TITLE: CAUSAL MECHANISMS BEHIND CHANGING MINDS ABOUT EVOLUTION USING CULTURAL COMPETENCE

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Problem Statement: It has now been established that religious culturally competent strategies for evolution education (ReCCEE, Barnes & Brownell, 2017) can be successful. We have developed a ReCCEE strategy, which we refer to as the Reconciliation Model (RM), that appears to be successful in a variety of settings and with a variety of religious affiliations in overcoming barriers to evolution acceptance, specifically among Judeo-Christian audiences (e.g., Ferguson & Jensen, 2021; Lindsay et al., 2019). Although some of the factors that influence acceptance have been studied, including religiosity (Glaze & Goldston, 2015; Rissler, et al., 2014), perceived conflict (Barnes et al., 2021), understanding the nature of science (Glaze & Goldston, 2015), and sometimes knowledge (see Dunk et al., 2017), very little is known about the causal mechanisms directly underlying this specific ReCCEE model (the RM). In this presentation, we will share the results of a combined analysis of nationwide survey data with classroom interventions that shed light on the potential causal mechanisms behind the RM.

Relevant Background: We have all seen the data on evolution acceptance rates in the United States. One of the most startling statistics shows a 40% rejection rate of human evolution (Gallup, 2019). As listed above, some of the factors influencing acceptance have been defined. Of those, religious worldviews are the salient factor (Dagher & BouJaoude, 1997; Hill, 2014) and suggest a need to specifically study the barriers within a religious worldview that can be overcome with direct classroom interventions.

We have now begun to study the causal factors behind this method. We will provide a brief background and theoretical rationale for each of our hypothesized mechanisms. (1) Biblical literalism. A literal reading of the bible can be in direct conflict with the science (Barnes et al., 2020; Evans, 2013). About 39% of Christians ascribe to a literal interpretation of the Bible (Pew, 2014). (2) Knowledge conflation with acceptance. If a student feels that confirming a piece of knowledge concerning evolution conflicts with their worldviews, they may appear to have lower knowledge due to identity-protective cognition (Kahan et al., 2007), which may also influence acceptance. (3) Exclusive Environment. The guiding theoretical framework for this hypothesis is two-fold: Concealable Stigmatized Identities (Quinn & Chaudoir, 2009), and perceived stereotyping (Steele et al., 2002). Students may disengage from learning controversial science topics due to feelings of stigma toward their competing identity (e.g., theist), and therefore, they may feel stereotyped thereby underperforming on tasks related to the topic. (4) Identity-protective cognition and cognitive dissonance. This hypothesis is based on Cognitive Dissonance Theory (Festinger, 1957), that individuals have an inner drive to maintain cognitive consistency between their beliefs and knowledge such that they strive to resolve tension. A consequence of this dissonance is identity-protective cognition (Kahan et al., 2007) in which individuals perceive the acceptance of any ideas or information contrary to their beliefs as a failure to be faithful to and will therefore ignore contrary information, particularly if it originates from an "out-group" source. (5) Understanding of the nature of science. Research shows a clear relationship between student understanding of the nature of science and evolution acceptance (Dunk et al., 2017). Preliminary data suggest that spending time in class discussing how science is done, what a theory is, and what questions science can and cannot answer are influential in helping students

accept evolution (Ferguson & Jensen, 2021). Additionally, recent research suggests that 50% of college students believe that to accept evolution, they must adopt atheism and that this belief directly influences acceptance levels (Barnes et al., 2020).

Research Design: We used a two-fold approach to investigate our hypotheses: a nationwide sample and classroom interventions.

Study Populations. We used the Qualtrics® surveying platform to gather nationwide responses from 829 individuals across the United States, half of which identified as being affiliated with a Judeo-Christian religion and half who identified as agnostic or atheist. Classroom interventions were performed in several introductory biology classes at a private, religiously affiliated institution in the West and a public institution in the South.

Nationwide Survey. In the nationwide sample, we aimed to understand the relationships between biblical literalism and evolution knowledge on evolution acceptance in religious and non-religious individuals. We measured biblical literalism using a six-item latent variable designed by us. To measure evolution knowledge, we used the Evolution Attitudes and Literacy Survey (EALS, Short & Hawley,2012). To measure evolution acceptance, we used the Inventory of Student Evolution Acceptance (I-SEA, Nadelson & Southerland, 2012).

