Evolutionary Attitudes and Literacy Survey: Development and Validation of a Short Form

Stephen D. Short & Patricia H. Hawley

Department of Psychology, The University of Kansas

INTRODUCTION

Kansas and the Midwest in general have come under fire in recent time concerning the issue of evolution education. The Kansas Evolution Hearings of 2005, invoked a dramatic change to the state's science education standards in favor of Intelligent Design, which was repealed 2 years later. However, the heated evolution 'debate' in Kansas left 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).

Hawley and colleagues interested in empirically examining evolutionary attitudes developed a variety of scale items to measure not only political and spiritual leanings, but also knowledge of evolution, distrust of the scientific enterprise, and attitudes towards and objections against evolutionary theory. The Evolutionary Attitudes and Literacy Survey (EALS; see Hawley et al., 2010) is a multidimensional scale that consists of 16 lower order and 6 higher order constructs developed to measure the wide array of factors that influence both an individual's endorsement of and objection to evolutionary theory.

The validity and utility of the EALS has been demonstrated (Hawley et al., 2010), however the current 104-item full scale may be too long for researchers looking to employ the scale for their own empirical study, or for assessments of the curricular effectiveness of courses on evolution and/or biology. The present study sought to reduce the number of items in the EALS while maintaining the validity and structure of the original full scale.

METHODS

Participants

Two groups of participants were examined. The first group was the sample collected from Hawley et al. (2010) for the original development of the EALS. The Hawley et al. (2010) sample consisted of 371 undergraduates at the University of Kansas (KU) and represented nearly 40 declared majors. 327 were drawn from a Child Psychology course and 44 came from a Social Psychology course. The sample consisted of 102 men and 269 women (Age: $M = 19.8$ $SD = 2.48$).

A new sample of 526 undergraduates representing over 30 majors and were drawn at the start of the semester from a first year Introductory Biology course on principles of cellular and molecular biology at KU. The sample consisted of 233 men and 290 women (Age: $M = 19.2$ $SD = 2.63$).

Analysis

First, a multiple group confirmatory factor analysis (CFA) demonstrated invariance between the two samples on the original full scale, which demonstrated no significant differences between two samples, and allowed for additional comparisons.

Items from the full scale were then retained if they possessed strong factor loadings, maintained face validity, demonstrated normal distributive properties, were succinct, and were not redundant with other items. Then, new parceled indicators for each construct were computed to be compared to the initial higher-order model.

For model comparisons, a multiple groups CFA was conducted to examine the levels of measurement invariance between the hierarchical model of the original EALS and the hierarchical model of the EALS- Short Form (EALS-SF). Finally, the equality of latent correlations between the 6 higher-order constructs of the original scale were compared to a similar pattern of relationships between the constructs of the full EALS and the EALS-SF. The latent correlations among the latent constructs for the EALS-SF are presented in **Table 2** and **Table 3** (note: these correlations are corrected for measurement error). Results from the multiple group CFA are found in **Table 4**.

RESULTS

Table 1 displays the confirmatory factor analysis on the EALS-SF. All items are displayed along with their standardized factor loadings. The model was identified by fixing each construct's variance to 1.0. Thus, squared factor loadings represent each item's variance accounted for by the latent variable. The factors are displayed with their alpha reliabilities, means, and standard deviations.

