

Emergentist Perspectives on Cognition and Development

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Four Questions

- What is emergence?
- Why does emergence matter?
- How well do we understand emergence?
- How can we advance our understanding?

Resultants vs. Emergents

Every resultant is either a sum or a difference of the co-operant forces. [...] It is otherwise with emergents, when there is a co-operation of things [...]. The emergent is unlike its components insofar as these are incommensurable, and it cannot be reduced to their sum or their difference.

(Lewes 1875, p. 412)

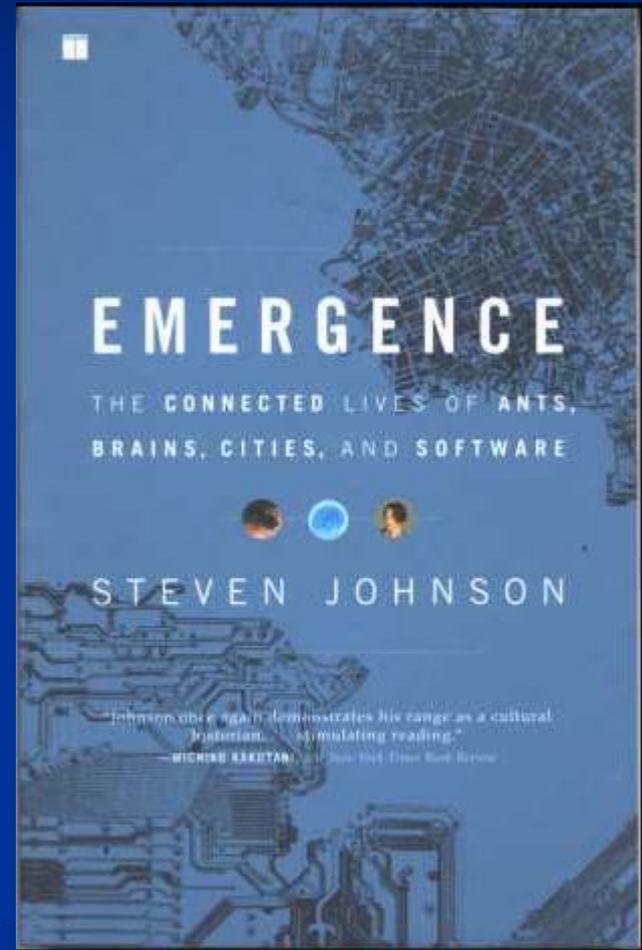
Emergent Properties

According to the Wikipedia

- An emergent property of a system is one that is not a property of any component of that system, but is still a feature of the system as a whole.
- According to an emergent perspective, intelligence *emerges* from the *interactions among* neurons, mediated by their connections.
- From this perspective it is not necessary to propose a “soul” (or *central executive*) to account for the fact that brains can be intelligent, even though the individual neurons of which they are made are not.
- Emergent phenomena may be more or less complex than the substrate from which they arise.

Examples of Emergent Phenomena

- Transitions between solid, liquid, and gaseous states
- Properties of molecules, proteins, organelles, cells, organs, organisms
- Bubbles, honeycombs
- Mountains, oceans, rivers, continents, planets, solar systems, galaxies, universes
- Evolution and development of organisms
- Ant colonies
- Properties of individuals in collections
- Markets, economies
- Cities



Some Phenomena in Cognitive Science – Are they all Emergents?

- Categories, prototypes, rules
- Lexical entries
- Grammatical and semantic structures
- Cognitive modules for words and faces
- Attention, working memory
- Choices and decisions
- Memories for specific episodes or events
- Deep dyslexia
- Category-specific deficits
- Deficits in the hierarchical organization of behavior
- Appearance/disappearance of behaviors in development
- Object permanence
- Stage transitions
- Sensitive periods
- Language structure and language change

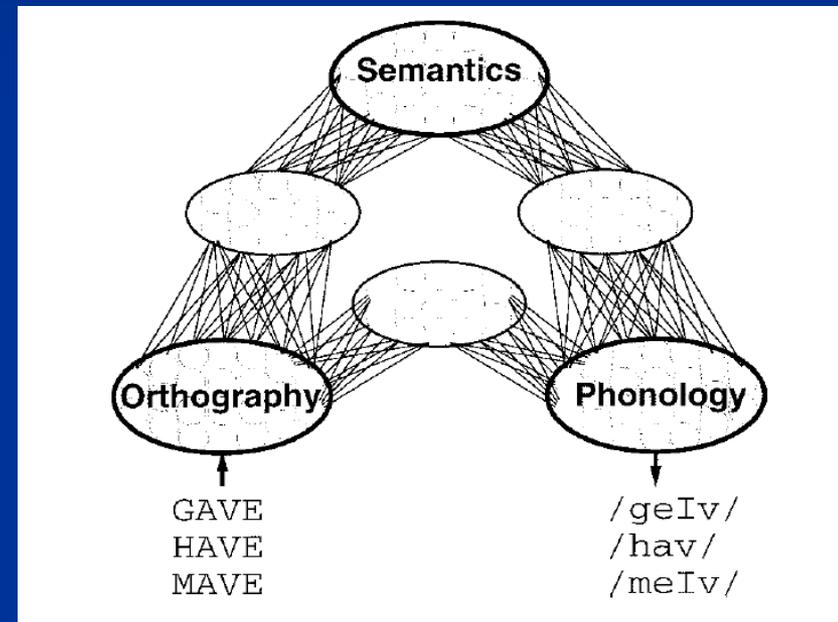
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Example:

PDP models of reading can...

