

# **Levels, reduction vs. emergence**

- Any science: theory at each level
- Complex systems observed - constructed in a hierarchy of levels
- Interactions between elements at any level
  - described without
    - (a) properties of elements at level below
    - (b) dynamics at level above
- Ex - A car: Mechanisms, Sub-mechanisms, quantum level (Herbert Simon '07)

# 1. Levels

- “Levels”: ontological, organizational (mechanisms or systems), epistemological or description or analysis
  - Explanation of cognition in micro- (neural states) and macro-levels (mental phenomena)
  - 2 types of interactions:
    - *Intralevel* (horizontal) interactions - same level
    - *Interlevel* (vertical) interactions - between levels
- (McCauley '98/'07)

# Wimsatt ('76)

- “*Intralevel*” relations = Relations over time between **successive** theories in a science
  - “*Interlevel*” relations = Cross-scientific relations between theories that reign at same time at **different analytical levels** in science
- Methodological + ontological implications for theories and sciences **contrast**

# **David Marr - Three Levels of Description**

## **(1) Computational level**

- What information is computed and why
- What the system is capable of doing
- Deep Blue and Kasparov – equivalent

## **(2) Representation and algorithm (software)**

- What program is used
- What are the symbols, how are processed
- Deep Blue and Kasparov - different

## **(3) Hardware – Neural level (Dawson '07)**

## Ex: *Linguistic understanding*

- **Task:** Identify syntax and meaning corresponding to speech sounds.
- **Algorithm:** What kind of computation and mental representations?
- **Implementation:** Which part of the brain?

a. “Ontological” levels- radical emergence  
(E)

b. “Organizational” levels – modest E

c. Levels of “analysis” - specific value E

- Analytical levels partially depend upon viewing nature as organized into *parts and wholes* (McCauley ‘07)

## *3-levels vs. more-levels*

- Understanding cognition = Understanding brain at different levels = Levels of organization

### Levels of the brain:

- Whole brain
- Large systems and pathways in brain (e.g. sensory pathways)
- Properties of specific centers + local circuits
- properties of neurons (single cell recording)
- structures within neurons (dendrites/axons)
- Individual synapses + molecular properties of membranes and ion channels (Dawson '07)



Using principles of organization and scale,  
7 sub-levels within neuroscience:

- molecules
  - synapses
  - neurons
  - networks
  - maps
  - sub-systems
  - central nervous system overall
- (Churchland and Sejnowski '92)

# “The Massive Redeployment Hypothesis” (Michael Anderson in Horst ‘07)

- **Localism** - meta-analysis of over one hundred *fMRI* studies by Michael Anderson (forthcoming) (See Bechtel)
- Neural areas correlates of some cognitive task

- *Authors:* Regions identified were “memory regions,” “attention regions”, depending on nature of task studied
- *Anderson:*
  - (a) Most regions - utilized in multiple tasks and multiple *types* of tasks (e.g., attention and memory)
  - (b) Most tasks involved multiple Brodmann areas

- “Cognitive tasks” not stand in a *one-to-one relation* with Brodmann areas, but in a **many-to-many** relationship (Horst ‘07)
- ↔ A “massive redeployment” of pre-existing brain areas to obtain new functionality
- Evolutionary history, brain areas redeployed (originally modular units)
- Evolution - for acquiring new functionality = Redeploying existing functionality in ensembles of neural areas working together (Not genetical mutations)

## **2. Reduction (R) (van Gulick '01)**

### **Ontological R (objects, properties, events ...)**

- Elimination
- Identity
- Composition
- Supervenience
- Realization

# **Epistemological R** (concepts, *theories*, models, frameworks)

- Replacement
- Theoretical–Derivational (Logical Empiricist)
- *A priori* Conceptual Necessitation
- Expressive Equivalence
- Teleo–Pragmatic Equivalence

### 3. Emergence (E)

- History of E complicated, many interpretations
- E = Vertical relationships low-level and high-level properties
- R/E = Property/level is reduced/emerge
- “Since around 1990, the idea of emergence has been making a big comeback, from decades of general neglect and disdain - analytic philosophy.”
- “‘Emergence’ is very much a term of philosophical trade; it can pretty much mean whatever you want to mean...” (Kim ‘05)

- E = “Xs are something *over and above* Ys.”
- E features - *beyond* features of parts from which they emerge
- “*Metaphysical E*” (relations between real things) or “*epistemic E*” (epistemic relations) (van Gulick ‘01)
- **Ontological** and **epistemological E** - people many times conflate them (Silberstein and McGeever ‘99; O’Connor and Wong ‘02)



- Some properties = Combinations of parts at same level
- E properties - different from  $\sum$  parts → **Novelty**
- Novel properties of object- “determinable properties whose determinates are not had by all of object’s parts” (Crane)

Ex: Surface colour and wetness

- Or E properties of whole - *supervenient* properties of parts
- Such properties = “**Over and above**” physical properties

### 3.1 Ontological emergence (van Gulick)

(1) Specific value  $E = \text{Whole and parts} - \text{features of same kind, different specific subtypes}$

(Ex: Statue + molecular parts = Property, mass)

(2) Modest kind  $E$ : “whole - features different in kind from those of its parts ...” (Ex: Color, life)

(3) Radical kind  $E$ : The whole - features

- Different in kind from parts
- Of kind whose nature and existence is not necessitated by features of its parts + macro-laws influence micro-laws/entities

- Ontological E - world = *Layered view of nature*
- Ontologically emergent properties are not determined or reducible to basic properties (ex. QM)
- Ontological E - Controversial

