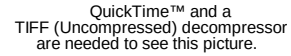
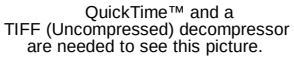
From Backyard to Black tie Science:
Mechanisms of learning and understanding in science



Kevin Dunbar PhD.

Dartmouth College

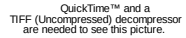


Department of Education

Department of Psychological & Brain Sciences

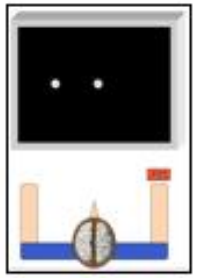
Director: Laboratory for Complex Reasoning & Scientific Thinking

http://www.dartmouth.edu/~kndunbar/research.html



Overall Goal

Understand scientific thinking reasoning, learning and understanding


In Vivo: The museum, the Science lab,

In Vitro: Controlled experiments

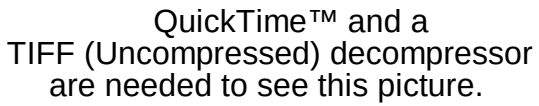
In Magnetico: fMRI experiments

Backyard & Black tie science

Multiple Methods:

Multiple interacting influences

Cultural, social, developmental,
cognitive, practice, neural, gen



Naturalistic (Backyard)

Museums

Lab meetings

Experimental (Black tie)

Psychological experiments

fMRI

Informal science?

- Our earlier work 1991-1992
  - Investigate scientists InVivo
  - Reasoning “live” about their own research
- Discover reasoning strategies they use
  - Use scientists “live” reasoning as data
    - Could use interviews
    - Use laboratory meetings as source of data
- Can combine formal and informal InVitro
  - Analogy, Causal reasoning

Informal-semiformal science

Data collected from

- 10 leading molecular biology labs
- over 1 year period in Canada, USA, & Italy

Access to all meetings

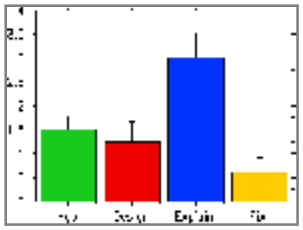
- Personnel, documents, data

Lab meetings

Over 200 Hours of tapes

- Live discoveries, Projects that failed
- Code data on 3 dimensions
  - Knowledge' Cognitive processes, Social interactions

Findings



Causal Reasoning: Unexpected Findings

Drives much of the reasoning

Analogical Reasoning

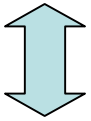
For hypotheses and explanations

Collaborative Reasoning

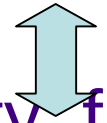
Reasoning distributed over individuals

Research agenda

Naturalistic science

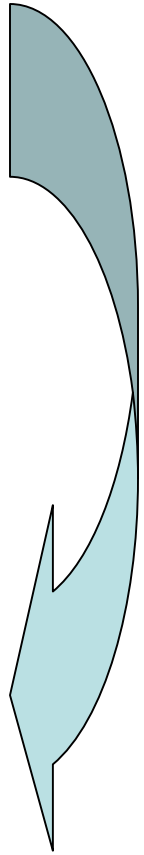


experimental analogy, experimental causality
politicians analogy, teaching analogy



fMRI causality, fMRI & experimental analogy

Museum analogy, museum causality



Research Team

Dunbar, Atkins, Nelson, Green, Fugelsang

Analogy

Blacktie scientists say it is important

Educators say it is important

Museums use analogies in their exhibit designs

Cognitive psychologists extol its virtues

Yet research shows people have great difficulty with analogy. Why?

Why is analogy so difficult

- Generation studies
- Memory studies
- Difficult to get people to attend to underlying concepts
- Most recently we used fMRI to investigate understanding of analogy

