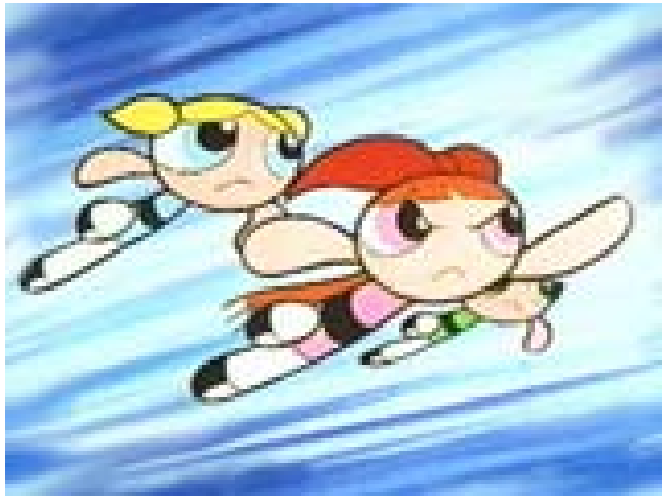
The concept of *emergence* in complexity science: finding coherence between theory and practice

parts



emergent sum

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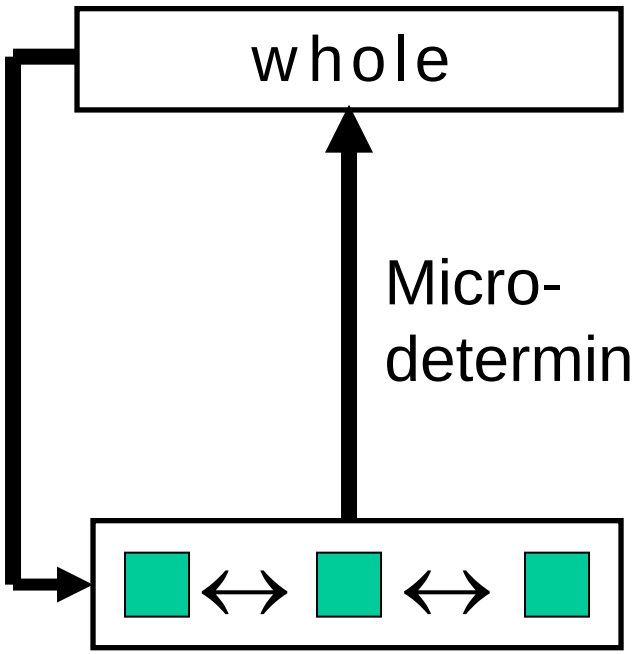
Complex Systems Summer School 2002

Emergence: Assumptions



Downward-causation

Micro-determination

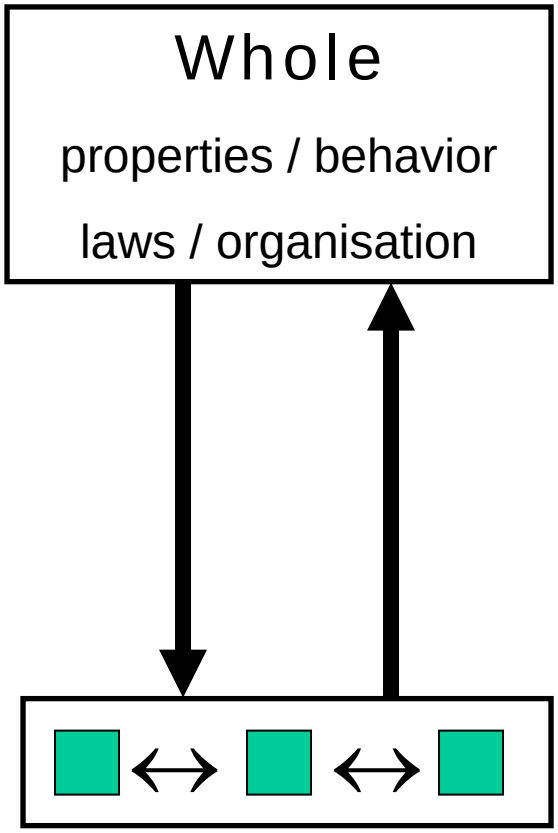
Ontological monism

Hierarchical realism

Emergence & Reductionism

Emergence:

