Can Children Read Trees

Shaaron Ainsworth

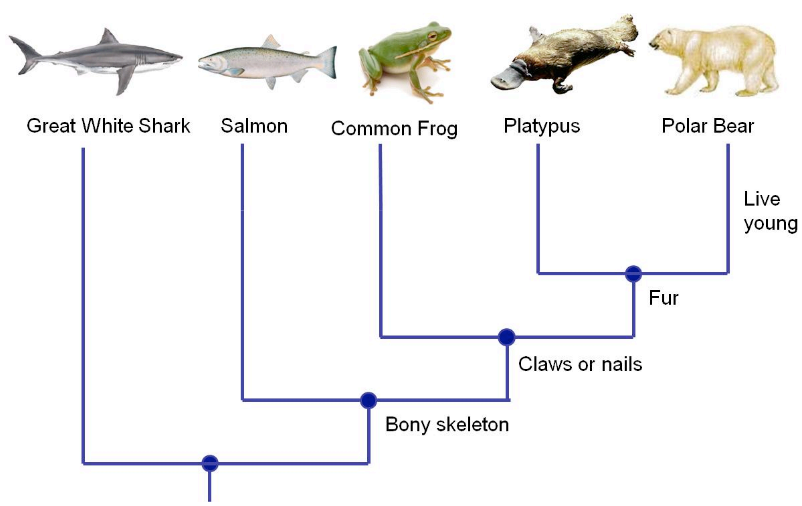
My assumptions

- 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.

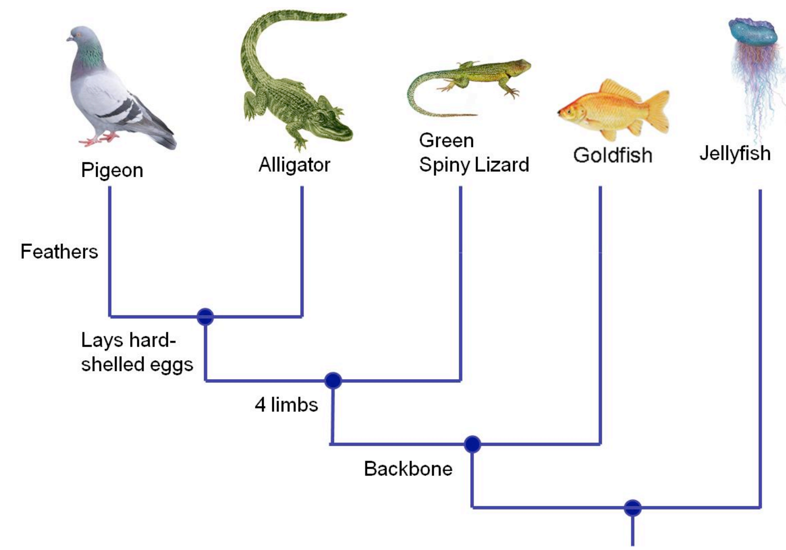
Research Questions

- 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?

Materials



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



Pigeon
Alligator
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Goldfish
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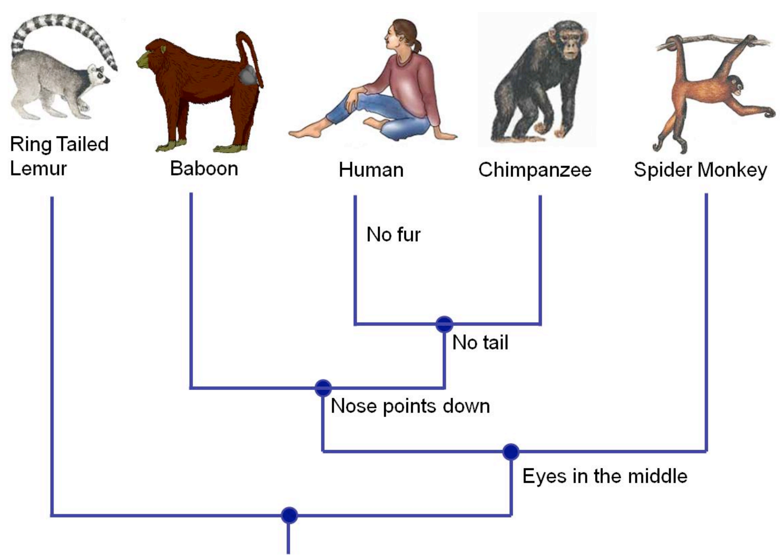
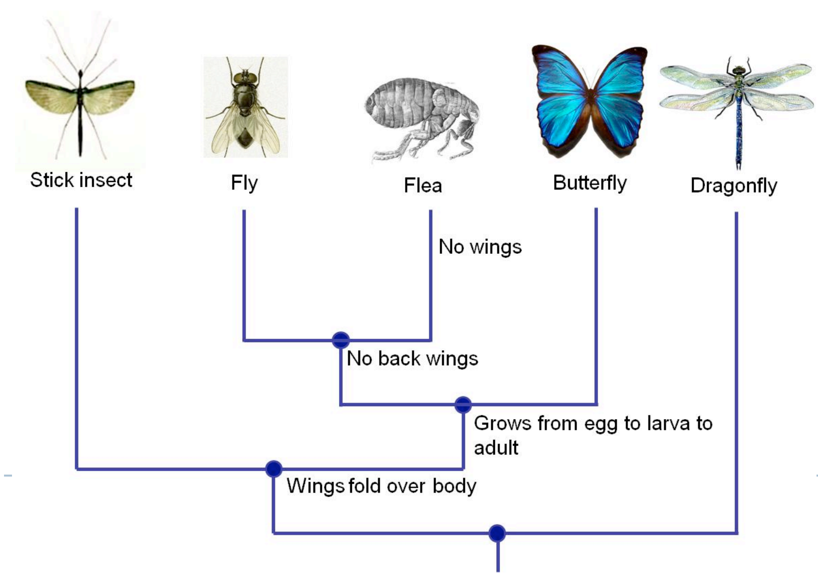
Feathers
Lays hard-shelled eggs
4 limbs
Backbone