Construct/Variable [b]	Example items	Standardized Factor Loading	Alpha	M	S
Political Activity			.88	2.86	1.25
	To what degree are you political?	.714			
	To what degree do your political views influence your daily life?	.940			
	To what degree do your political views influence your decisions?	.898			
Religious Activity			.96	4.07	1.95
	To what degree are you religious?	.943			
	To what degree does religion impact your daily life?	.959			
	To what degree does your religion influence your decisions?	.960			
	Religion is especially important to me because it answers many of my questions about the meaning of life. [A]	.751			
Conservative Self Identity			.87	4.05	1.55
	To what degree are you conservative?	.866			
	In general, how do you self identify politically? [B]	.835			
	In general how liberal/conservative are you on Economic issues (welfare, taxation, free market policies, etc)? [C]	.751			
Attitudes Toward Life [D]			.83	4.38	1.69
	Life begins at conception.	.813			
	After conception, a developing human is only a cluster of cells, and it makes no sense to discuss its moral condition. (R)	.688			
	All stages of human life- embryo, fetus, child, adult- should have the same legal protections.	.860			
Intelligent Design Fallacies			.89	3.16	1.32
	There is scientific evidence that humans were created by a supreme being or intelligent designer.	.708			
	There is no evidence that humans evolved from other animals.	.790			
	There are no transitional fossils (remains of life forms that illustrate an evolutionary transition).	.812			
	Complex biological systems cannot come about by slight successive modifications (i.e., they are irreducibly complex).	.692			
	Evolution is a theory in crisis.	.770			
	Natural selection cannot create complex structures; It is like a tornado blowing through a junkyard and creating a 747.	.736			
Young Earth Creationist Beliefs			.87	3.04	1.45
	I read the bible literally.	.749			
	The Earth isn't old enough for evolution to have taken place.	.708			
	There was a time when humans and dinosaurs lived on earth together.	.461			
	Present animal diversity can be explained by the Great Flood.	.755			
	Adam and Eve of Genesis are our universal ancestors of the entire human race.	.835			
	All modern species of land vertebrates are descended from those original animals on the ark.	.870			
Moral Objections			.81	2.33	1.21
	People who accept evolution as fact are immoral.	.787			
	If you accept evolution, you really can't believe in God.	.663			
	Darwinism strips meaning from our lives.	.844			
Social Objections			.83	2.71	1.17
	The theory of evolution has contributed to racism.	.789			
	The theory of evolution has contributed to sexism.	.825			
	The theory of evolution has contributed to genocide (the deliberate killing of a group based on nationality, race, politics, or culture).	.751			
Distrust of the Scientific Enterprise			.79	3.00	1.06
	Contemporary methods of determining the age of fossils and rocks are untrustworthy. [E]	.776			
	The data used to support evolution is untrustworthy.	.860			
	The available data are ambiguous as to whether evolution actually occurs. [G]	.622			
Relevance of Evolutionary Theory			.89	4.76	1.24
	Evolutionary theory is highly relevant for biology.	.872			
	The theory of evolution helps us understand human origins.	.899			
	Evolutionary theory is highly relevant for the social sciences (e.g., anthropology, psychology, sociology).	.793			
	Evolutionary theory is highly relevant for the humanities (e.g., history, literature, philosophy).	.578			
	Evolutionary theory is relevant to our everyday lives.	.672			
Genetic Literacy			.76	4.92	0.95
	Humans share a majority of their genes with chimpanzees. [I]	.817			
	Humans share more than half of their genes with mice. [I]	.670			
	Humans have somewhat less than half of the DNA in common with chimpanzees. [I] (R)	.555			
	Mutations are never beneficial. [D] (R)	.635			
Evolutionary Knowledge			.77	4.91	0.89
	In most populations, more offspring are born than can survive.	.464			
	Mutations can be passed down to the next generation.	.655			
	Increased genetic variability makes a population more resistant to extinction.	.758			
	The more recently species share a common ancestor, the more closely related they are.	.728			
	Mutations occur all the time.	.559			
Misconceptions about Evolution			.49	4.06	0.88
	Characteristics acquired during the lifetime of an organism are passed down to that individual's offspring.	.270			
	Evolution means progression towards perfection.	.600			
	Evolution is a linear progression from primitive to advanced species.	.697			
Knowledge about the Scientific Enterprise			.78	5.55	1.05
	For scientific evidence to be deemed adequate, it must be reproducible by others.	.683			
	Scientific ideas can be tested and supported by feelings and beliefs. (R)	.710			
	Scientific explanations can be supernatural. (R)	.719			
	Good theories give rise to testable predictions.	.609			
Self Exposure to Evolution			.81	2.37	0.81
	I've watched evolution related videos on the web (e.g., Ted.com, YouTube).	.615			
	I read science magazines featuring evolution (e.g., Discover, National Geographic, Nature).	.827			
	I've watched nature shows that discussed evolution (e.g., PBS/Nova, Discovery, National Geographic)	.837			
Youth Exposure to Evolution			.54	2.50	0.73
	I have visited natural history museums on field trips or with family.	.672			
	As a child, I attended science and nature camps (e.g., Outdoor Ed Lab, local nature centers or zoos).	.460			
	How much training in evolution did you receive in high school?	.453			

A See also Dudley and Cruise (1990)
B cf ANES 2000
C From Carney et al. (2008)
D From Miller et al. (2006)
E See also Ingram and Nelson (2006)
F Item was drawn from R. Deaner (personal communication, January 20, 2009)
G See also Rutledge and Sadler (2007)
(R) Indicated Reversed Scored Item

Table 2 displays the intercorrelations among the 16 latent constructs of the EALS-Short Form.

