

What's the matter with Kansas? The Development and Confirmation of the Evolutionary Attitudes and Literacy Survey

Patricia H. Hawley, Stephen D. Short, Luke A. McCune, Mark R. Osman, & Todd D. Little
Department of Psychology, The University of Kansas

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Introduction

It is certainly no secret that Kansans have problems with evolutionary theory. The 'debate' in Kansas has led the state to be the brunt of jokes on the web (the Onion), television (Jon Stewart's The Daily Show), and print magazines (The New Yorker). Kansas claims John Calvert, J.D., Managing Director of the ID Network, as one of its residents. Calvert played a central role in the "Kansas Evolution Hearings" in May of 2005, an event widely held by the scientific community to be a 'kangaroo court'.

So, *what's the matter with Kansas?*

To find out, we created a survey to assess not only political and spiritual leanings, but also knowledge of evolution, distrust of the scientific enterprise, and attitudes towards and objections against evolutionary theory. Our goal is to predict understanding of and attitudes toward evolutionary theory, and endorsement of intelligent design fallacies. Ultimately, we would like to derive a more manageable tool (i.e., short form) to assess the curricular effectiveness of courses on evolution and/or biology.

Over the course of 3 semesters, we developed a multi-item survey comprising 16 meaningful constructs (see **Table 1**) and tested it on students in Lawrence, KS.

Hypotheses:

- 1) Vulnerability to intelligent design propaganda is largely a function of theological orientation, exposure to evolutionary theory, and openness to experience (see also Stanovich, 1999; Sintra, Southerland, McConaughy, & Demastes, 2003).
- 2) Religious and political conservatism hinders understanding and perceived relevance of the theory of evolution.
- 3) Kansas demographics (e.g., rural upbringing, high school size, educational attainment of parents) will play a significant role in predicting understanding and acceptance of evolutionary theory.

Method

Participants. 371 undergraduates at the university participated and represented nearly 40 declared majors. 327 were drawn from Child Psychology and 44 came from a Social Psychology course. 102 were men, 269 were women.

Analytic plan. We first conducted an item-level confirmatory factor analysis of the 104 variables associated with the 15 expected first-order constructs. This analysis confirmed the unidimensional structure, but Knowledge broke into two separate constructs (*Knowledge of Evolution* and *Evolution Misconceptions*). The model fit of this CFA was acceptable: RMSEA = .052 (.051-.054) (note: values of RMSEA below .08 are deemed acceptable). The amount of reliable variance explained in each item by its respective construct is presented next to each item listed in **Table 1**.

The correlations among the latent constructs are presented in **Table 2** (note: these correlations are corrected for any measurement error).

We then conducted a CFA analysis of the scale scores by taking the average of the items for each lower-order construct and using these scores as the 16 indicators of 6 higher-order latent constructs. This CFA fit the data very well: RMSEA = .049 (.042-.057). The relationships of the lower-order scales on the higher-order constructs are presented in **Figure 1**. The latent correlations among the higher-order constructs are presented in **Table 3**.

Finally, we examined the predictive relationships to the higher order constructs of the various demographic variables and openness to experience. The results of these latent regression analyses are presented in the lower half of **Table 3**.

1 Frank, T. (2004). *What's the matter with Kansas? How conservatives won the heart of America*. New York: Metropolitan Books.
2 Attitude Toward Life Scales: From Miller, Scott, & Okamoto (2006). Public acceptance of evolution. *Science*, 313, 765-766.
3 Items drawn from Index of Genetic Literacy: Miller, Scott, & Okamoto, 2006; Public acceptance of evolution. *Science*, 313, 765-766.
4 Benet-Martinez, V., & John, O. P. (1998). *Los Cinco Grandes* across cultures and ethnic groups: Multitrait, multimethod analyses of the Big Five in English and Spanish. *Journal of Personality and Social Psychology*, 75(3), 729-750.

RESULTS

Table 1 displays the confirmatory factor analysis. All items are displayed along with their variance accounted for by the underlying factor. The factors are accordingly named and displayed with their alpha reliabilities, means, and standard deviations.