- Read regular words, exception words, and nonwords without rules or lexical entries.
- Match data showing graded sensitivity to consistency and frequency in response choices and reaction times.
- Account for detailed aspects of deficits including
 - Graded effects of damage
 - Co-occurrence of semantic and visual errors in deep dyslexia
 - Regularization errors in surface dyslexia
 - Correlation of semantic impairment and surface dyslexia
 - Patterns of individual differences in these correlations



Sem: APRICOT

“peach”

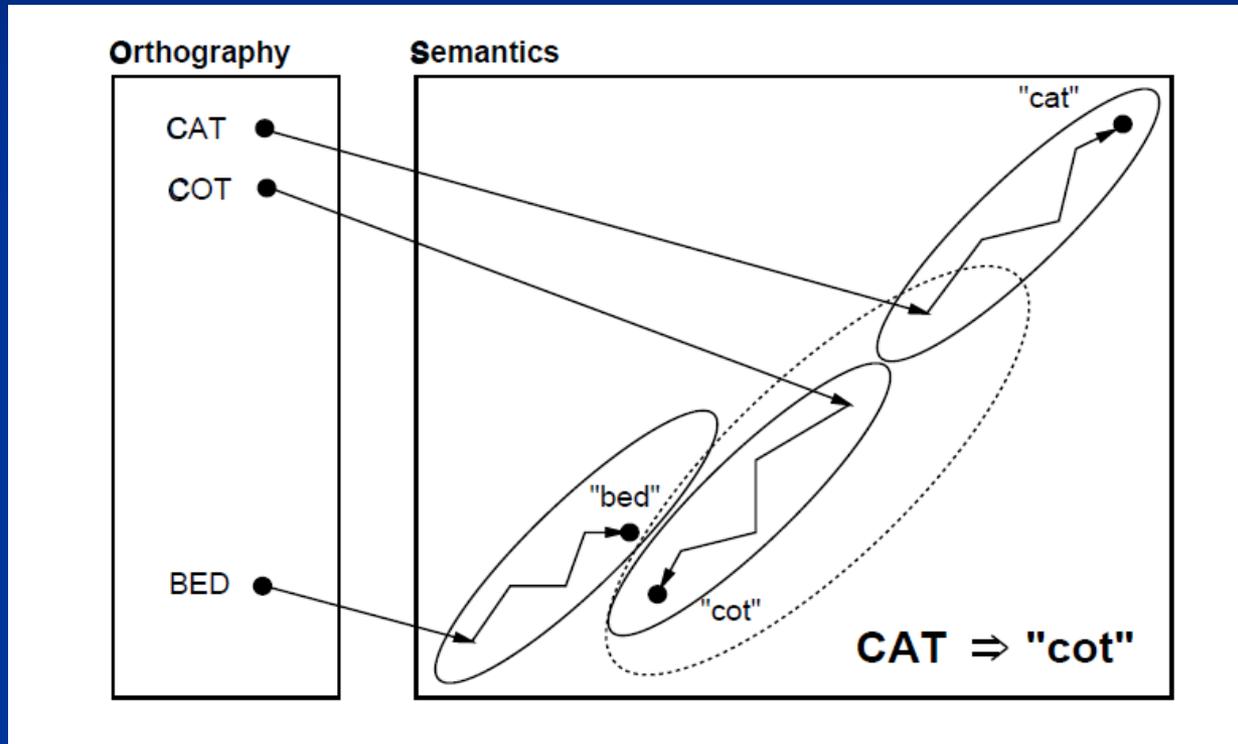
Vis: FLASK

“flash”

Reg: CAFE

“caif”

Basis of Visual Errors in Deep Dyslexia



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Object Permanence and The A not B Error

(Thelen et al, BBS, 2001; Munakata et al, Psych Rev, 1997; Munakata, Devel Sci, 1998)

- Do young children lack “The Principle of Object Permanence”?
- Or have they not yet acquired the ability to sustain a tendency to respond to an object that is no longer visible?
- What underlies the striking A-not-B error?
 - Failure of knowledge or competing response tendencies?
- Basic object permanence behaviors and the A-not-B error are both highly sensitive to task details – ages at which these effects can occur are easily manipulated.
- In emergentist accounts, these effects emerge from gradually-developing abilities that must be strong enough to withstand delays and other impediments and to compete with other forces favoring alternative response tendencies.

Why Does Emergence Matter?

- Because it explains phenomena in terms of their substrate without reducing them to it.
- Because it explains how phenomena arise without the need for a blueprint or plan.
- Because an emergent account allows us to see more clearly how the phenomenon is more graded, approximate, and context sensitive than would otherwise be apparent.
- Because the phenomenon is contingent on the details of what it emerges from, explaining when it does and does not occur.
- Because the explanation may not require the postulation of something that itself remains to be explained.
 - Gravity
 - Preformation
 - Universal Grammar

How well do we understand emergence?

- Only to a very limited extent –
 - More work is clearly necessary!

What can be done to increase our understanding?

- Increase awareness of emergent phenomena in other domains of science and foster an understanding of their mechanistic basis
- Increase acceptance of and reliance on computational models as vehicles for explaining observed cognitive, developmental and linguistic phenomena
- Work harder on making the explanations for the emergent properties of models more clear
- Increase emphasis on understanding underlying mechanisms and processes

Credits and Bibliography

- Braitenberg. *Vehicles*
- Rumelhart et al. *Parallel-Distributed Processing*.
- Elman, Bates, Johnson, Karmiloff-Smith, Parisi and Plunkett. *Rethinking Innateness*
- Thelen and Smith. *A Dynamic Systems Approach to the Development of Cognition and Action*
- MacWhinney. *The Emergence of Language*.