Table 2
Latent correlations between 16 lower order constructs of EALS-Short Form

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1. Political Activity	1.0															
2. Religious Activity	.12	1.0														
3. Conservative Self-Identity	-.14	.39	1.0													
4. Attitudes Towards Life	-.08	.62	.56	1.0												
5. Intelligent Design Fallacies	-.04	.65	.52	.64	1.0											
6. Young Earth Creationist Beliefs	-.04	.71	.49	.64	.96	1.0										
7. Moral Objections	-.04	.54	.48	.51	.92	.84	1.0									
8. Social Objections	.02	.45	.36	.38	.72	.65	.74	1.0								
9. Distrust of the Scientific Enterprise	-.03	.59	.49	.59	.98	.87	.90	.79	1.0							
10. Relevance of Evolutionary Theory	.09	-.48	-.35	-.46	-.80	-.71	-.69	-.56	-.78	1.0						
11. Genetic Literacy	.11	-.41	-.26	-.40	-.70	-.60	-.61	-.48	-.63	.70	1.0					
12. Evolutionary Knowledge	.08	-.32	-.30	-.34	-.67	-.58	-.58	-.50	-.65	.77	.83	1.0				
13. Knowledge about Scientific Enterprise	.07	-.27	-.24	-.20	-.54	-.43	-.49	-.51	-.53	.57	.60	.68	1.0			
14. Evolutionary Misconceptions	.07	.02	-.09	.06	-.02	-.05	-.01	-.03	-.03	-.20	.04	-.11	.07	1.0		
15. Self Exposure to Evolution	.24	-.25	-.30	-.28	-.43	-.43	-.41	-.26	-.45	.41	.44	.46	.28	.05	1.0	
16. Youth Exposure to Evolution	.29	-.15	-.23	-.22	-.36	-.39	-.33	-.25	-.41	.35	.38	.47	-.31	-.03	.84	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 the higher-order constructs are presented in **Table 3**. Thirteen of the scales uniquely load on a given higher-order construct. Three 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.
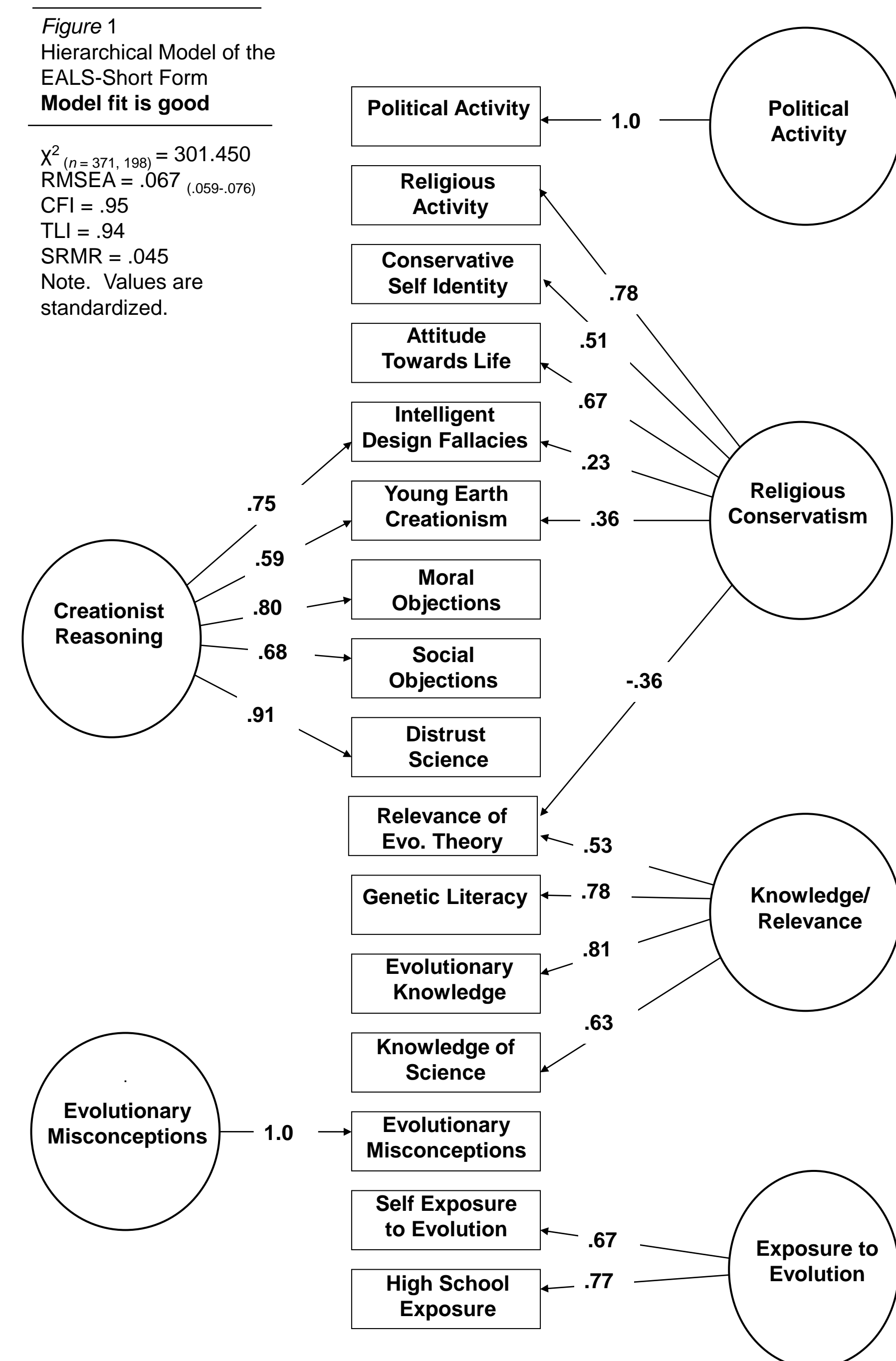