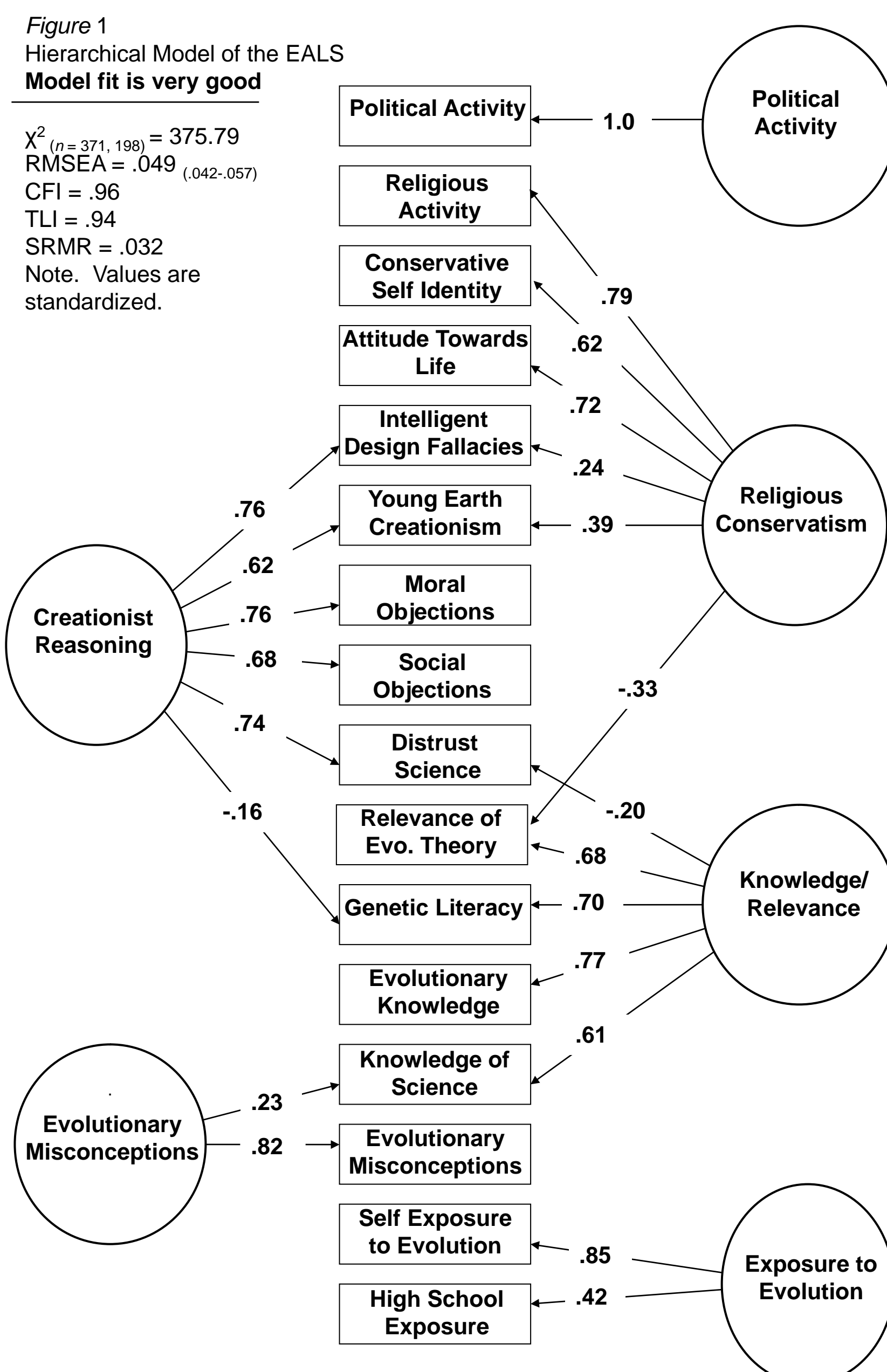
Construct/Variable	Example Items	Item Variance Explained	Alpha	M	S
Political Activity	To what degree are you political?	.713	.89	2.96	1.14
	To what degree are you politically active?	.504			
	To what degree do you politically involve yourself?	.458			
	To what degree do your political views influence your daily life?	.696			
	To what degree do your political views influence your decisions?	.720			
Religious Activity	To what degree do your political views influence courses you enroll in?	.371	.95	3.75	1.79
	To what degree are you religious?	.878			
	To what degree does religion impact your daily life?	.878			
	To what degree does your religion influence your decisions?	.865			
	To what degree do you participate in religious activities?	.723			
Conservative Self-Identity	How much do you believe in God?	.563	.84	3.88	1.29
	Religion is especially important to me because it answers many of my questions about the meaning of life. ¹	.793			
	To what degree are you conservative?	.708			
	In general, how do you self identify politically?	.772			
	In general how liberal/conservative are you on -Social issues (abortion, same-sex marriage, flag burning, etc)?	.211			
Attitudes Towards Life ²	In general how liberal/conservative are you on -Economic issues (welfare, taxation, free market policies, etc)?	.508	.84	4.24	1.70
	In general how liberal/conservative are you on -Foreign policy and defense issues (defense spending, combating terrorism, pre-emptive war)?	.368			
	Life begins at conception.	.631			
	After conception, a developing human is only a cluster of cells, and it makes no sense to discuss its moral condition.	.516			
	All stages of human life- embryo, fetus, child, adult- should have the same legal protections.	.736			
Intelligent Design Fallacies	There is scientific evidence that humans were created by a supreme being or intelligent designer.	.473	.91	3.06	1.17
	There is no evidence that humans evolved from other animals.	.630			
	The theory of evolution is a matter of faith and belief, just like religion.	.361			
	Humans were specially designed.	.412			
	There are no transitional fossils (remains of life forms that illustrate an evolutionary transition).	.593			
Young Earth Creationist Beliefs	It is statistically impossible that life arose by chance.	.260	.91	2.93	1.35
	The theory of evolution does not explain similarities or differences between chimps and humans.	.434			
	Complex biological systems cannot come about by slight successive mutations (i.e., they are irreducibly complex).	.445			
	Evolution is a theory in crisis.	.516			
	Evolution violates the 2nd law of thermodynamics (that systems move toward disorder, not order). ³	.361			
Moral Objections	Natural selection cannot create complex structures; it is like a tornado blowing through a junkyard and creating a 747.	.600	.85	2.24	1.17
	I read the bible literally.	.519			
	God created humans in their present form. (used to be: A supreme being created humans in their present image.)	.469			
	Humans never could have been related to apes.	.644			
	The Earth isn't old enough for evolution to have taken place.	.456			
Social Objections	There was a time when humans and dinosaurs lived on earth together.	.113	.84	2.82	1.16
	Present animal diversity can be explained by the Great Flood.	.582			
	A majority of present-day geological features are the result of the Great Flood.	.443			
	Adam and Eve of Genesis are our universal ancestors of the entire human race.	.694			
	All modern species of land vertebrates are descended from those original animals on the ark.	.756			
Distrust of the Scientific Enterprise	People who accept evolution do not believe in God.	.454	.83	2.93	1.63
	People who accept evolution as fact are immoral.	.628			
	If you accept evolution, you really can't believe in God.	.575			
	Darwinism strips meaning from our lives.	.367			
	People can be moral and believe in evolution at the same time.	.455			
Relevance of Evolutionary Theory	Applying the theory of evolution to human affairs implies we are not fully in control of our behavior.	.295	.94	4.97	1.16
	The theory of evolution has contributed to racism.	.455			
	The theory of evolution has contributed to sexism.	.519			
	The theory of evolution has contributed to an increase in abortion.	.397			
	The theory of evolution has contributed to genocide (the deliberate killing of a group based on nationality, race, politics, or culture).	.586			
