *viability* and also when they differ in their *fertility*" (Sober 2000, p.57): Fertility rate: number of living born children of a parent. Viability rate: number of children reproducing themselves. Memes: Fertility rate: perhaps via a citation index operationalizable (first citation). Viability rate: perhaps via a citation index (re-citation) operationalizable.
- A meme is the more reproducible, the less cognitive dissonant it is with respect to main stream ideas (cf. Schurz 2011, p.230), (cf. Distin 2005, p.61) Cf. also Quine's web of belief where logic is at the core of our beliefs.
- One general selection criteria: The more a meme is organism self-defeating, the less fit it will be (cf. Schurz 2011, p.231).

Fitness Properties of Memes II

- Complexity theory: Hierarchical structure of repeatedly nested sub-units increases the reproduction rate of so-called memplexes (cf. Distin 2005, p.41).
- Complexity theory: The more complex a system of memes, i.e. a memplex, is, the more unlikely it is that a meme/idea can be integrated. This is some kind of conservatism of complex systems (cf. Distin 2005, p.59).
- It's also possible to model frequency dependent fitness (selection parameter s includes also the frequency of a variant)
  - Positive dependence: E.g.: Peer pressure (cf. Schurz 2011, p.235)
  - Negative dependence: E.g.: Avant-garde streams, exclusiveness constraints (in fashion etc.)

Important Properties Lost

- Species ⇒ Quasispecies (there are no reproduction barriers for memes; so also a genealogy of memes or ideas fails in the classical sense)
- There is no meiosis. For this reason variation must come into play differently.
- There is no unguided or undirected selection and variation. A consequence of directed selection is fast evolution.
- In general it holds:
  - NE: mean variation and high selection rate
  - CE: high variation and low selection rate

Summary

Starting question: How can meme theories of culture cope adequately with cultural diversity if there is disagreement about the meme-concept?

We named three necessary conditions for a natural system to be a natural evolutionary system: reproduction, variation and selection.

In cultural evolutionary theory analogue processes are assumed. The cultural processes of reproduction and variation are based on the replicator meme.

Although memes are seen as imitable entities, information contents, brain dispositions, brain software or so-called neuromemes, their main relevant properties are considered to be reproducibility and adequate variability.

A detailed analysis of the main NE-CE-analogy shows: these different understandings of 'meme' share these three main relevant properties of memes (V^*) to such a degree that they are acceptable for the present descriptions of the fitness (f^*) and the variation/mutation (m^*) factor.

So, our partial understanding of the expression 'meme' is at least currently unproblematic. But of course this hinges on the generality of f^* and m^*.

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