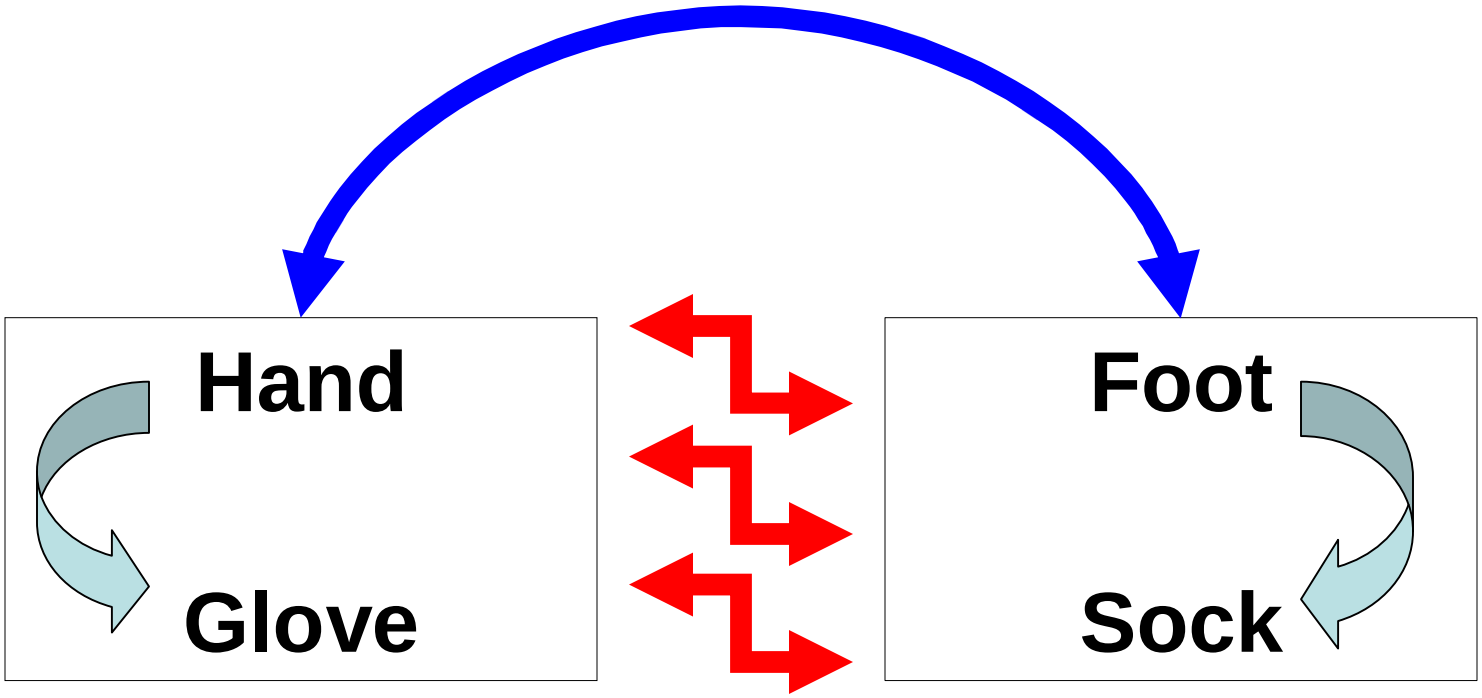
fMRI work

Decompose the different components of analogy

- Semantic relations
- Categorical relations
- Underlying abstract relations

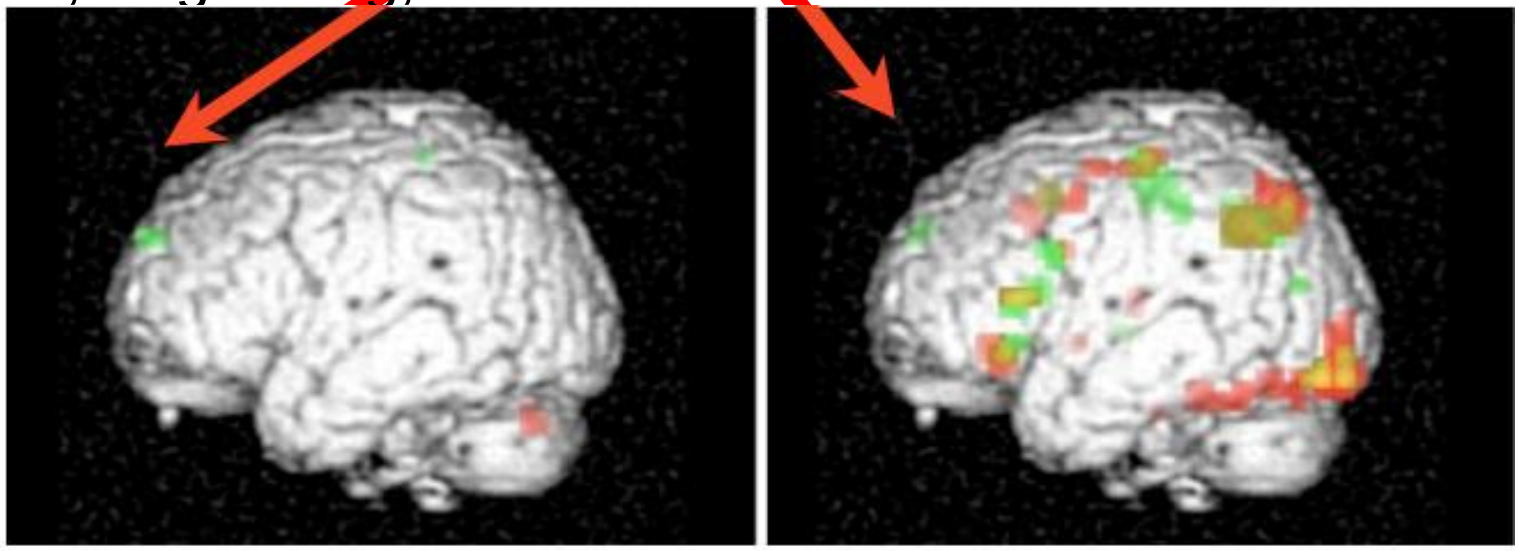
Do different brain sites show different activations for these components of analogy

