

REDUCTION 1: Theory Reduction

Intertheoretic Reduction

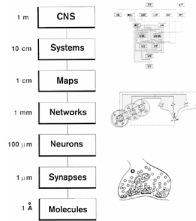
* Intertheoretic reduction has been understood as involving the derivation of the laws of one theory from the laws of another that is more general or more fundamental:

Laws of reducing theory

Bridge principles that relate terms of the reducing theory to those of the reduced theory

Boundary conditions under which the derivation is to work

∴ Laws of reduced theory



* The Churchlands sometimes relax these demands, holding only that the reducing theory provide an “equipotent image” of the reduced theory’s most important explanatory principles

Example: Kepler to Newton

* Based on his own observations and those of Tycho Brahe, Kepler advanced three laws governing planetary motion

1. All planets move on ellipses with the sun at one locus;
2. A given planet always sweeps out equal areas in equal times;
3. The square of planet’s period is proportional to the cube of its mean orbital radius.



* Newton provided a set of laws governing all moving objects

1. Inertial motion is constant and rectilinear;
2. Acceleration = force/mass;
3. For any change in momentum something suffers an equal and opposite change in momentum.
4. Gravitation law: $F = Gm_1m_2/R^2$

* One can derive Kepler’s laws from Newton’s

* Kepler’s account is a special case of Newton

Example: Temperature to Mean Molecular Motion

- * The Boyle-Charles Gas Law makes reference to temperature
 - * $PV=pR \cdot T$
- * But what is temperature?
 - * The kinetic theory of gases replaced the right side with reference to properties of particles
 - * $PV=(2n/3 mv^2)/2$
 - * In which temperature is understood as mean velocity of particles
- * The mean motion of gas molecules is not something that we observe
 - * Rather, it is characterized in terms of the reducing theory
- * What is to be gained by introducing new entities?
 - * Claim: Theoretical **unification**

Clicker Question

Among the examples of successful reductions that the Churchlands offer is that of theories about the pressure, temperature, and volume of a gas to theories about kinetic energy of molecules. What relation is claimed to hold between temperature and the kinetic energy of an average corpuscle?

- The kinetic energy is due to the temperature
- The kinetic energy explains the temperature
- Temperature is identical to the kinetic energy
- Temperature sometimes affects kinetic energy

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The Project of Theory Reduction

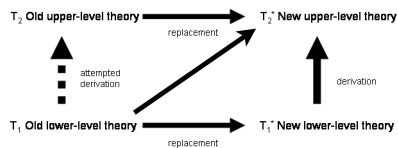
- * The framework of theory reduction was developed as part of the unity of science movement
 - * As new scientific specialities and disciplines were being created, a number of scientists/philosophers in Europe in the 1930s sought to understand how they might be unified
 - * Extension of their logical positivist framework
- * Question: Should psychology be brought into this unified framework? "Should one expect and work for a reduction of all psychological phenomena to neurobiological and neurocomputational phenomena?"
- * The Churchlands note five principled oppositions to reducing psychology:
 - * Qualia arguments: Qualitative character of experience cannot be explained
 - * Intentionality argument: Semantic content of thoughts cannot be explained
 - * Emergent properties: loyalty to a moral ideal not a brain property
 - * Human freedom: physical objects like the brain are deterministic
 - * Multiple instantiation/realization: cannot reduce psychology to just one type of brain

Reductions vs. Replacements

- * Einstein's special theory of relativity is often viewed as providing a reduction of Newton's laws of motion
 - * But the two are formally inconsistent
 - * Newton's theory allows for infinite velocities, Einstein's doesn't
 - * Newton's theory assumes absolute rest, Einstein's denies it
 - * Newton's theory assumed objective mass, Einstein's considers only mass relative to a reference frame
- * Einstein's theory explains the same phenomena as Newton did
 - * At velocities much less than the speed of light, predictions from the two theory are nearly indistinguishable
- * But given Einstein's theory, Newton's theory is FALSE
 - * And so not reduced to (cannot not be derived from) Einstein's

Schaffner's Reduction Model

- * Insofar as the reduced theory is false, it cannot literally be derived from the reducing theory
- * Schaffner proposed that it is a new replacement theory T_2^* that is derived, either from the lower-level theory T_1 or from some modified lower-level theory T_1^*
 - * Old and new theories sometimes stand in a similarity or close-approximation relation
 - * Other times they differ so much that the old theories get replaced



Reduction vs. Elimination

- * While some theories can be viewed as approximately correct, and so retained for many purposes, after they have been supplanted, others are seen to be simply false and not worth preserving
 - * Phlogiston chemistry
 - * Ptolemaic astronomy
- * Kuhn (also Feyerabend) construed scientific revolutions as the radical replacement of one theoretical framework by another
 - * In these cases intertheoretic reduction is not possible since the theories are incommensurable
 - * Rather, the old theories are simply eliminated, only to be discussed again in philosophy classes

Clicker Question

What do the Churchlands claim should happen when it is not possible to view an older upper-level theory as approximated by the newer lower-level theory?