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

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

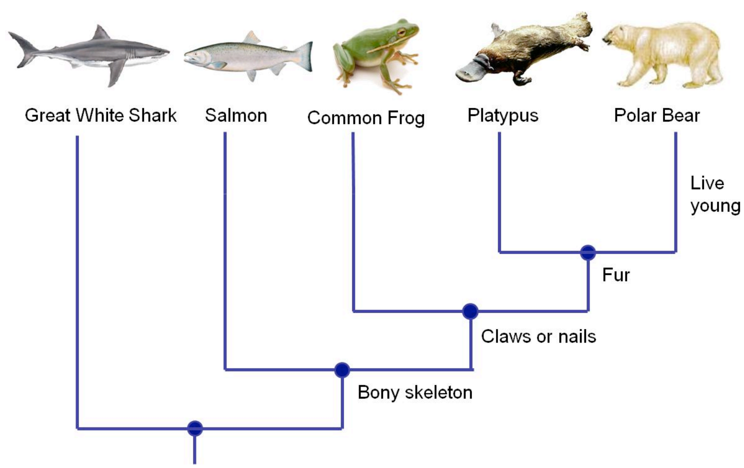
- Children were given ‘fake’ cladograms and given simple instruction about the syntax and semantics of cladograms (n.b. no evolution theory)
  - Were reminded of the terms of ancestor and descendant
  - Shown how to find a MRCA
  - Shown how to determine relatedness based upon this
  - Given cladograms 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).