Analogical relations



Analogies: Multiple conceptual binding

Green, Fugelsang, Shamosh Dunbar 2006



Multiple conceptual binding

Hypothesis

For analogies to work they need multiple conceptual binding sites

Implication is that lasting learning and understanding needs multiple conceptual binding sites: not just a fact

Anomalies in blacktie and backyard science

Blacktie science: attend to anomalies

Bring to my lab:

Participants Given

data and theories

What happens when data

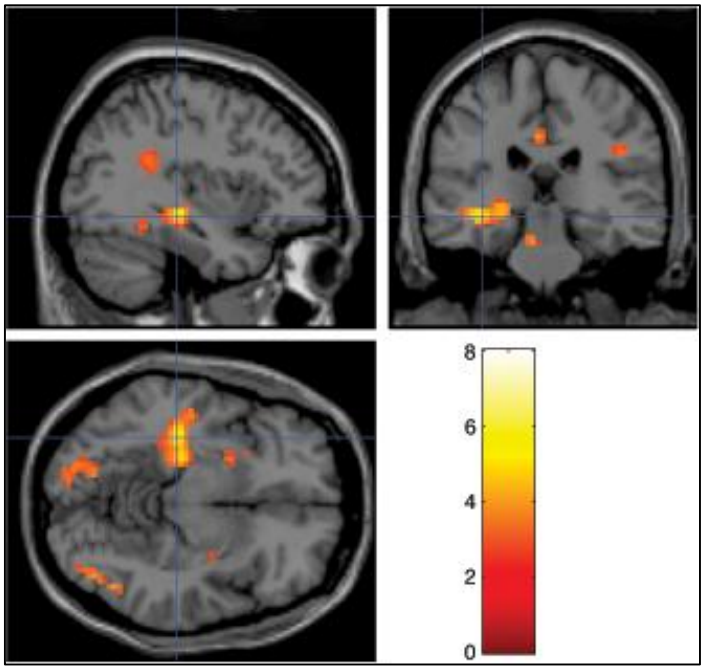
consistent

inconsistent?

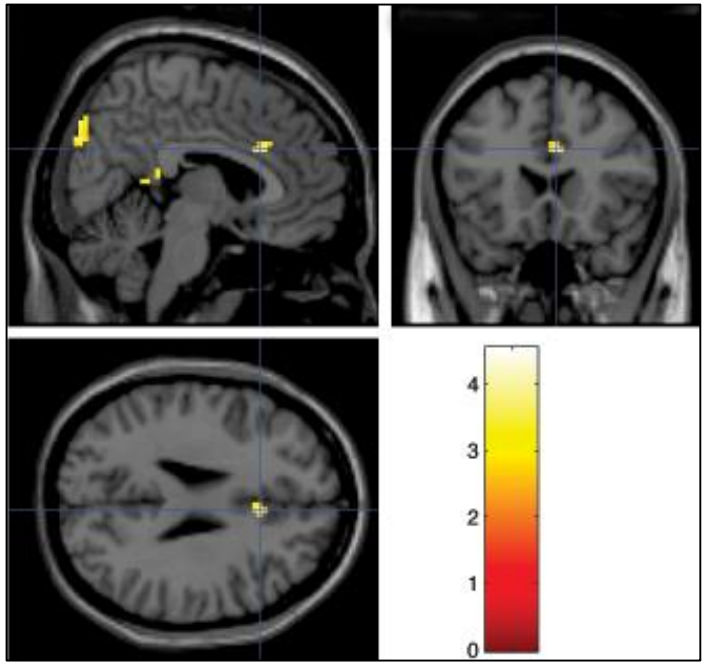
Gave students theory then 20 data points