Genetic Literacy ³	The theory of evolution has contributed to an increase in euthanasia (the act of killing someone painlessly or allowing to die to stop the suffering, also called mercy killing).	.607	.78	4.97	0.91
	Contemporary methods of determining the age of fossils and rocks are untrustworthy. ⁴	.596			
	The data used to support evolution is untrustworthy.	.731			
	The theory of evolution is capable of explaining the diversity of life.	.387			
	Evolutionary theorists believe that something is natural then it is good or right.	.241			
Evolutionary Knowledge	Evolutionary theorists believe that inevitable inequality is morally acceptable.	.236	.72	5.92	0.86
	Evolutionary theorists believe that because the strongest survive, it's a mistake to help the weak.	.377			
	The available data are ambiguous as to whether evolution actually occurs.	.452			
	The theory of evolution helps us understand plants.	.628			
	The theory of evolution helps us understand animals.	.794			
Evolutionary Misconceptions	The theory of evolution helps us understand human origins.	.743	.68	2.15	0.79
	For explaining human behavior, evolutionary theory is irrelevant.	.364			
	Evolutionary theory is highly relevant for the social sciences (e.g., anthropology, psychology, sociology).	.607			
	Evolutionary theory is highly relevant for the humanities (e.g., history, literature, philosophy).	.396			
	Evolutionary theory is relevant to our everyday lives.	.472			
Knowledge about the Scientific Enterprise	The theory of evolution helps explain the world as it is in the present.	.689	.78	5.65	1.00
	Humans share a majority of their genes with chimpanzees.	.453			
	Humans share more than half of their genes with mice.	.307			
	Ordinary tomatoes do not have genes, whereas genetically modified tomatoes do.	.095			
	All plants and animals have DNA.	.121			
Self Exposure to Evolution	Humans have somewhat less than half of the DNA in common with chimpanzees.	.301	.84	2.15	0.79
	You can see traces of our evolutionary past in human embryos.	.298			
	Humans developed from marine life forms.	.408			
	Mutations are never beneficial.	.356			
	In most populations, more offspring are born than can survive.	.234			
Youth Exposure	Mutations can be passed down to the next generation.	.150	.57	2.49	0.63
	Increased genetic variability makes a population more resistant to extinction.	.383			
	The more recent species share a common ancestor, the more closely related they are.	.276			
	Natural selection is the only cause of evolution. (reverse scored)	.199			
	Mutations occur all the time.	.317			
Youth Exposure	Natural selection is a random process.	.160	.84	2.15	0.79
	Natural selection is synonymous (means the same) as evolution.	.246			
	Characteristics acquired during the lifetime of an organism are passed down to that individual's offspring.	.323			
	Species evolve to be perfectly adapted to their environments.	.189			
	Evolution means progression toward perfection.	.338			
Youth Exposure	Evolution is a linear progression from primitive to advanced species.	.372	.78	5.65	1.00
	Good theories can be proven by a single experiment.	.284			
	For scientific evidence to be deemed adequate, it must be reproducible by others.	.483			
	Scientific ideas can be tested and supported by feelings and beliefs.	.342			
	Scientific explanations can be supernatural.	.416			
Youth Exposure	Theories requiring more untested assumptions are generally better than theories with fewer assumptions.	.290	.84	2.15	0.79
	Good theories give rise to testable predictions.	.421			
	I've visited evolution related websites (e.g., Science Daily, Pharyngula, Edge.org)	.417			
	I've watched evolution related videos on the web (e.g., Ted.com, You Tube)	.497			
	I read science magazines featuring evolution (e.g., Discover, National Geographic, Nature).	.589			
Youth Exposure	I read science magazines featuring evolution (e.g., Discover, National Geographic, Nature).	.589	.57	2.49	0.63
	I've watched nature shows that discussed evolution (e.g., PBS/Novo, Discovery, National Geographic)	.609			
	I've read evolution related books (e.g., by Richard Dawkins, ED Wilson, Steven Pinker)	.382			
	I have visited natural history museums on field trips or with family.	.376			
	As a child, I attended science and nature camps (e.g., Outdoor Ed Lab, local nature centers or zoos).	.222			
Youth Exposure	How many evolution related courses did you have in high school?	.164	.84	2.15	0.79
	How many evolution related courses did you have in college?	.222			
	How much training in evolution did you receive in high school?	.183			