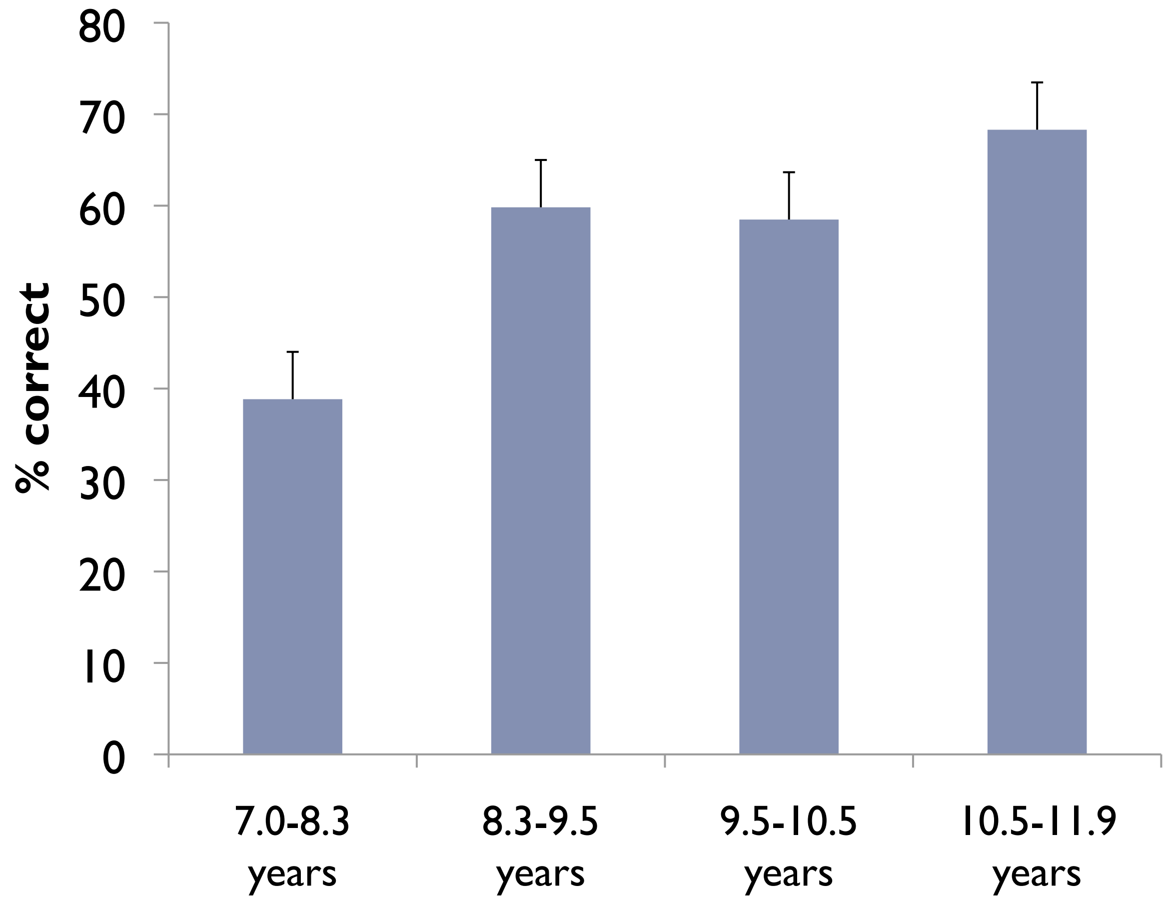
Questions



- 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%

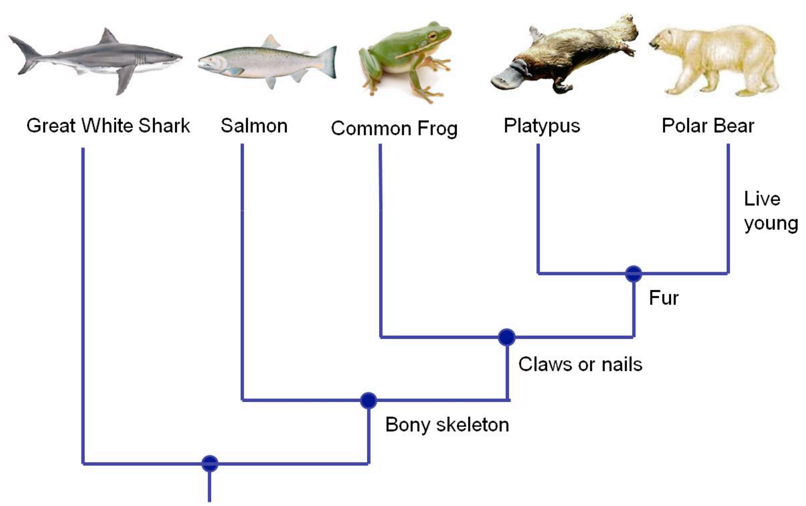
- Children saw 4 trees, answered 8 questions (17 answers) per tree and were prompted to explain '*'how they worked it out'*' 4 times per tree.

Results



% correct
80
70
60
50
40
30
20
10
0
7.0-8.3 years
8.3-9.5 years
9.5-10.5 years
10.5-11.9 years

Materials



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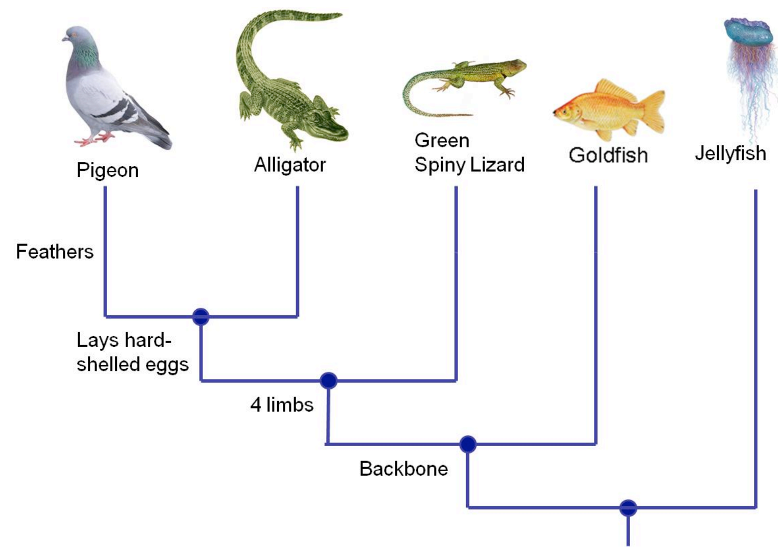
Bony skeleton



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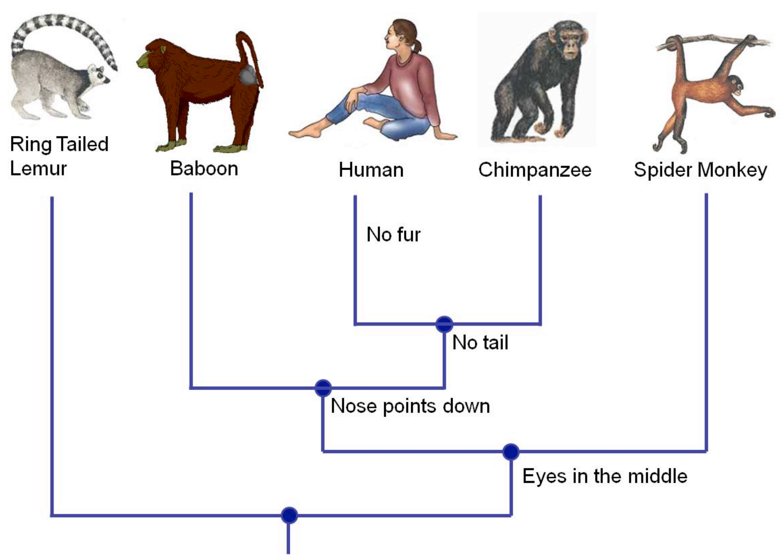