Responding to Data

Fugelsang & Dunbar 2005, Neuropschologia



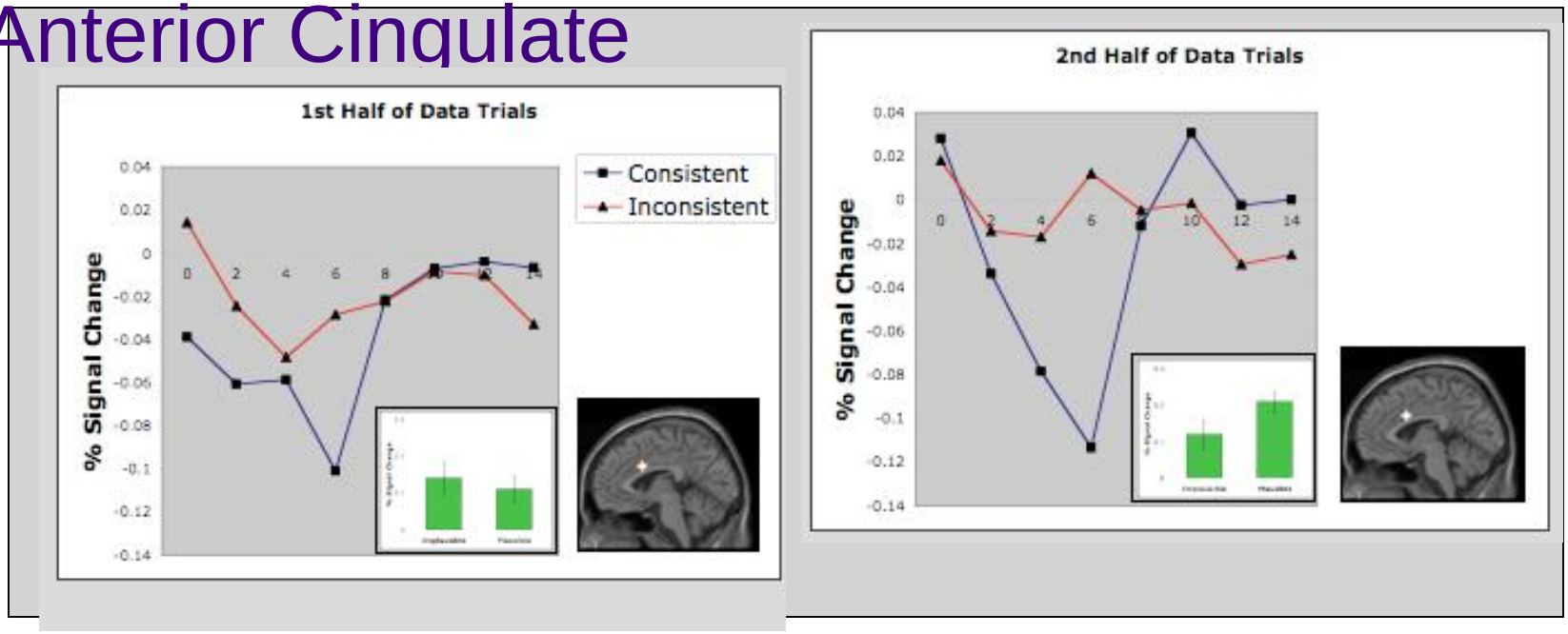
Data Consistent: attended to



Data Inconsistent Gated out

Amount of Inconsistent Data

Anterior Cingulate



fMRI showing rejection of data Just presenting many times doesn’t help

Apply multiple conceptual binding theory to museum practice

TEAMS: Traveling Exhibits at Museums of Science

An exhibit collaborative for small museums NSF funded

Montshire Museum of Science, Norwich Vermont

Discover ways that enhance exhibit design

Leslie Atkins Postdoctoral fellow

David Goudy, Director Montshire museum of Science

Maureen Callanan

QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

What happens at an exhibit?