- **Unpredictable**
- **Irreducible**
- **Downward causation**



Reductionism:

- **ontological**
- **epistemic**
- **methodological**
- **explanatory**

Different kinds of Emergence

- phenomenological emergence
- epistemic emergence

- emergence of organisation
- theoretical emergence
- weak causal emergence

- strong causal emergence
- mystic emergence

Reductionism

Complexity Scientists vs. Philosophers

Complexity science emergence data sources:

- 1) survey of SFI and CSSS opinions on emergence concepts
- 2) ‘emergence’ as used in complexity science literature

csss and sfi survey

32 yes-or-no questions on emergence, prediction, reduction, and causation

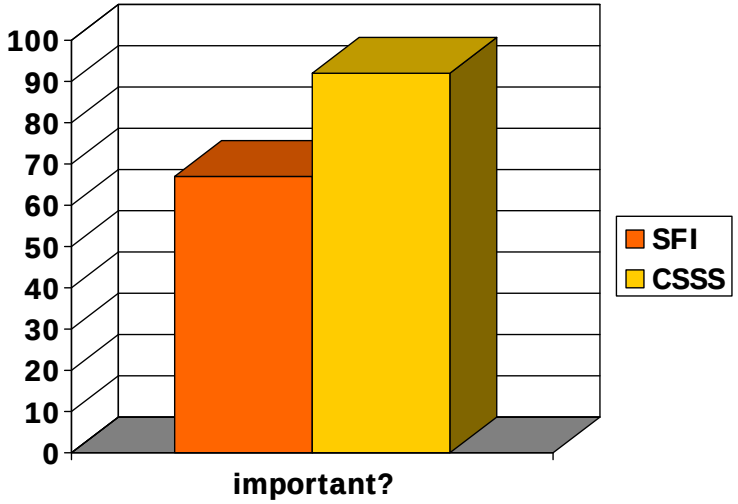
32/60 CSSS participants responded

(10 before drinks were offered as bribe)

6/50 SFI researchers responded

small, self-selected population, possibly biasing results...nevertheless...

Emergence: who cares?



--many complexity science researchers!

--50 books related to emergence in complex systems written since 1990

--concept used by life scientists, philosophers, physical scientists, and social scientists

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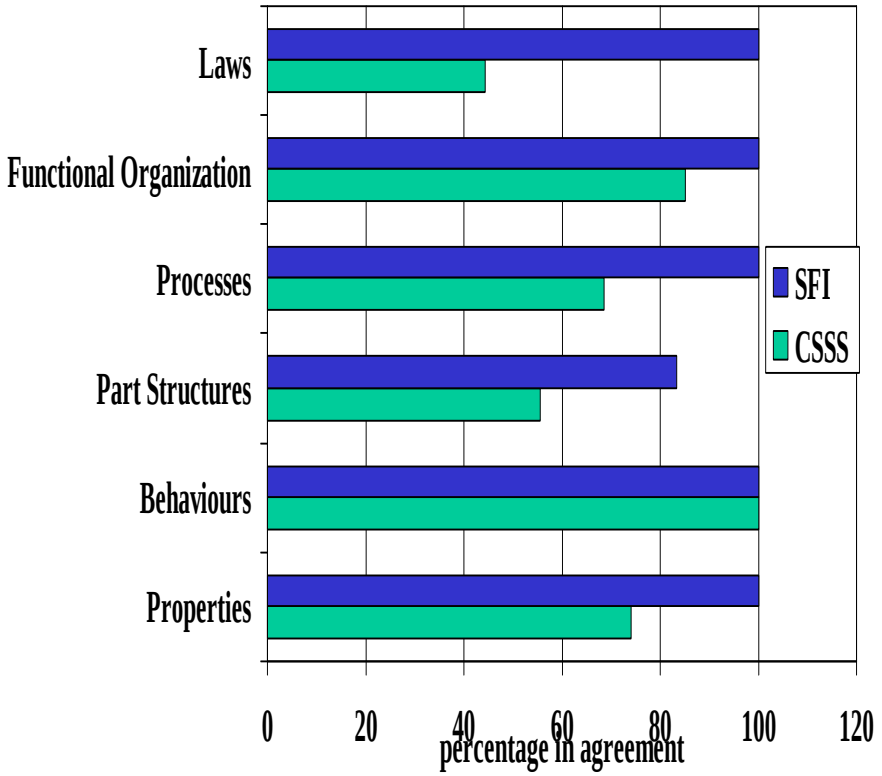
Emergence is “a buzzword to be avoided”? (booooo!)