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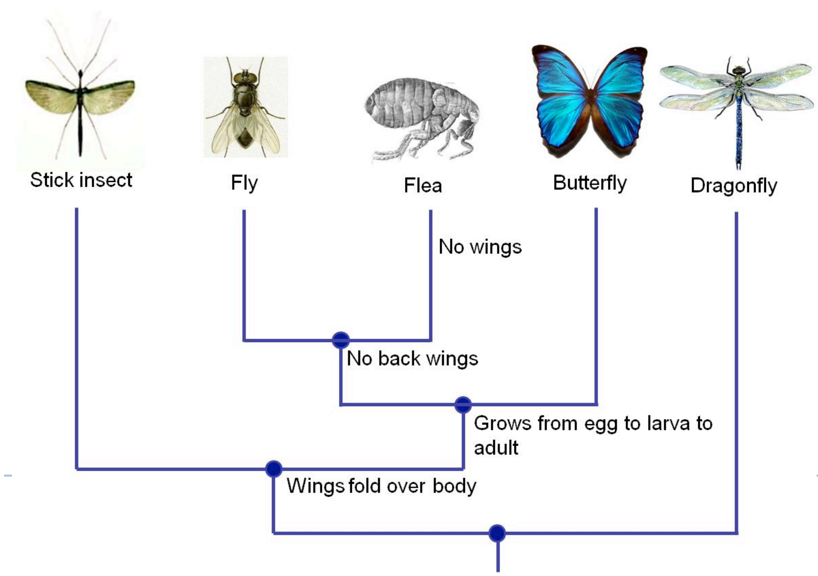

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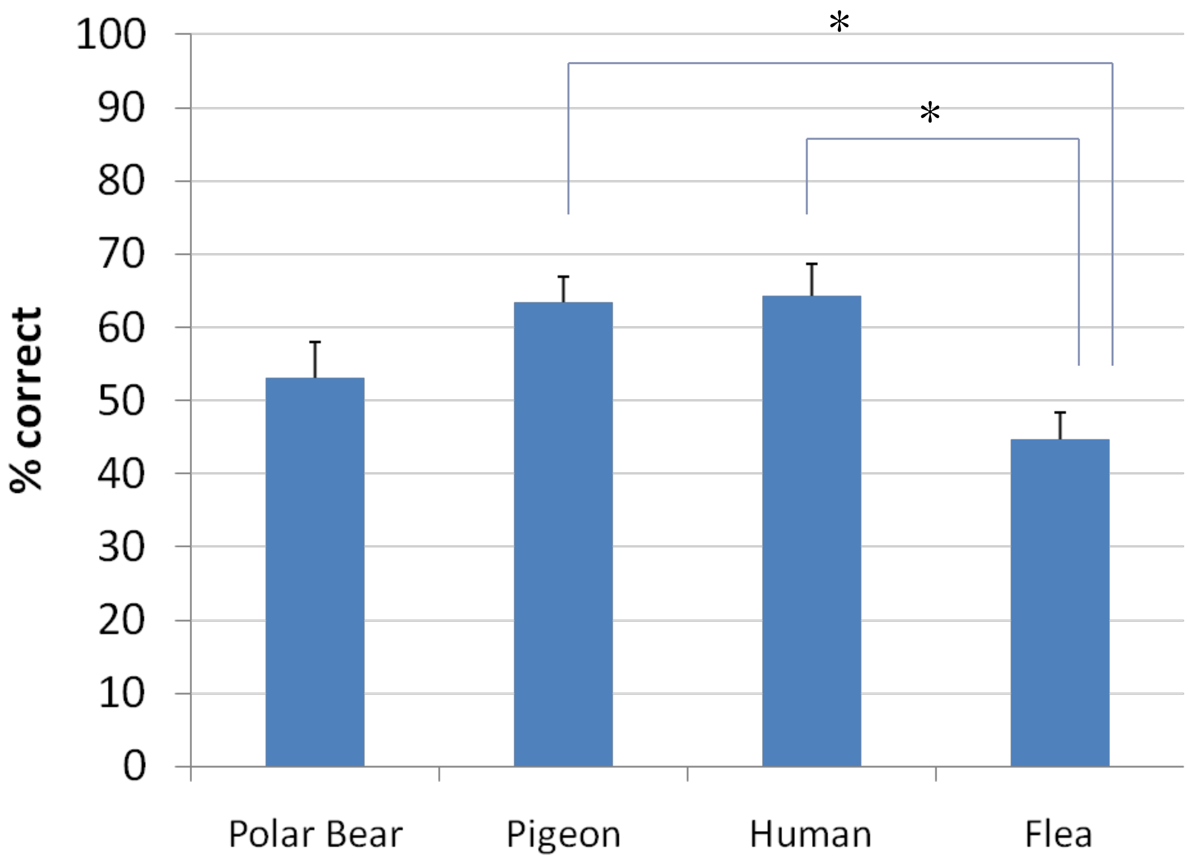
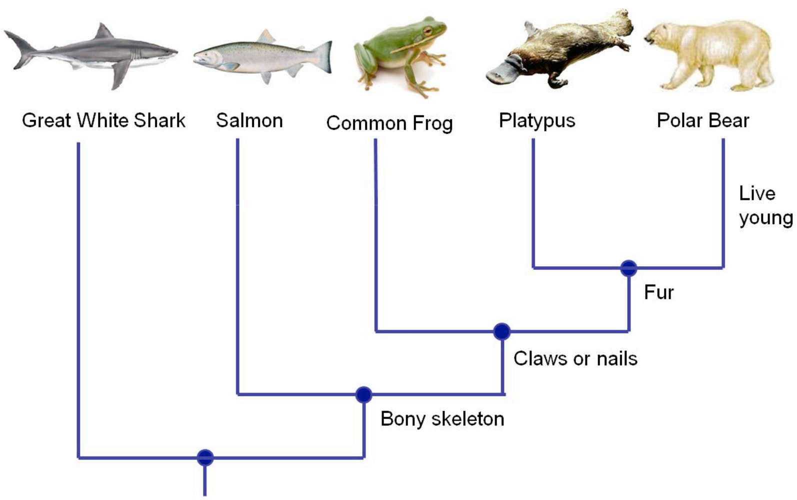
Species