Classroom Interventions. In the first intervention, students in an introductory biology class at a private religious institution were administered a pre-survey to measure their religiosity (Manwaring et al., 2015), biblical literalism, and evolution acceptance. They were then taught a lesson using the RM followed by the evolution unit. They were administered a post-survey including the same instruments as above. 186 students participated.

The second intervention took place in two sections of an introductory biology class at the same private institution. Both courses received similar pre-surveys, educational interventions, and post-surveys. However, the biblical literalism questions were omitted and evolution knowledge questions from the EALS were included. In the control section (N=153), students were given the original EALS-SF questions on Evolution Knowledge. In the intervention section (N=141), students were given the EALS-SF questions with the phrase, "According to science…" preceding each item.

The third intervention took place in an introductory biology class at the same private institution as well as two introductory biology sections at a large public institution in the South. At the private institution (N=195), students were administered a pre-survey that included the religiosity measure, the I-SEA, and a questionnaire about several causal mechanisms referring to their experience with evolution instruction prior to the course. Following instruction they were given the same post-survey asking about the causal mechanisms in reference to the current course. At the public institution, the instructor administered the RM prior to evolution instruction in one section (N=206) and after evolution instruction (following the post-survey) in the other (N=164) to test the effects of the RM on causal mechanisms.

The Reconciliation Model. The RM has been described previously (e.g., Lindsay et al., 2019). Additionally, sample lesson plans can be accessed on our website (BLINDED). In brief, the model includes an in-class discussion about the nature of science as an agnostic epistemology, an exploration of potential cultural beliefs that may conflict with evolution, and a discussion of possible ways to reconcile these beliefs with the evolutionary science.

Statistical Analyses. Confirmatory Factor Analyses (CFA) were performed on all survey instruments to confirm fit of our data to our latent variables. Structural Equation Modeling (SEM), *t*-tests, and Linear Regression were used to study relationships between variables.

Results: The main results are as follows.

Nationwide Data. To test the effects of "Biblical Literalism," we included only religious respondents. SEM showed that **religiosity predicts biblical literalism** (see Figure 1a) and **biblical literalism predicts evolution acceptance** (see Figure 1b).
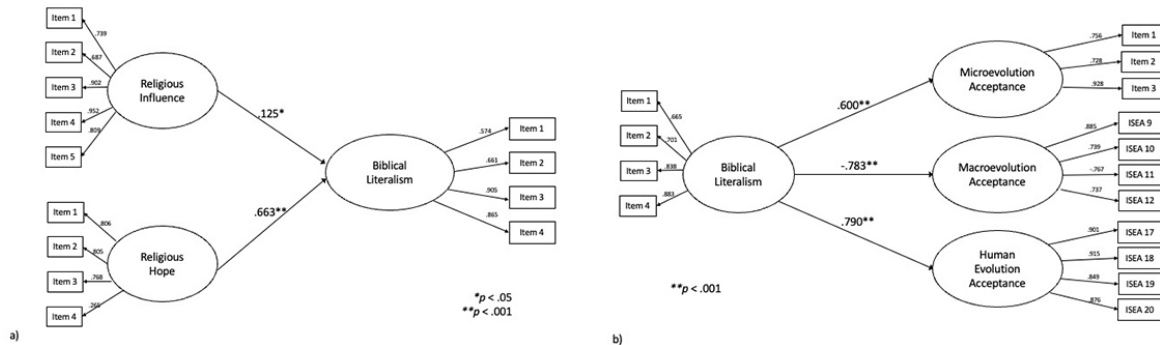

Figure 1. Nationwide Structural Equation Models

To test the effects of knowledge on evolution acceptance, we used the full data set. A *t*-test revealed that those respondents who identified as agnostic or atheist scored higher on the knowledge questions than those who identified as religious [$M_{ag/ath}$=24.00, M_{rel}=21.94 on a 30-point scale, $t(827)$=7.79, $p<.001$]. Because we failed to confirm measurement invariance on the acceptance instrument between agnostic/atheist respondents and religious respondents, we will only report the means for each group: Agnostic/atheist respondents reported high acceptance of evolution ($M = 119.55$, on a 138-point scale) while religious respondents reported a much lower acceptance ($M = 96.32$). SEM showed that knowledge significantly predicted acceptance within each group. **All relationships indicate that the greater your evolution knowledge, the greater your acceptance of evolution**.

