Can Children Read Trees

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My assumptions

- Children in middle childhood have some ‘meta-representational competence’ (diSessa, 2004) but reject graphical superlativism (Green et al, 1991)
- Representational learning is a long term intertwined process of learning with & about representations in specific domains
- Learners need to understand
  - syntax (format (lines, nodes, tips) & operators (how to relate nodes and tips)
  - semantics (e.g. how this represents inheritance)
- Representational competence develops with experience as learners slowly move from seeing representations as depictions, through symbolic understanding, syntactic, semantic and finally reflective use (Kozma & Russell, Halverson)
- This process will be influenced by specific features of the representation – the form of the cladogram and taxa shown.
Research Questions

- O’Hara (1997) claims that just as geography students are taught to read maps, so biology students should learn how to interpret evolutionary trees.
- But we begin to teach map reading at the very earliest years of education… Why not cladograms?
- Can young children reason with cladograms?
- What aspects of cladogram design influence this process?
Participants

- 13 boys and 15 girls, aged between 7:1 and 11:11 years. Parents reported their children's religious faith as 7 Atheist, 16 Christian, 2 non-observing Christian, 1 Hindu and 2 Muslim.
- Attended a summer scientists event at University of Nottingham
15 Minutes Training

- Children were given ‘fake’ cladograms and given simple instruction about the syntax and semantics of cladograms (n.b. no evolution theory)
  - Were reminded of the terms of ancestor and descendant
  - Shown how to find a MRCA
  - Shown how to determine relatedness based upon this
  - Given cladograms with characters and shown how they are inherited
  - Practiced this on new cladogram (with feedback and explanation of reasoning)
  - Finally shown that rotation were equivalent
Design

[4 by 4 by 4 by 4] repeated measures design

- ‘Species’ (content)
- ‘Rotation’, (RRRR, RLRL, LLLL and LRLR).
  - Species and rotation were counterbalanced using a Graeco Latin square design.
- Depth of the tree that needed to be searched to determine the correct answer (1, 2, 3, 4).
- Question type, which also had four levels (ancestor, feature, animal, relation).
Ancestor questions asked children to find the most recent common ancestor (MRCA) of two species. There is always a single correct answer and chance performance @ 25%.

Feature questions asked children to describe what characters a species had. 1 to 4 correct answers with chance performance @ 6.67%

Animal questions ask children to describe what species have particular characters. 1 to 4 answers chance @ 3.22%

Relations questions asked children to say which other species 1-4 correct answers species with chance @ 6.67%

Children saw 4 trees, answered 8 questions (17 answers) per tree and were prompted to explain ‘how they worked it out’ 4 times per tree.
Results

![Bar chart showing % correct across different age groups (7.0-8.3, 8.3-9.5, 9.5-10.5, 10.5-11.9 years).]
Materials
Species

![Bar chart showing the percentage of correct responses for different species. The y-axis represents the percentage correct, ranging from 0 to 100. The x-axis lists the species: Polar Bear, Pigeon, Human, and Flea. Asterisks indicate statistical significance.](chart.png)
Rotation

![Bar chart showing the percentage of correct responses for different rotation types (RRRR, RLRL, LLLL, LRLR).]
Materials

Great White Shark, Salmon, Common Frog, Platypus, Polar Bear
- Live young
- Fur
- Claws or nails
- Bony skeleton

Pigeon, Alligator, Green Spiny Lizard, Goldfish, Jellyfish
- Feathers
- Lays hard-shelled eggs
- 4 limbs
- Backbone

Ring Tailed Lemur, Baboon, Human, Chimpanzee, Spider Monkey
- No fur
- No tail
- Nose points down
- Eyes in the middle

Stick insect, Fly, Flea, Butterfly, Dragonfly
- No wings
- No back wings
- Grows from egg to larva to adult
- Wings fold over body
Depth

![Bar graph showing depth and percentage correct.](image)
Question Types

% correct

Ancestor | Feature | Animal | Relation
---|---|---|---
70 | 60 | 60 | 40

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Correct answers: Strategies

- There was evidence for semantic interpretation
  - "because that’s [a2] the ancestor of the stick insect and the flea"
  - "Because it’s the descendants. You go down, find the ancestor and whichever it goes to means it’s got those feature"
  - because they are all descended from that ancestor

- But unsurprisingly many responses were not semantic
  - "that’s the first dot they have in common"
  - "that leads down there and the rest goes up to all of them"
Incorrect Answers: Strategies

- Still mostly based on reasoning from the tree but misunderstanding the representation (like adults)
  - E.g. Most recent ancestor “Because it’s nearest the top of the descendants”.
  - E.g. Tip proximity “because they are next to each other”.
  - E.g. Node counting “only one dot in between”

- Limited use of ‘real world’ knowledge about physical similarity – less than older learners?
  - “Because I have seen a polar bear once in a film”

- Less evidence of ‘main line and side track’ misconception
Conclusions

- Children from as young as 9 demonstrated a surprising competence with these trees.
- This was influenced by the number of levels they needed to search, the content of the representation and the type of reasoning... But not the rotation.
- However, does not mean they understand evolution...
- For formal education: should we now develop curriculums for younger children based on tree thinking?
  - If so, how?
- For informal ed: how can we help visitors read trees given that performance for these children would have been at a chance without training.