% correct
100
90
80
70
60
50
40
30
20
10
0
*
*
Polar Bear
Pigeon
Human
Flea

Materials



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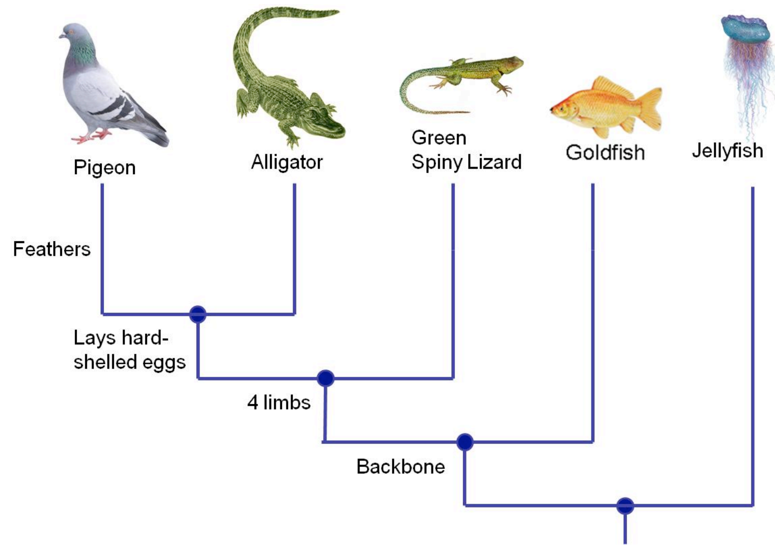

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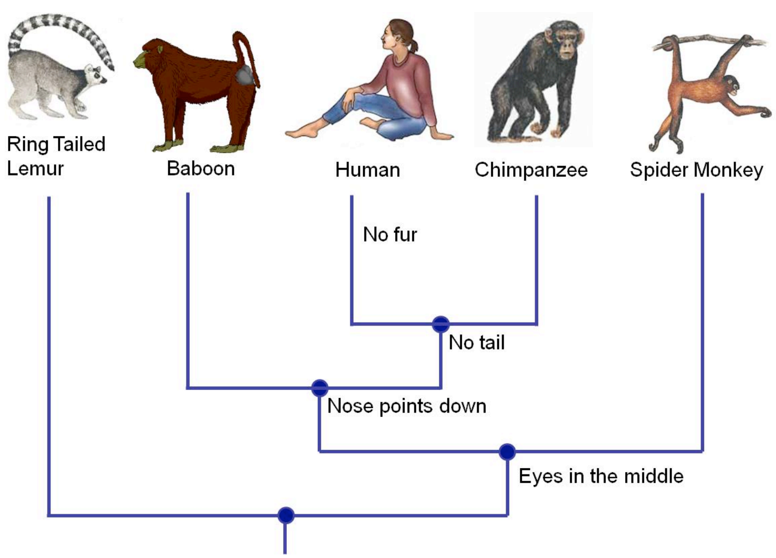

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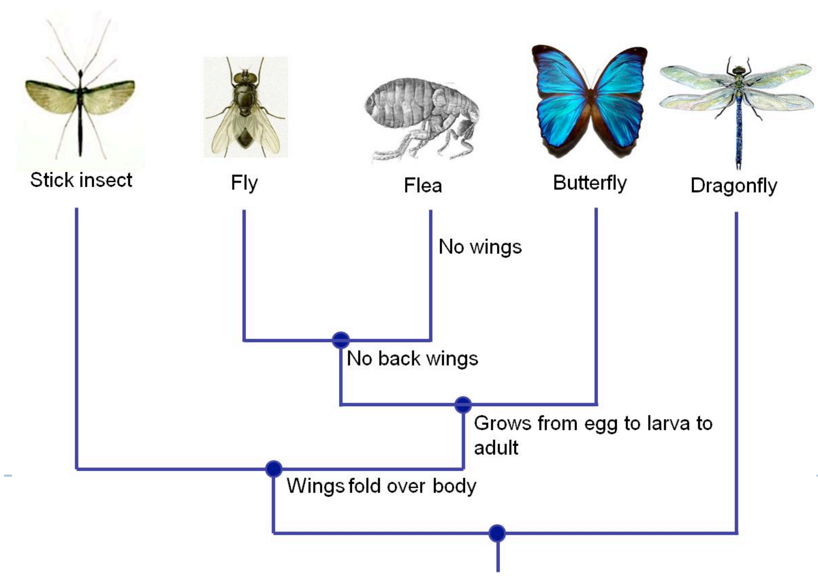