Classroom Interventions. In the first intervention, as in the nationwide data, religiosity predicts biblical literalism and biblical literalism predicts acceptance ($p<.001$). Additionally, acceptance significantly increased on all three measures (micro, macro, and human) following the RM ($p<.001$; see Figure 2), while biblical literalism significantly decreased ($p<.001$) without a decrease in religiosity ($p=.176$). In addition, the change in biblical literalism was a significant predictor of changes in evolution acceptance (Micro: R^2=.07, β=-.267, $p<.001$; Macro: R^2=.03, β =-.158, p=.05; R^2=.09, β =-.302, $p<.001$). This indicates that **by directly addressing biblical literalism, we may be able to increase evolution acceptance among highly religious individuals**.
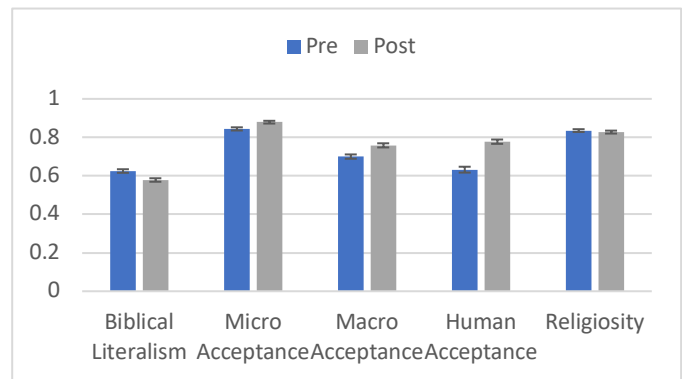
In the second intervention, *t*-tests showed equivalence of acceptance and religiosity between sections (p=NS). However, by adding "According to science…" preceding

Figure 2. Comparison of Pre and Post Instruction

each knowledge statement of the EALS, evolution knowledge increased by 4% making knowledge in the treatment group significantly higher than in the control group ($M_{control}$=74.0%, $M_{intervention}$=78.7%, $p<.001$). This indicates that **by simply by qualifying the statement to**

suggest this is what "science" believes, rather than what they personally believe, students showed more agreement with the scientific consensus.
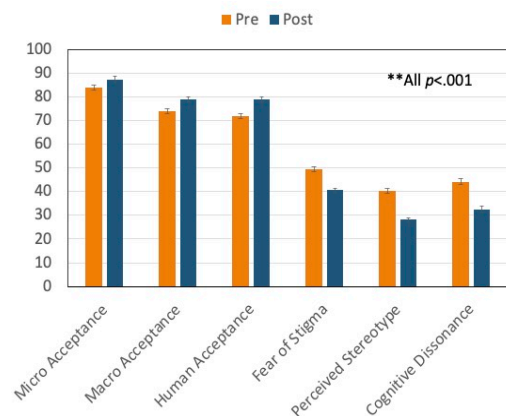

Figure 3. Comparison of Pre to Post Instruction at the Private Institution

In the third intervention, at the private institution, we found that after RM instruction and the evolution unit, we significantly increased evolution acceptance on all three measures of the I-SEA as well as significantly decreasing a fear of stigma, perceived stereotyping, and cognitive dissonance (see Figure 3). Additionally, we found that the most significant predictors of evolution acceptance were identity-protective cognition (b=-.390, $p<.001$), cognitive dissonance (b=-.232, $p=.012$), and understanding of the nature of science (b=.190, $p=.018$).

At the public institution, the students did not gain in acceptance in either treatment condition, however, religiosity significantly increased over the course of the semester (45.1% to 46%, $p=.045$). The only difference resulting from the RM model being used prior to instruction was an increase in a correct understanding of the nature of science ($M_{control}=67.8\%$, $M_{intervention}=74.3\%$, $p=.015$). Similar to the private institution, the most influential predictors of acceptance of evolution were religiosity (b=-.332, $p<.003$), a reduction in identity-protective cognition (b=-.219, $p<.001$), and a reduction in cognitive dissonance (b=-.339, $p<.001$), indicating that **the most significant factors influencing acceptance are religiosity, identity-protective cognition, and cognitive dissonance**.

Contribution and General Interest: These studies have shed light on the potential causal mechanisms involved in the success of the RM, a form of culturally competent evolution education. By understanding the factors involved, we can better inform our pedagogical decisions as we approach this topic in undergraduate classrooms, especially if our audience is likely to include Judeo-Christian individuals who may see a worldview conflict with the content being taught. Additionally, we hypothesize that these same causal mechanisms might be applied to other controversial topics such as climate change, vaccine hesitancy, and conservation issues.

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