15% of CSSS and 33% of SFI

Emergence is a filler term, to be replaced when an entity is understood?

22% of CSSS and 16% of SFI

Ontology: to which sort of entities can and should the term ‘emergence’ apply?

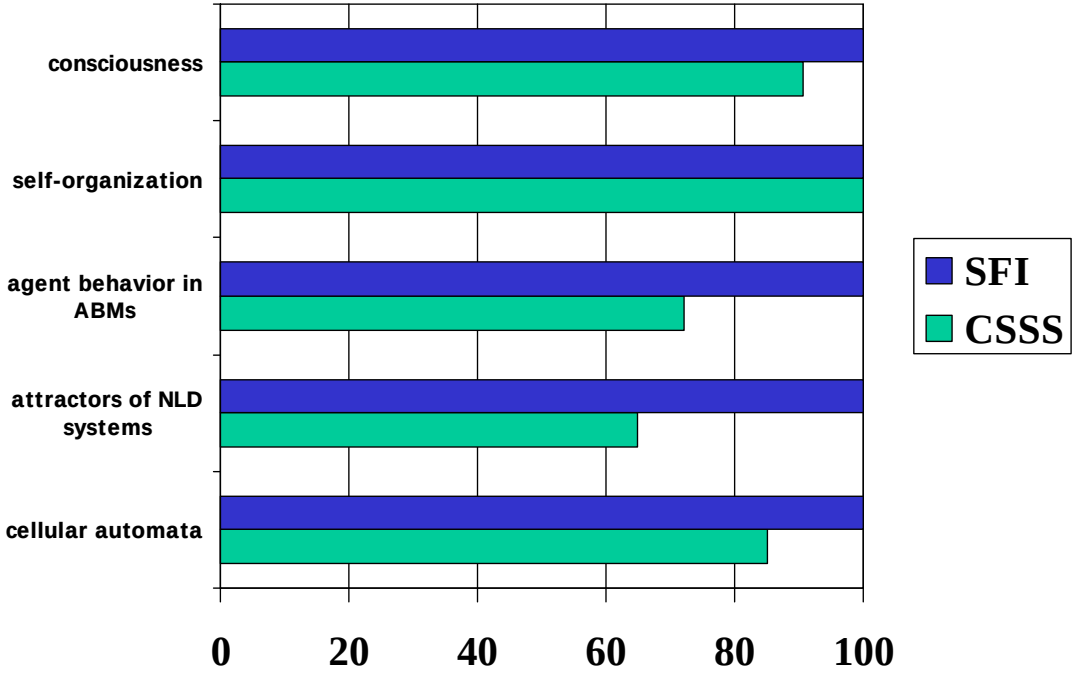


Complexity scientists aren’t picky about ontology!

Examples of emergence: on which can we agree?

Concepts can be defined in at least two ways:

1. Necessary and sufficient conditions
2. Definition by example, making up for vagueness: "The explanatory component of reductionism is vague, but despite the vagueness I think we often know when it has been satisfied and when it has not"(Field)



particular examples:
life,
stock-market,
immune system,
animal schooling behaviors,
culture,

Concepts of *prediction* in complexity science

Prediction concepts:

1. *Simulation Only* -- you can't predict the future of a system without running a simulation
2. *Inductive prediction* -- if you see the base and the emergent linked, you can 'predict' the emergent when seeing the base in the future
3. *Theoretical prediction* -- the emergent can be predicted from lower level even without prior experience with higher level
4. *Prediction-only-in-theory* -- although theoretically possible, prediction might be impossible due to flaws in models and sensitive dependence on initial conditions