Two Open ended exhibits

(Atkins, Goudy Dunbar -2006 under revision)

Radically different interactions

Kalliroscope: what do people do?

Dad: What's that?
Girl: I don't know. I don't know how to work it.
Dad: 'Spin me' it says.
Girl: I spinned it. What's so great? Nothing's happening.
Dad: I don't know what it does. It says 'spin me.'
I don't know what it is. What are these things? Speakers.
Is there a button here?
Girl: Yeah. 'Fifteen.'
Dad: Hit it.
Girl: It's not a button.
Dad: If you stand back here, Abby, it looks kinda cool.

Label Not enough

Just giving a label doesn’t provide any conceptual hook

Need to provide multiple conceptual binding points, goals, contexts

Multiple Conceptual Binding Points

We've highlighted one aspect of the exhibit

Turbulence.

Gave Multiple Conceptual Entry points:

Things to notice.

The vocabulary necessary to discuss it.

Pictures that relate it to real world phenomena.

Questions that lead them to notice important aspects of the exhibit.

Introduced walls

kalliroscope

Kalliroscope: Multiple conceptual binding points

Conversations were about science:

Heat camera

The Infrared Camera Originally used at the Exploratorium

- Detects IR and turns into a B&W image.
- The brighter it is, the higher the temperature.
- Visitors might discuss: radiation, temperature, conduction, friction

A successful exhibit

Can we improve the exhibit with more tools?

- Give visitors tools to explore heat (alternate conceptual bindings)
- Tap into vast educational and psychological knowledge of heat concepts
- Designing experiments
  - familiar concepts
  - familiar tools
  - fun

Look at the screen to see how gloves and mittens look through the "eyes" of a heat camera.

Notice that all of the gloves/mittens look the same on screen before you put them on.

Try the gloves/mittens on.

- Which glove traps your heat better?
- Which glove lets more of your heat leak out?

Turning museum into a lesson

Look at the screen to see how gloves and mittens look through the "eyes" of a heat camera.

Notice that all of the gloves/mittens look the same on screen before you put them on.

Try the gloves/mittens on.

- Which glove traps your heat better?
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Why the difference in exhibits?

Kalliroscope

- Open-ended unhelpful
- Need conceptual binding points
  - Unfamiliar concept
  - no background knowledge readily available

Heat Camera

- Open-ended very productive
  - Have too many conceptual entry points
  - No way to bind: Props decrease interest