Both theories should be kept and used as appropriate

One should modify each theory until it is possible to identify the phenomena of one with those of the other

The older upper-level theory should be eliminated in favor of the new, more basic level theory

The newer theory should not be trusted until it can provide an approximate account of the old upper level theory

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What is the Point of Reduction?

- * A reduced theory is a vindicated theory (not eliminated)—it has been shown to be a special case of the reducing theory
 - * Hence, it can be employed with high confidence that it is true
- * The reduced theory can be corrected by using the reducing theory
 - * One can identify contexts where the old theory made mistakes and avoid using it in such contexts
- * The reducing theory gives us better insight and ways to control the phenomenon
 - * The reducing theory explains the reduced theory (why it works)
 - * It identifies more ways to manipulate the phenomenon
- * By integrating the two theories, we have a simpler account
 - * There are not two sets of entities doing two sorts of things
- * The reducing theory inherits all the evidence accumulated for the reduced theory

The Co-Evolutionary Perspective

- * Often the intertheoretic reduction framework is viewed as applying to ultimate theories reached at the end of science
 - * But the concern of scientists is with contemporary theories and how they might or should relate to one another
 - * Can the theory reduction framework be applied to current theories?
- * Theories are not static entities—they are undergoing continual change both to account for already known phenomena or for newly discovered ones
 - * Can the project of attempting reduction help in guiding change?
- * Drawing on the process of coevolution between biological species, Patricia Churchland has advanced the *co-evolutionary* picture of reducing and reduced theories changing over time to better fit the reduction picture
 - * Seeking reduction becomes a strategy of theory development
- * McCauley argues that there the Churchlands slide between different types of co-evolution

Co-Evolution Micro-reduction

- * Co-evolution in the direction of approximate microreduction—"it is reasonable to expect, and to work toward, a reduction of all psychological phenomena to neurobiological and neurocomputational phenomena"
- * On this view, the lower-level theory is typically given priority—the upper level theory must be changed to fit the lower-level one

Discussion Question

What might be a reason to give priority to a lower-level theory (e.g., one from neuroscience) in the process of theory co-evolution?

- The lower-level theory is supported by more objective evidence (real studies of the brain)
- The lower-level theory makes available more high-credibility research tools (e.g., single cell recording)
- There isn't a good reason. Privileging the lower-level theory is simply prejudice.
- Other

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Co-Evolution Scientific Revolutions

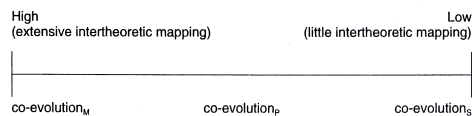
- * In scientific revolutions, old theories get eliminated, not reduced—theories about phlogiston were not reduced but simply eliminated
- * This is the position that most clearly embraces eliminativism
- * Sometimes Patricia Churchland emphasizes that psychology may need to be reconfigured before reduction: "... the possibility that psychological categories will not map one to one onto neurobiological categories ... does not look like an obstacle to reduction so much as it predicts a fragmentation and reconfiguration of the psychological categories"
- * Some parts of psychology may have to be eradicated in the process ("remembering stands to go the way of impetus")

Co-Evolution Pluralism

- * Preserve “a diverse set of partially integrated yet semi-autonomous explanatory perspectives”
 - * This acknowledges that some of the pressure for revision may come from higher level theories imposing constraints on lower-level ones
 - * “. . . the history of science reveals that co-evolution of theories has typically been mutually enriching”
 - * “[r]esearch influences go up and down and all over the map”
- * Higher level theory (psychology) developed using different research tools and tries to answer different questions
 - * It needs to pursue its own investigations and develop its own theories with a degree of autonomy from lower level inquiry (neuroscience)

A Continuum of Co-Evolutionary Positions

- * In an initial attempt to relate the three version of co-evolution, McCauley tries to put them on a continuum which emphasizes how good or bad the mapping from the reduced to the reducing theory is



- * McCauley goes on to argue that this one-dimensional story is insufficient

Clicker Question

What is McCauley's main criticism of the Churchlands' account of Co-evolution_s?

