Creationism is not the (Only) Problem:
Cognitive Constraints on Undergraduates' Understanding of Evolution

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Psych 232/Bio 262/UC 262: Evolutionary Biology & Human Disease

ABSTRACT

Modern research in areas as diverse as medicine, climate change, and complex systems depends on an understanding of evolution, but communicating such ideas is difficult. Based on prior research (Evans 2001), we predicted that cultural and cognitive factors would differentially impact students' grasp of evolutionary principles. Undergraduates from two courses on evolution and human disease (Nesse, 1996) completed pre- and posttest instruments. Their a*cceptance* of evolutionary origins was related to religious belief, while an *understanding* of natural selection was related to (a) the intuitive belief that biological change is goal-directed and (b) to how much students learned before and during the course. On open-ended questions, from pre- to post-test, goal-directed intuitive concepts were supplemented by evolutionary concepts, without replacement, suggesting that goal-directed reasoning does not disappear.

We conclude that cognitive and cultural biases differentially constrain students' acceptance and understanding of the evolutionary principles of descent with modification and of natural selection. These findings pave the way for course instruction that specifically targets these cognitive constraints.

RESEARCH QUESTIONS

- Do students' rejections of evolutionary origins impact their understanding of the mechanism of change: Natural selection?
- Do students' intuitive beliefs that biological change is goal-directed (teleological), impact their understanding of natural selection?

METHOD

Participants
- 186 students: Two semesters-Psych 232
- 72% female: mean age 19.5 years; 65% non-Hispanic white; 19% Asian-Amerian; 4% African-American; 4% Hispanic.
- Desired occupations: 68% Medicine or Public Health; 4% biology; 5% psychology

Procedure
- Students completed pretest instruments before the course began and a subset of the same instruments after course completion
- One researcher carried out data collection
- Course instructors had no information about student participation.

Closed-ended Measures
- *Acceptance of Evolutionary Origins*: Mean agreement-three questions
- *Religion-Compatibility:* Are your religious beliefs compatible with evolution?
- *Religiosity:* How important is religion in your life? [Scale: 1-4]
- *Parents' Attitude:* Parents attitude towards evolution? [2 questions]
- *Natural Selection Understanding*: 20 item multiple choice test on material NOT included in the course (CINS)
- *Prior Knowledge:* Questions on prior exposure to evolution [2 questions]
- *Goal-Directed (Intuitive) Reasoning:* Is evolution goal-directed/need-based? [3 questions]

Open-Ended Measures
- Students' pre- and post-test responses to 2 questions: HIV, antibiotic resistance
- Two raters independently coded the transcribed responses to 100% agreement
- Coded for Evolutionary & Intuitive (e.g., Goal-Directed) reasoning (19 Themes).
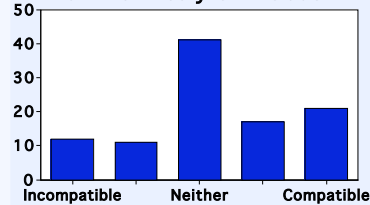
Post-Test Course Grade
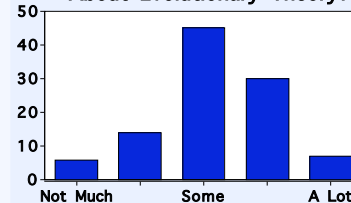Overall score on all class assessments

PRETEST PREDICTORS

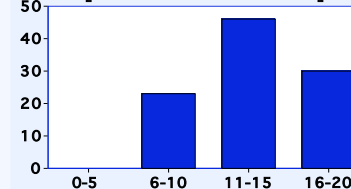### Does Evolution Explain the Origin of Humans, Reptiles, and Viruses?
(bar chart; x-axis: Disagree — Neither — Agree; y-axis: 0–50)
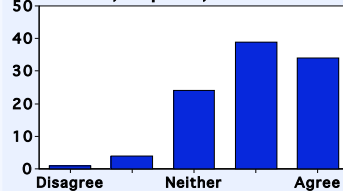
Are Your Religious Beliefs Compatible With The Theory of Evolution?
(bar chart; x-axis: Incompatible — Neither — Compatible; y-axis: 0–50)

How Much Have You Learned Already About Evolutionary Theory?
(bar chart; x-axis: Not Much — Some — A Lot; y-axis: 0–50)

Natural Selection Understanding [Number Items Correct]
(bar chart; x-axis: 0-5, 6-10, 11-15, 16-20; y-axis: 0–50)

PRE- to POSTEST RESULTS

Pretest Predictors (Independently of other variables)
- *Acceptance of Evolution Origins*: 57% variance explained; *Religiosity (-)* & *Parent Attitudes* (+) ($p<.0001$)
- *Natural Selection Understanding*: 30% variance explained; *Prior Knowledge* (+) & *Goal-directed Reasoning* (-) ($p<.001$)

Posttest Results
- *Natural Selection Understanding*: Improved from pre- (*M*=13.6, *SD*=3.7) to post-test (*M*=16.0, *SD*=3.7) ($p<.0001$)
- *Predictors* 54% variance explained: *Pretest Natural Selection Understanding* (+) & *Course Grade* (+) ($p< .0001$)

Open-Ended Responses
Natural Selection Reasoning
- Improved: pre-48% to post-67% ($p<.001$)
- Pretest responses included *differential survival;* at posttest, both *differential reproduction* & *differential survival*.

Goal-Directed Reasoning
- No significant change (44% to 39%)
- "The bacteria transform in order to stop being killed" "The bacteria grew an immunity to it" "The virus fought back" "The virus mutated in order to survive"

CONCLUSIONS

- **Acceptance of Evolutionary Origins:** Predicted by students' creationist beliefs and parents' attitudes towards evolution, only.

- **Natural Selection Understanding**: Predicted by students' course grade and goal-directed reasoning (not by creationist beliefs).

- **Cognitive and Cultural Constraints:** Differentially impact the understanding and acceptance of evolutionary principles.