Focus of our museum research, so far

The exhibit

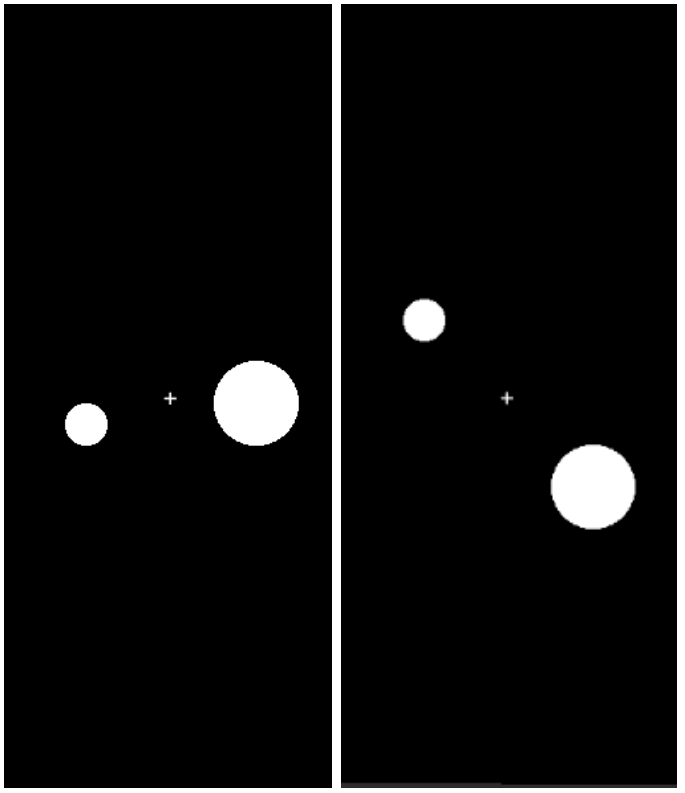
The social interactions

But what about the visitor's conceptions

Emerging view

Visitor brings knowledge of

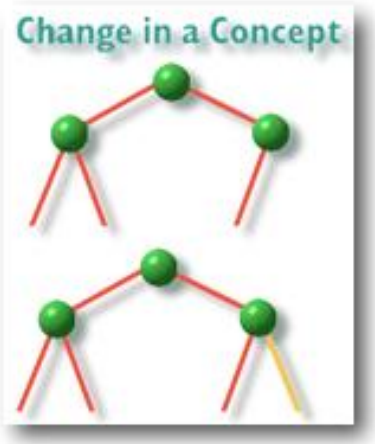
- Core Content areas
  - To many tasks
  - Can inhibit new info
  - Can elaborate new info

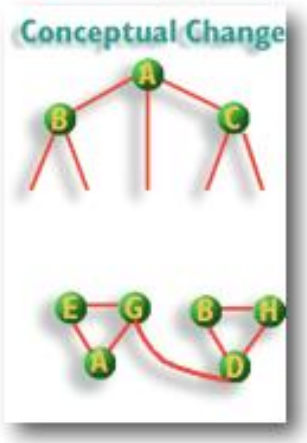


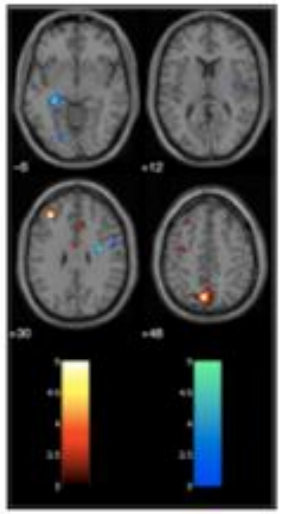
Can we change peoples concepts?

Very difficult

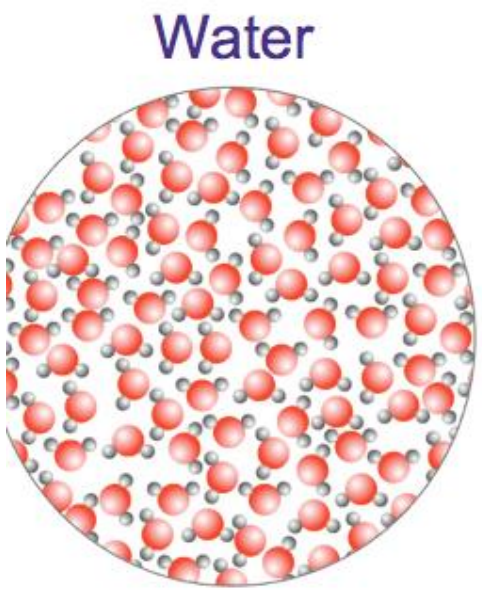
If visitors enter with one conceptual binding

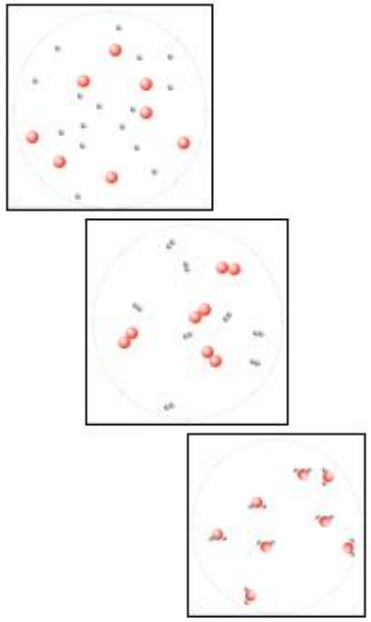






Understanding conceptions





Other Directions

Nature as an exhibit

Trail of Time

Karl Karlstrom

Needs for informal science

1. Use informal and experimental together
2. Make a public repository of informal data like CHILDES, or fMRI, or Genome
3. Use multiple methods and approaches

Educational neuroscience not a replacement but works in conjunction

(a) The types Multiple conceptual binding sites driving learning and understanding

(b) The control mechanisms that underlie learning

Thank you

Collaborators

Museums:

Leslie Atkins

David Goudy

Lisanne Velez

Maureen Callanan

fMRI and conceptual Change

Jonathan Fugelsang

Jim Nelson

Adam Green

Raphael Lizcano