¹ From Miller et al. (2006)
² See also Ingram & Nelson (2006)
³ From Miller et al. (2006)
⁴ From Rutledge & Sadler (2007)

Table 2 displays the intercorrelations among the 16 latent constructs. As highlighted, *Young Earth Creationist Beliefs*, *Moral Objections*, *Social Objections*, and *Distrust* are all highly correlated with endorsement of *Intelligent Design Fallacies*.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1. Political Activity	1.0															
2. Religious Activity	-.13	1.0														
3. Conservative Self-Identity	-.27	.53	1.0													
4. Attitudes towards Life	-.24	.60	.64	1.0												
5. IDF	-.28	.59	.55	.64	1.0											
6. YEC	-.26	.69	.58	.69	.95	1.0										
7. Moral Objections	-.28	.43	.47	.51	.81	.79	1.0									
8. Social Objections	-.22	.32	.42	.48	.71	.64	.67	1.0								
9. Distrust	-.28	.52	.53	.59	.99	.90	.84	.75	1.0							
10. Relevance	.24	-.47	-.44	-.41	-.80	-.73	-.70	-.52	-.82	1.0						
11. Genetic Literacy	.14	-.45	-.47	-.41	-.78	-.70	-.64	-.50	-.78	.81	1.0					
12. Evolutionary Knowledge	.12	-.22	-.30	-.26	-.58	-.50	-.53	-.40	-.61	.72	.86	1.0				
13. Knowledge of Scientific Enterprise	.05	-.12	-.08	-.17	-.25	-.26	-.15	-.14	-.26	.05	.21	.17	1.0			
14. Evolutionary Misconceptions	.08	-.22	-.03	-.18	-.52	-.46	-.51	-.44	-.58	.60	.68	.77	.29	1.0		
15. Self Exposure to Evolution	.39	-.35	-.38	-.37	-.51	-.45	-.41	-.38	-.53	.51	.47	.39	.05	.27	1.0	
16. High School Exposure to Evolution	.41	-.23	-.32	-.31	-.44	-.40	-.41	-.37	-.48	.45	.37	.36	-.02	.23	.80	1.0