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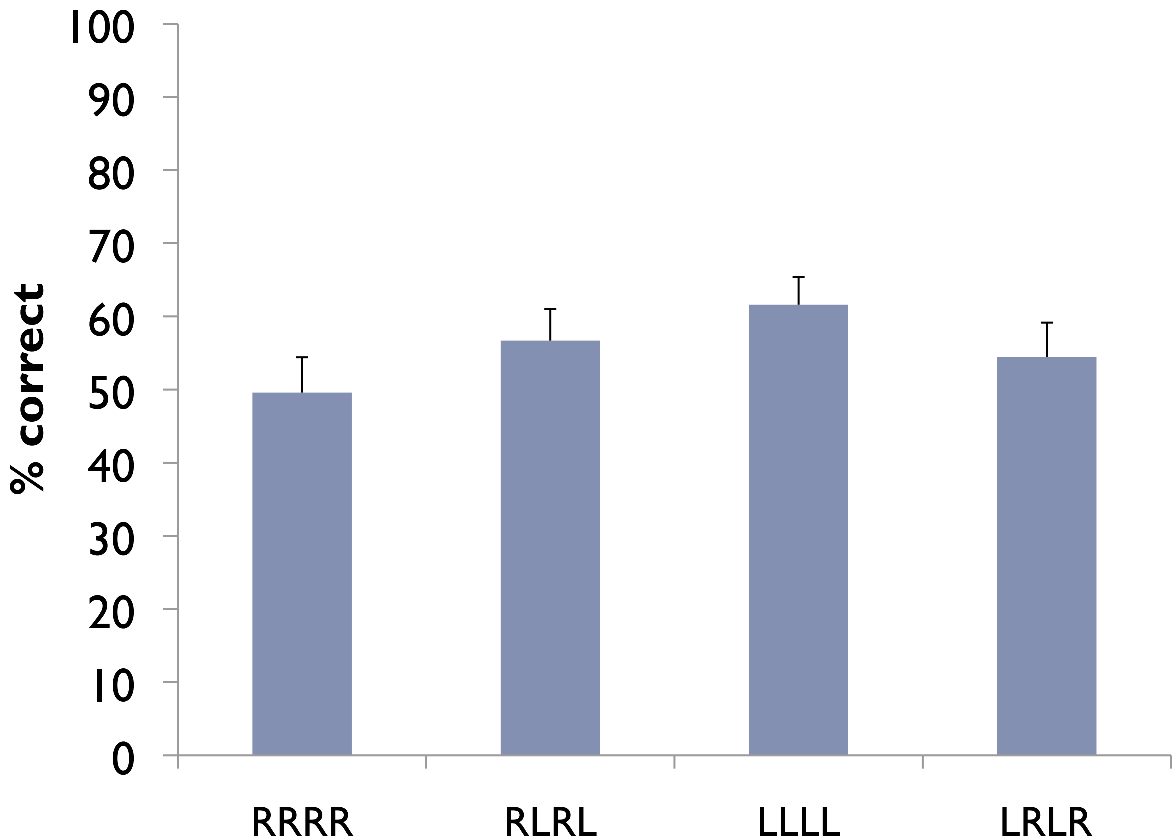
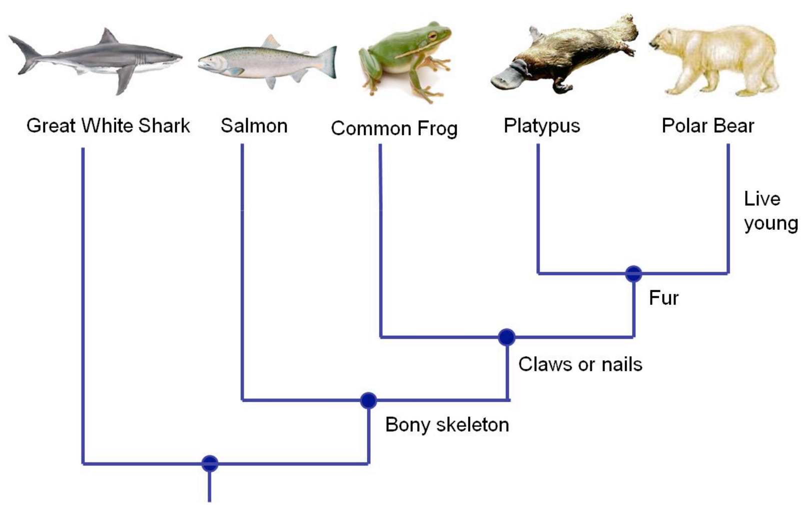
Rotation



