Tree-thinking: Do Pictorial Representations of Evolutionary Relationships Help or Hinder Museum Visitors' Understanding?

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Understanding the Tree of Life Conference

Carnegie Museum of Natural History
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1. **YOUR AUDIENCE:** Public’s & Students’ Understanding of Evolution

*Differs by: Evolutionary Theory, Age-group, Species.*

2. **Study One:** Museum visitors’… (no trees)

3. **Study Two:** Museum visitors’… (with trees)

4. **Implications:** Building on our intuitions…
NATIONAL/INTERNATIONAL SURVEYS
Focus: Common Descent

US Gallup Poll (2007: unchanged 20 Yrs)
• 45%: God created humans (God Only)
• 38%: Theistic evolutionist (both)
• 13%: Evolutionist (no God)

• Creationism NOT -general ignorance of science! (Mazur, 2005)
CHILDREN’S EXPLANATIONS
Focus: Common Descent

• 5-7 yrs: Proximate cause ("it was someplace else" "it appeared") & creationist.
• 8-10 yrs: Creationist ("God made it") regardless of community or parental beliefs.
• 10-12 yrs: Like the adult community (creationist, evolutionist, mixed)
  (Evans, 2000, 2001, 2008; Poling & Evans, 2004)
Explanations Differ by Species
Focus: Common Descent (Evans, 2008)

Who Evolved? (Range: 1-4 + SE)
Humans, Other Mammals, Frogs, or Butterflies

- Humans/Mammals
- Frogs/Butterflies

6-7 years: [Graphical representation]
8-9 years: [Graphical representation]
10-12 years: [Graphical representation]
Adult: [Graphical representation]
High school, college, & medical students resist instruction (e.g., Brumby, 1975; Bishop & Anderson, 1990)

• “Need-based” adaptation: Rabbits get white fur in winter in order to hide themselves from predators

• Ignores within-species variability

• Natural Selection: Rabbit ancestors with white fur more likely to survive and reproduce
CLAIM One reason we don’t get evolution: Intuitive “essentialism”

Each kind of animal has a unique unchanging “essence:” (Mayr, 1982)

Implications:
1. Common Descent: One kind of animal cannot change into another
2. Natural Selection: Ignore within species variability

Research Prediction: “Tree-thinking” challenges 1, but not 2
Study 1: A Conceptual Guide to Museum Visitors’ Understanding of Evolution

- 30, adult, natural history museum visitors
- 60% college educated or beyond
- Asked to explain 7 problems about the emergence of “new” species:
- Were NOT told that these were “evolutionary” problems
- Responses transcribed & coded (IRR >85%)

(Evans, Spiegel, Gram, Frazier, Tare, Thompson, & Diamond, 2010)
HIV
Diatom *Stephanodiscus yellowstonensis*
Ant - Fungus - Microfungus - Bacteria
Hawaiian *Drosophila*
Finch *Geospiza fortis*
Human and Chimp
Whale *Rodhocetus*
Study One: Example of Question (NO Trees; No scaffolding)

FRUIT FLIES. There were once no fruit flies on Hawaii (*show map*). Then, about 8 million years ago, a few fruit flies landed on one of the islands. Now there are 800 different kinds of fruit flies in Hawaii (*show photos of flies*). How do you think that happened?
Explanation Patterns

1. Evolutionary Reasoning
   Evolutionary Themes: Term or Concept

2. Intuitive Reasoning
   Need-based; Anthropomorphomic

3. Creationist Reasoning
   Explicit rejection; implicit belief
Museum Visitors Explanations

Not ONE visitor was exclusively evolutionist

MIXED PATTERNS

• Evolutionary/Intuitive (72%)
• Evolution/Intuitive/Creationist (28%)
  (Creation - Human mostly < public at large)

DOMINANT (Most Frequent) PATTERN
• 38% Evolutionary Reasoning
• 53% Intuitive Reasoning
• 6% Creationist Reasoning
Themes: Related to Essentialism Claims...

Possible Range: 0-7 for each theme

1. Common Descent (Rarely Mentioned)
   *Common descent:* $M = 0.8$; Range 0-2
   *Between-species relationships:* $= 0$

2. Natural Selection ( Mentioned more often)
   *Natural Selection:* $M = 1.0$; Range 0-5

3. Need-Based ( Mentioned more often)
   *“Need-based:”* $M = 1.6$; Range 0-6
FINCHES
Evolutionary & Intuitive Patterns
“Need-Based Reasoning”

• “Evolution for survival. ...Well, in order to survive, their body parts had to adjust to certain things, similar to the way giraffes' necks probably grew long as they reached for the plants at the top of the trees, so the beak grew longer in order to deal with the tougher seeds.”
SUMMARY (No Trees)