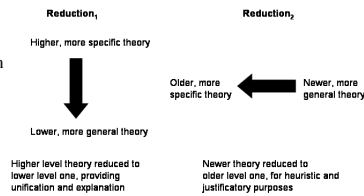
- Co-evolution_s is typically an intra-level relation, not inter-level
- Co-evolution_s is typically an inter-level relation, not intra-level
- Theories typically don't get eliminated in science, only revised
- Higher-level theories should be treated as autonomous from those at lower levels, not reduced to them

Eliminativism and Levels

- * McCauley argues that elimination, of the sort brought about in scientific revolutions, is typically a within-level phenomenon
- * A new theory, couched at the same level of organization, supplants a prior one
 - * Oxygen chemistry replaced phlogiston chemistry
 - * Newtonian physics replaced Aristotelian physics
- * In less drastic cases, the new theory may bear a resemblance to the old, at least in specific circumstances
 - * Einsteinian physics reduces to (note the direction) Newtonian physics in the limit of low velocity
- * These relations are all between theories at the same level—the new theory fills the same niche as the old theory, but employs different conceptual resources
- * *Co-evolution embodies a *category mistake* (in that it confuses an intra-level phenomenon with an inter-level one)

Direction of Reduction

- * Reduction_M involves deriving a (current) higher level theory from a (current) lower level one—the higher is reduced to the lower
- * In intralevel reduction one is asking whether an older theory can be derived from the current one
- * The different types of reduction serve different ends
 - * Reduction_M—unification and explanation
 - * Intralevel reduction—heuristic guidance and justification

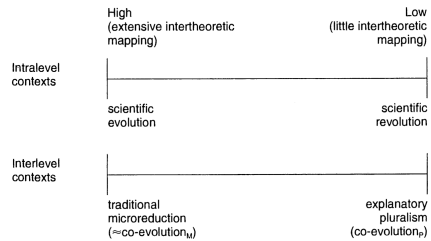


Reductions that Traverse Levels

- * Although inter-level reductions may result in modifications to the reduced (or the reducing) theory, they may also result in a perfect match
 - * This wouldn't happen in the intra-level case—we wouldn't exchange an old theory for a new one that was equivalent in all respects
- * Inter-level connections are developed in the service of further developing each inquiry
 - * Each of which maintains a degree of independence from the other (in terms of methods, theories, etc.)
 - * They may reach a point of relatively smooth connections between levels (Reduction_M)
 - * But they may not
 - * This provides grounds for maintaining both levels, not eliminating one (Reduction_P)

McCauley's Alternative Picture

- * Co-evolution_M and Co-evolution_P are on a continuum of interlevel relations
- * Co-evolution_S is eliminated
- * Replaced by a continuum of modes of change between theories at the same level



NETalk and Explanatory Pluralism

- * In the early days of neural networks Sejnowski and Rosenberg developed a neural network model that learned to read English text by generating a phoneme corresponding to the central letter in a 7-letter moving window
- * Each output was compared to the target output and an error signal was sent back through the network to revise its weights
- * Sejnowski and Rosenberg used NETalk to simulate psychological findings such as the spacing effect (spaced practice leads to better long-term recall)
- * NETalk demonstrated behavior similar to humans
- * Pluralism: there is no presumption that a lower-level account trumps a higher level one
- * Quite the reverse: "When NETalk deviates from human performance, there is good reason to believe that a more detailed account of brain circuitry may be necessary."

Consequences for Folk Psychology

- * When the Churchlands adopt the eliminativist line, their primary target is folk psychology
- * The explanation of behavior in terms of attitudes towards propositions
 - * Fodor believes *that the Churchlands are wrong*
 - * Eugen fears *that the Churchlands are right*
- * They contend folk psychology is an ancient, unchanging, and failed attempt to explain behavior
- * McCauley contends propositional attitudes still have a place
 - * While they do not figure in explanations in cognitive psychology, they are invoked in social psychology
 - * Ex. Cognitive dissonance
 - * Folk psychology often guides the investigations in cognitive psychology
 - * And in these contexts it is undergoing change

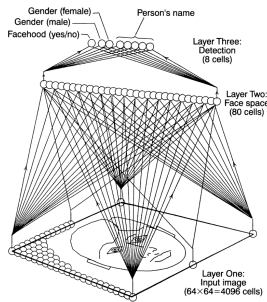
The Churchlands' Reply

- * Replacement in astronomy
 - * Newtonian mechanics (a general account of the motion of physical bodies) replaced Aristotelian style astronomy
 - * Which held that astronomical bodies obeyed different laws than terrestrial ones
 - * More standard story: Ptolemaic astronomy replaced by Copernican astronomy as modified by Kepler
 - * Newtonian mechanics explains (Reduction_M) Kepler's version of Copernicus



The Connectionist Alternative to Folk Psychology

- * "Legitimizing the office need not legitimate the current office holder."
- * And there is a new candidate for the office
- * Without encoding the propositions of folk psychology, networks of connected *neurons* can perform many cognitive tasks
- * A network developed at UCSD by Garrison Cottrell learns to recognize drawing of faces and classify individuals as male or female



Connectionism Minus Neurons

- * Connectionism provides an abstract (higher-level?) theory of cognition sufficient to replace folk psychology
- * Conceptual space of a trained network:
 - * "fleeting high-dimensional patterns being transformed into other such patterns by virtue of their distributed interaction with an even higher-dimensional matrix of relatively stable transforming elements. The fleeting patterns constitute a creature's specific representations of important aspects of its changing environment. And the relatively stable matrix of transforming elements constitutes the creature's background knowledge of the general or chronic features of the world."