Materials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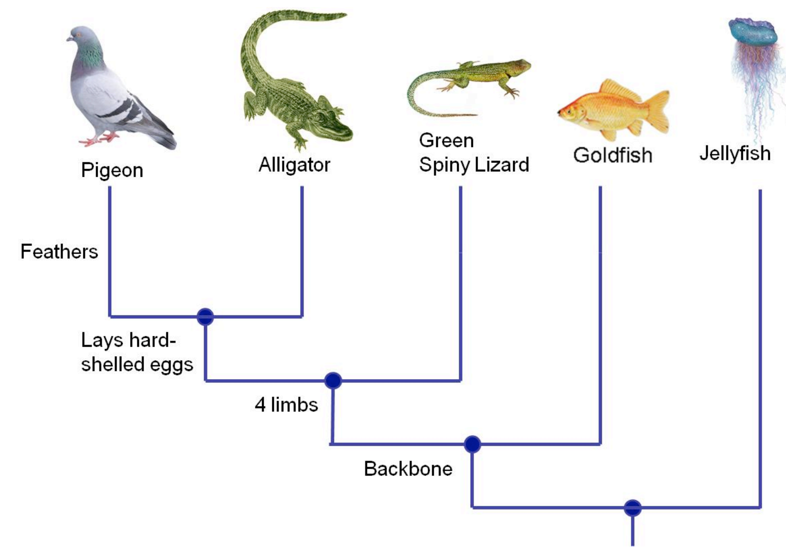
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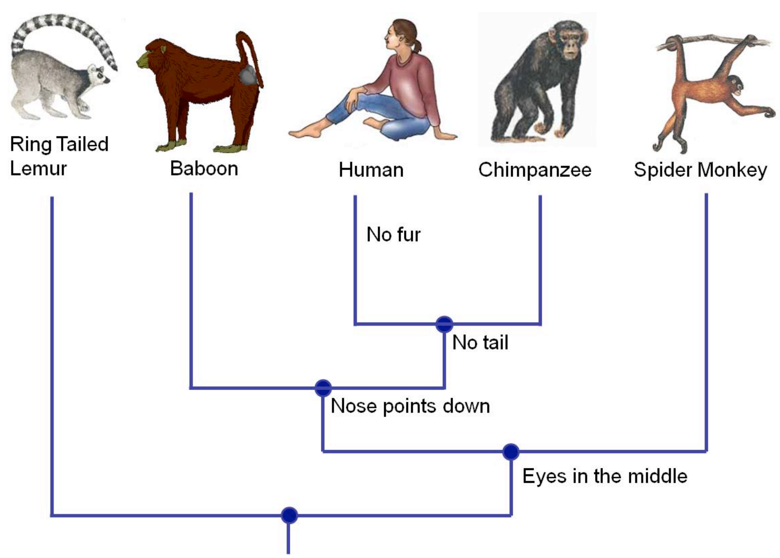
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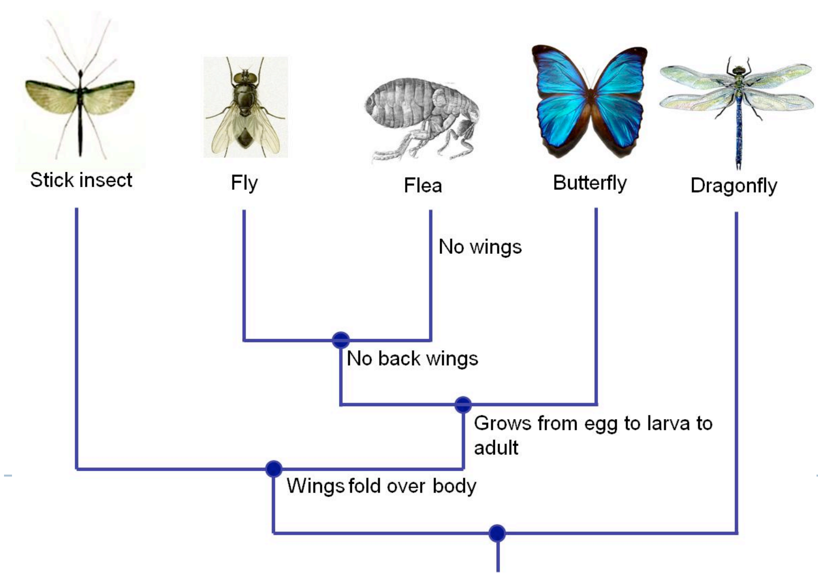