• Only, 38% visitors consistently give evolutionary explanations

• (see also Macfadden et al., 2007 & Abrahams-Silver & Kisiel, 2008 – Australia & Canada)

• Humans elicit more creationist reasoning

• Common descent and taxonomic relationships rarely mentioned

• Significantly more likely to mention a mechanism of change (natural selection and/or need-based reasoning)
Study 2: “Tree-Thinking”

- 30 Adults (Novices)
- 13, 15-18 year-olds (youth)
- 21, 11-14 year-olds (child)
- Similar demographics to Study 1 participants
- Typical gallery visit to “Explore Evolution”
- Pre- and Post-test qualitative and quantitative Interviews; demographics
- 15 Evolutionary Biologists (Expert Control)

(Evans et al., in preparation)
Stimuli: Evolutionary Graphics

- Virus, fly, whale and human graphics

Two Main Questions
- What do you think this picture is trying to show?
- How do you think that happened?
- Responses transcribed & coded (IRR > 85%)
The Genealogy of a Killer

HIV causes AIDS, one of the greatest threats to public health worldwide today.
The disease evolved from viruses that infect African primates.
Hawaii as a Nursery of Evolution

More than 800 species of *Drosophila* flies live on the islands of Hawaii and nowhere else on Earth. They may all descend from a single pregnant fly that came there several million years ago.
Our Closest Living Relatives

DNA reveals that humans share a common ancestor with apes, our closest living relatives.

- Chimpanzee
  *Pan troglodytes*

- Bonobo
  *Pan paniscus*

- Human
  *Homo sapiens*

- Gorilla
  *Gorilla gorilla*

- Orangutan
  *Pongo pygmaeus*

The common ancestor humans share with chimpanzees and bonobos lived about five to six million years ago.
Whales: Evolution from Land to Sea

Today's whales evolved from four-legged land mammals that lived about 55 million years ago.
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Linking Whales to the Past

Philip Gingerich compares the bodies of ancient whales with the skeletons of living whales. By discovering their similarities and differences, he is learning how whales evolved from land mammals.
Focus 1: Common Descent
“Between” Species Change

Do “trees” (graphics) elicit themes related to common descent?

1. Relationships
2. Common Descent
What do you think this picture is trying to show?

• Adult Novice (Virus): “First thing I guess that leaps out at me is I see pictures of humans, primates and the HIV virus. And it’s set up to show some sort of relationship between the three. ...”
What do you think this picture is trying to show?

• Expert (Fly): “…it’s the relationship, the phylogenetic relationship between the fruit flies that live in the Hawaiian Islands.”
What do you think this picture is trying to show?

Relationships Between Species

Percent of Responses

11-14 Years  15-18 Years  Adults  Experts
What do you think this picture is trying to show?

Common Descent

• Adult Novice “How hippopotamuses and modern whales have a common ancestor. And how some of the earlier fossil records they think played a part in that.”

• Youth “… and they both evolved from a land walking mammal”
What do you think this picture is trying to show?
Focus 2: Within-Species Variability

Do “trees” elicit themes related to within-species variability?
1. Natural selection
2. Need-based reasoning
How do you think that happened?
How do you think that happened?
Conclusion: In contrast with Study One (no “Trees”)

Common Descent
“Tree-thinking” elicits explanations of:
- Between species relationships
- Common descent

Natural Selection
“Tree-thinking” impedes visitors’ (but not experts’) grasp of:
- Natural selection

Elicits need-based reasoning
Why? Trees both challenge and reinforce intuitive beliefs

1. “Trees” challenge the essentialist intuition that change from one kind of animal to another is impossible
   - Foster grasp of species relationships
2. “Trees” reinforce visitors’ intuitions about the mechanism of change
   - No portrayal of within-species variability
   - Present prototypical members of a taxon
   - Implied directionality, towards a goal
Whales: Evolution from Land to Sea

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Gorilla
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Pongo pygmaeus

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Primate Graphic: Easiest to interpret - many noted the human

Adult Novice: “I think it’s interesting it’s done this way, that the picture of the human was right in the middle rather than off to the end...”
Additional Results

1. Nature of science: No visitor mentioned the scientific process (Experts often did)
2. Scientific language: (Experts > Novices)
3. Time (Experts > Novices)
4. Intuitive belief: Change from one “kind” to another (Novices > Experts)
Interpretation: Implications for Exhibit Design

What is your message? Who is your audience?
1. A different learning progression for common descent and for natural selection
   *Fostering one does not necessarily help the other* (see also Evans et al., 2010a; 2010b)
2. Consider age-group/expertise differences
3. Consider species/taxon differences
4. Consider the context/the entire exhibition
Conceptual Gap: The Case of Evolution

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What are the Effects of “Evolution Interventions”?

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