- *Strong E* property = “High-level phenomenon *arises* from a low-level domain, but **truths** concerning that phenomenon - not deducible even *in principle* from truths in low-level domain.”
- If strong E phenomena - Not deducible from laws of physics ↔ New **laws** of nature for consciousness
- Colorblind scientist + zombies
- Consciousness - *supervenes* on neural states  
(Chalmers '06)

## 3.2 Epistemological E

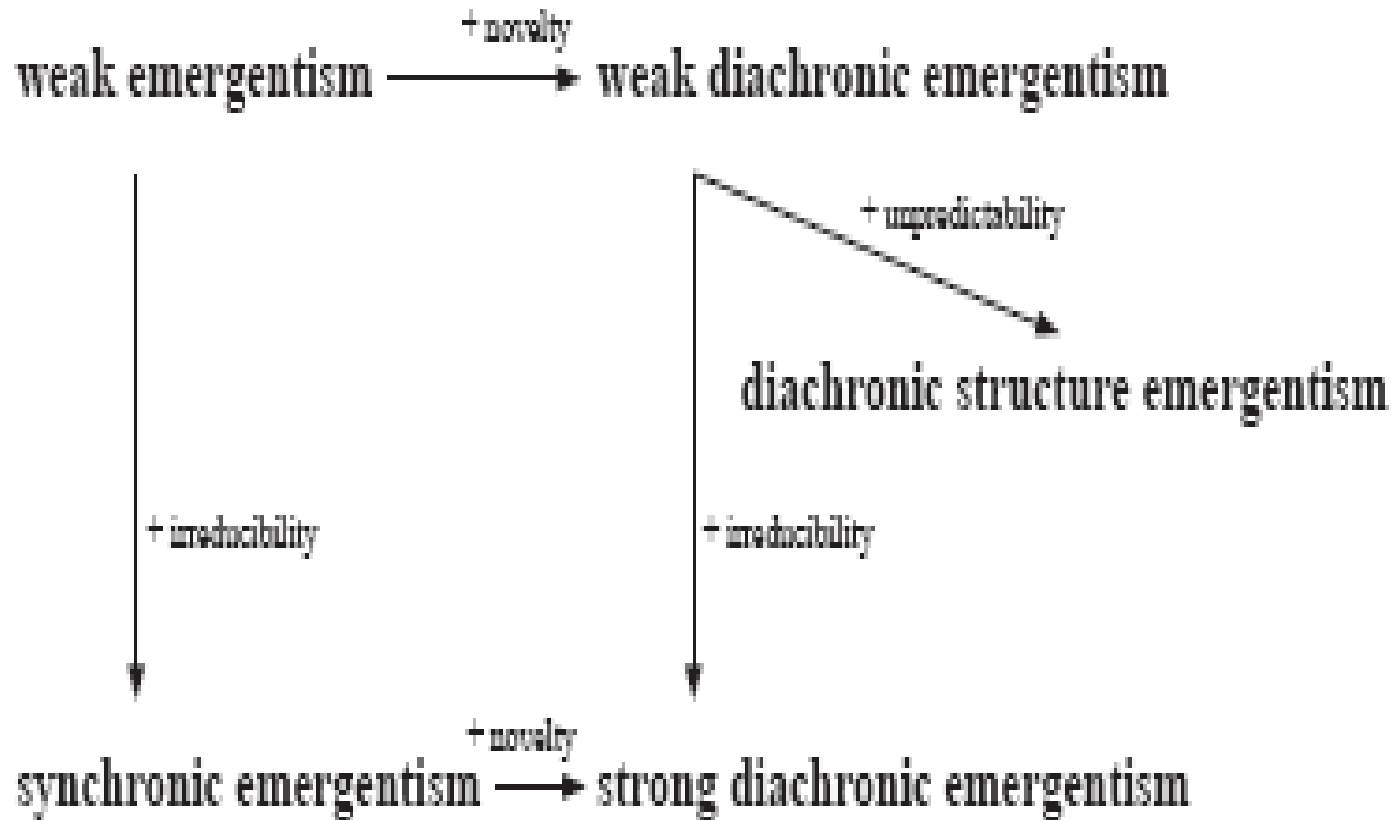
- Epistemic E - Incapacity *explain/predict* property of whole system in terms of parts
- Property of whole - *determined* by properties of parts
  
- Epistemic E: Weak and strong E (van Gulick)
- Property = Epistemological E - determined to/deducible from intrinsic properties of fundamental entities that compose objects

- Difficult to *explain/predict* such a property in terms of its fundamental constituents
- “Epistemologically E properties - *novel at level of description*”
- High-level phenomenon = *Weak E* to low-level when phenomenon is *unexpected* in accord with laws from low-level
- “Unexpected” - E properties - somehow deductible from low-level properties (Chalmers ‘06)

- Ex: “Game of life”, connectionist networks, evolution (for intelligent creatures), high-level patterns CA
- Weak E
  - (a) High-level properties of system are not of any of its parts
  - (b) Deductibility without reducibility

- *Predictive*: E properties = Features of complex systems - not predicted by knowledge of features + laws of parts
  - *Irreducible-Pattern*: E properties + laws = Features of complex systems governed by true, lawlike generalizations within a **special science**
- = Irreducible to fundamental physical theory for *conceptual reasons*
- Macroscopic patterns - Not captured in concepts + laws physics
- (O'Connor and Wong '02)





**Stephan (2002, 1998)**

- Nonreductive physicalism (Davidson '70; Putnam '72; '78; Fodor '74; Boyd '80; Searle '92; van Gulick '92) (in Gulick '01)

vs.

- *Left* (dualists – Chalmers '96; Hasker '99) and *right* (reductive physicalists such as Kim '89)

- Fodor ('74) – “Autonomy of special sciences”

vs.

- Old **unity of science** view (Oppenheim & Putnam '58): All true theories must ultimately be translatable into language of physics