Figure 1 displays the results of the higher-order CFA of the 16 scale scores of the items in Table 1. The correlations among these higher-order constructs are presented in **Table 3**. Ten of the scales uniquely load on a given higher-order construct. Six scales, however, showed more nuanced relationships by cross loading on a second construct. For example, 'Relevance of Evolution Theory' is a marker variable of *Knowledge/Relevance* latent construct, but it has a moderate negative loading on the *Religious Conservatism* construct. This cross-loading indicates that the more persons hold conservative religious beliefs, the less they view evolution as relevant.



CONCLUSIONS

Creationist ideology is a complex combination of *Young Earth Creationism*, believing God and evolution cannot be reconciled (*Moral Objections*), blaming the theory for social ills (*Social Objections*), and *Distrust* of data and scientists. As such, it appears to be a prime impediment to understanding evolutionary theory and finding it relevant (see also Miller, Scott, & Okamoto, 2008; Smith, 1994). (However, in the present analyses, the causal direction is unclear; simply increasing knowledge may change attitudes; Lawson & Warnop, 1992, but see Lord & Marino, 1993). *Political Activity* was positively associated with seeking exposure while *Religious Conservatism* was negatively related to seeking exposure. *Exposure* (the *raison d'etre* of science education), in turn, is positively associated with *Knowledge/Relevance*.

Kansas demographics are not nearly as important as we had anticipated. However, openness to experience played a very large role in predicting *Knowledge and Relevance*, alone accounting for 10% of the variance in this construct (see also Sintra et al., 2003). Openness *doubles* the variance accounted for by demographics for *Creationist Reasoning*. At present, we have found no evidence suggesting that openness can be significantly changed by college educators.

Regarding our educational mission, *Evolutionary Misconceptions* (e.g., essentialism, teleology, intentionality) was positively indicated by knowledge of the scientific enterprise (which more strongly indicated *Knowledge/Relevance*). We explain this by noting that a scientific understanding can be undermined by the use of common-place definitions for words like "adapt" and "theory", etc., which have specific scientific meanings in the context of evolution (Alters & Nelson, 2002; Moore et al., 2002; Sinatra et al. 2003). Furthermore, falsehoods become more believable with repeated exposure (i.e., the "illusion of truth"; Wegner, Wenzlaff, Kerker, & Beattie, 1981; Halpern, 2003). Exposure to the scientific enterprise may simply result in more exposure to the figurative and metaphorical language that reinforces these misconceptions. Our examination of evolutionary misconceptions suggests that as educators, we should be cognizant not only of *what* we teach, but *how* we teach it (e.g., O'Brien, Wilson, & Hawley, 2009).

The results of both sets of analyses provide strong psychometric validation of the Evolutionary Attitudes and Literacy Survey. The lower-order CFA (Table 1) demonstrates the strong internal validity of the items as they relate to the 16 dimensions. The results of the lower-order CFA provide information that will be used to develop a shorter version of the questionnaire. The higher-order CFA (Figure 1) shows the structure of evolutionary attitudes and literacy. The pattern of cross loadings, for example, are quite telling in terms of the underlying basis for one's standing on any of the constructs. The results of the higher-order CFA also form the basis for explicating and then testing theoretically derived predictions about the etiology and consequences of one's standing on any of the six higher-order constructs.

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Contact: PHawley@ku.edu
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