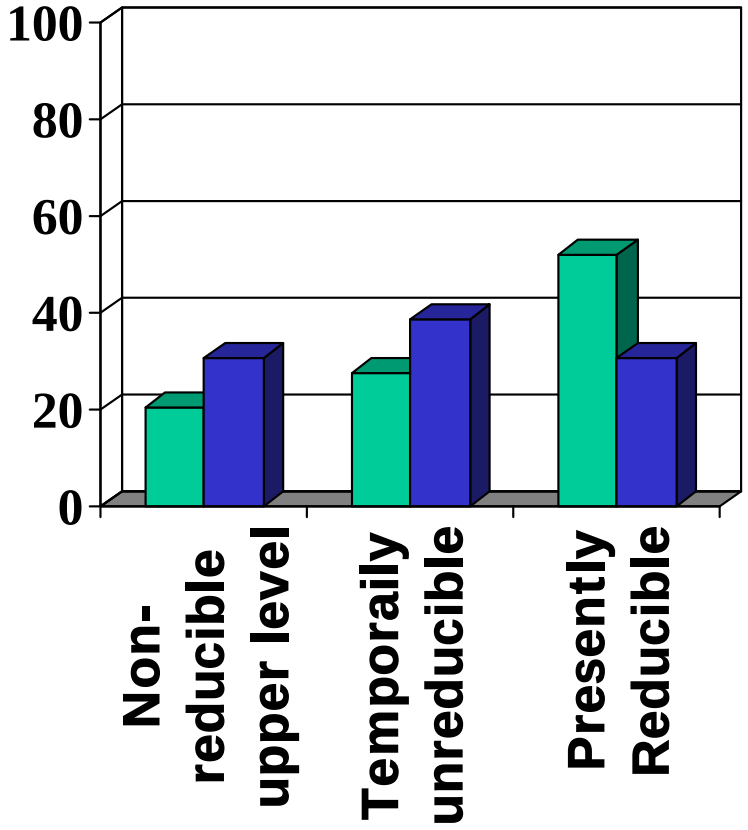
Prediction Survey Data: can we predict emergents?

	CSSS	SFI
•in due time--but right now we're too ignorant! (*theoretical predictability*)	100%	70%
• by computer simulation (*simulation*)	100%	76%
• they're practically unpredictable (*predictability-in-theory*)	50%	54%
• never: there's no hope!	17%	52%

CS methodology goes again absolute unpredictability of emergent entities.

Problem: there are different levels of prediction -- could predict the specific state

Reduction: are emergents reducible?



About 60% of those surveyed think emergents are either presently reducible, or will be in due time.

Responses make sense in light of complexity methodology --methods like cellular automata and agent based models are based on explaining and producing emergent behavior in a way which connects the upper and lower levels directly, possibly allowing for reduction.

Causation: confusion in concepts

Two questions for complexity science:

1. Does downward causation make sense?

Answer 1:

--complexity scientists don't generally consider simultaneous downward causation, so it's hard to tell if they think it is incoherent.

--philosophers find the concept incoherent.

--in our survey, 1/3 of each group thought downward causation incoherent

2. Is downward causation related to emergence?

Answer 2:

--research methods in complexity science don't allow for downward causation. e.g. cellular automata don't allow for the violation of local laws by emergent entities -- the emergent entities *result* from the local laws

9% of CSSS and none of SFI think that downward causation allows laws to be broken on the lower level

62% of CSSS and 75% of SFI think that downward causation, if it means anything is a product of feedback, and doesn't involve law violations.

Conclusions

1. Complexity scientists generally agree that emergence is important, but key terms--emergence, reduction--are not defined to everyone's agreement, and are often defined by example rather than be sets of necessary and sufficient conditions.

2. Complexity scientists seem to rely on one of two concepts of emergence:
a. phenomenological -- those who think that entities are only emergent because they are novel or unexplained -- this is observer-relative;
b. epistemic -- there might be emergent phenomena better described at different levels of description (particle-level CA descriptions).

3. Strong downward causation is not a part of the consensus complexity science emergence concept. While irking the philosophers, this does not bother the scientists, for whom normal feedback relations are sufficiently interesting.