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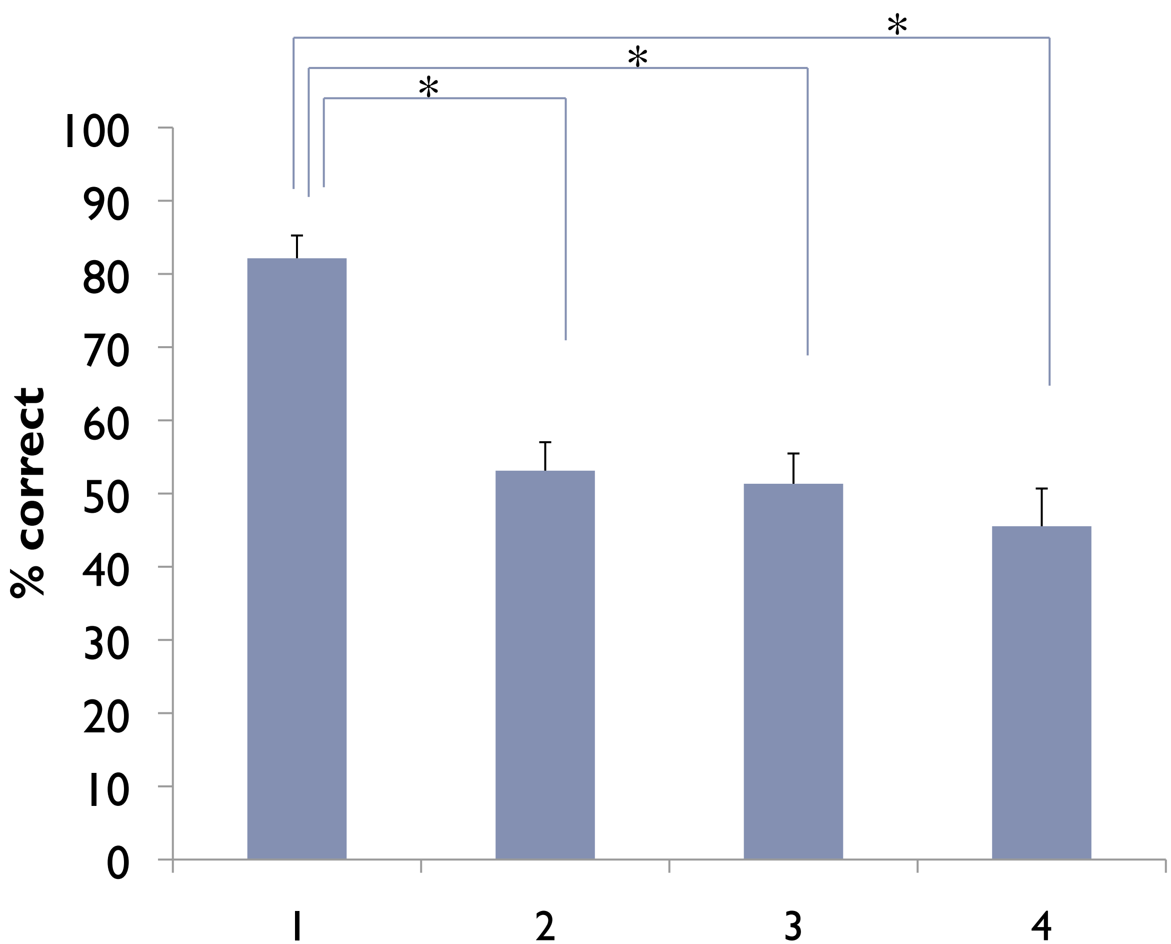
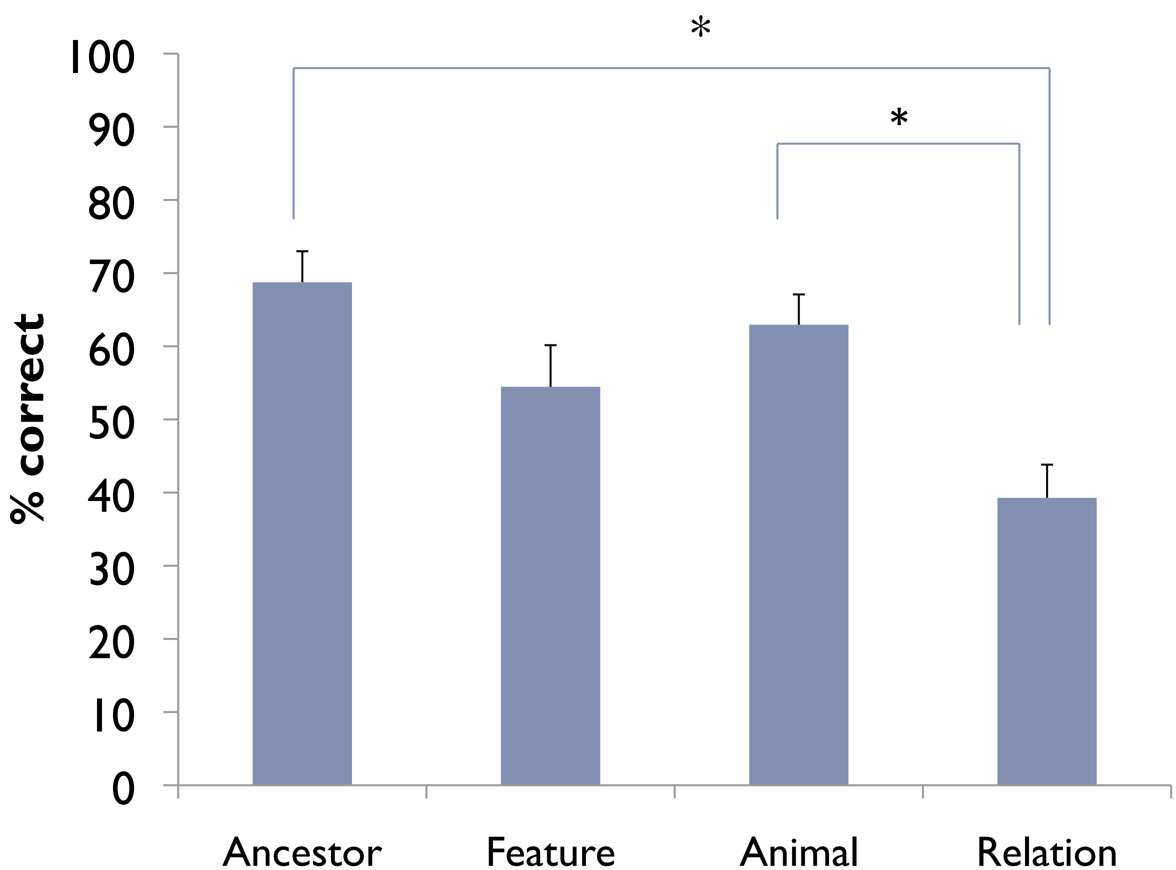
Depth



Question Types



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.