Figure 1
Hierarchical Model of the EALS-Short Form
Model fit is good
$\chi^2_{(n=371, 198)} = 301.450$
RMSEA = .067 (.059-.076)
CFI = .95
TLI = .94
SRMR = .045
Note. Values are standardized.

Table 3 shows the latent correlations among the six higher-order constructs of the EALS-SF.

	Political Activity	Religious Conserv.	Knowledge/ Relevance	Creationist Reasoning	Evolutionary Misconcept.	Exposure to Evolution
Political Activity	1.00					
Religious Conserv.	-.022	1.00				
Knowledge/ Relevance	.150	-.496	1.00			
Creationist Reasoning	-.078	.780	-.799	1.00		
Evolutionary Misconcept.	.066	-.039	.012	-.053	1.00	
Exposure to Evolution	.297	-.344	.533	-.457	.053	1.00

Table 4 shows the results of the invariance tests between the long form and the short form of the scale. Due to the sensitivity of the Chi square difference test, a "reasonableness" test was used where the constraint was considered tenable if the two model's RMSEAs were within one another's confidence intervals, and the Δ CFI was < .01.

Table 4
Establishing measurement invariance between the original EALS and the EALS-Short Form

Model	χ^2	df	p	RMSEA	90% CI	NNFI	CFI	Constraint Tenable
Null	8242.90	240	<.001	---	---	---	---	---
Configral Invariance	580.48	180	<.001	.070	.064-.077	0.933	0.950	---
Loading Invariance	637.10	194	<.001	.071	.065-.078	0.945	0.932	Yes
	$\Delta \chi^2_{(14)} = 56.62$, $p < .001$							
Intercept Invariance	658.19	200	<.001	.071	.065-.078	0.931	0.943	Yes
	$\Delta \chi^2_{(6)} = 21.09$, $p < .001$							
Homogeneity Var/Covar	721.69	213	<.001	.073	.067-.079	0.928	0.936	No
	$\Delta \chi^2_{(18)} = 21.09$, $p < .001$							
Equality of Correlations	643.10	205	<.001	.069	.063-.075	0.936	0.945	Yes
	$\Delta \chi^2_{(21)} = 6.00$, $p = .99$							

DISCUSSION

A total of 61 items met the criteria detailed in the analysis section and were retained for the EALS-SF. The retained items largely presented strong factor loadings onto their respective constructs, and acceptable reliability constructs. Thus, the CFA on these 61 items demonstrates the strong internal validity of the items as they relate to the 16 dimensions

The multiple group CFA demonstrated that the EALS and the EALS-SF were both loading invariant with the 16 subscales factor loadings being similar (i.e., weak factorial invariance), and intercept invariant with the 16 subscales having similar intercepts (i.e., strong factorial invariance). The test for homogeneity of variance/covariance matrix between the groups was significant, suggesting that the two forms of the scale not did not have homogenous covariance matrixes. However, this significant result may be due to the sensitivity of the Chi-square difference test and the unequal sample sizes of the two groups. Finally, the test of differences in associations (i.e., equality of correlations) was not significant, suggesting that 6 higher order factors of the full EALS and the EALS-SF have a similar latent correlation matrices.

Overall, the results of these analyses provide psychometric validation of the EALS-SF. With an acceptable shorter form of the EALS, researchers can now more easily adopt the EALS-SF as a capable measurement tool for testing theoretically derived predictions about the etiology and consequences of one's standing on any of the measured constructs. Additionally, the EALS-SF may benefit educators interested in assessing the curricular effectiveness of their evolutionary and biology themed courses. Indeed, future longitudinal research will asses individuals in a variety of evolutionary themed courses with the EALS and EALS-SF, as well as continue to validate these scales with cross-national samples.

THE UNIVERSITY OF KANSAS

KU CENTER FOR RESEARCH METHODS & DATA ANALYSIS
College of Liberal Arts & Sciences