A User's Guide:

Evolution Attitudes and Literacy Survey (EALS) and

Evolution Attitudes and Literacy Survey-Short Form (EALS-SF)

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This guide is a draft of a 'white paper' developed by the authors. Please direct comments and questions to Pat Hawley.

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Data Analysis with the EALS and EALS-SF

This document serves as a brief guide to using the Evolution Attitudes and Literacy Survey (***EALS***; Hawley et al., 2011) and the Evolution Attitudes and Literacy Survey- Short Form (***EALS-SF***, Short & Hawley, 2012). We target our narrative to both SEM and ANOVA/regression users.

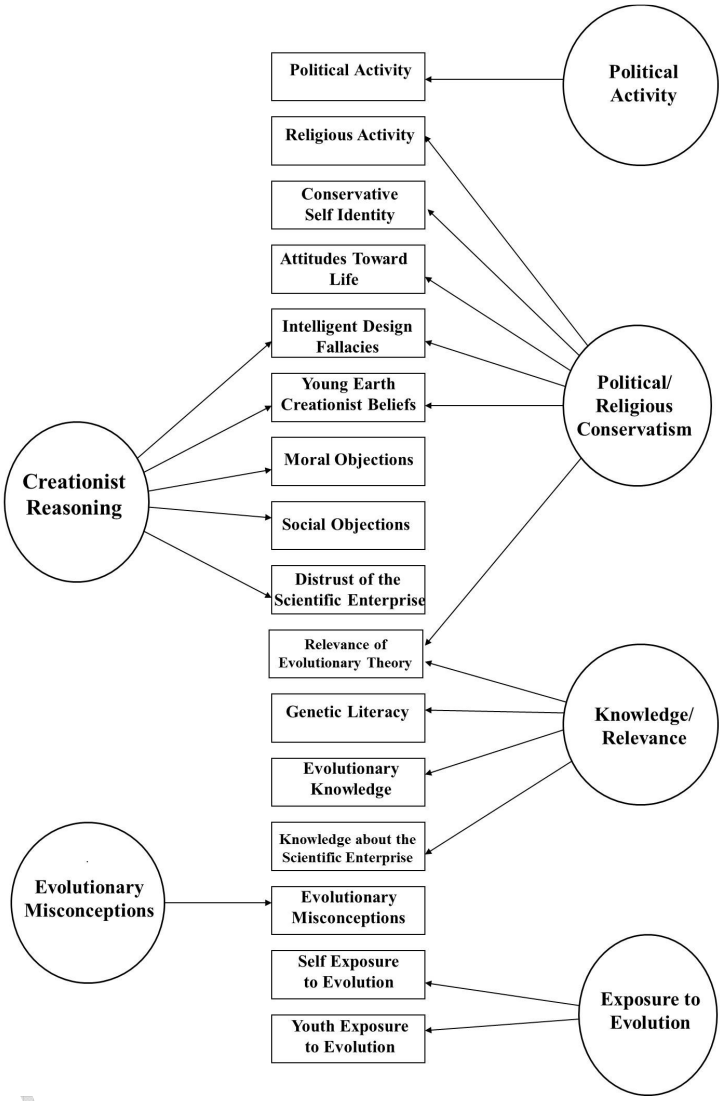
What is the EALS?

The EALS is a comprehensive survey designed to assess attitudes and knowledge about evolutionary theory. We designed it with college/university students in mind, but are ourselves at present administering it to the population at large through Amazon's M-Turk.

In more formal language, it is a multidimensional scale consisting of 16 lower-order factors (i.e., subscales) which in turn comprise six higher-order constructs. We developed it to measure the wide array of factors that influence both an individual's endorsement of and objection to evolutionary theory. Past research has demonstrated the validity and utility of the EALS, in both its long form (Hawley, Short, McCune, Osman, & Little, 2011) and short-form versions (Short & Hawley, 2012).

A unique feature of the EALS and EALS-SF is the hierarchical structure which contains a wide array of lower-order and higher-order constructs. Figure 1 depicts the factor structure for the EALS (and EALS-SF). Squares represent the subscales, circles represent the higher order factors. Also shown in Figure 1, note that the three lower-order constructs young-earth creationism, intelligent design fallacies, and relevance of evolutionary theory are technically indicators for multiple higher-order constructs. We will deal more with this below. Items comprising the subscales can be found in Appendix Table 1 for the long form, and Appendix Table 2 for the short form.

Figure 1. Hierarchical Structure of the EALS and EALS-SF



Why we created the EALS

We created the EALS because we felt published tools lacked a comprehensive scope and validated structure. We see this tool as being useful to assess a) predominant regional and local belief systems, b) curricular effectiveness and attainment of specified learning goals, and c) changes in attitudes about course material.

How we created the EALS

We were well informed by others' works and scales. For example, work from the museum sciences has demonstrated that those who seek out information about evolutionary theory tend to know more about it and have more positive attitudes than those who do not seek out such information. Full explication of the whys and wherefores of our subscales can be found in Hawley et al. (2011). There also we document which items were drawn from previously published scales.

Administering the EALS and the EALS-SF

We prefer to administer the EALS by web interface, such as Survey Monkey or Qualtrics. To do this, you will need to type in the items yourself, being careful to name each variable according to the subscale to which it belongs (e.g., PolAct1-3; RelAct1-3). With these programs, data are automatically collected and organized in columns, with rows representing individuals, and the item name given will serve as the column header. We prefer to save such files in a plain text format such as .csv because the plain text data file can be easily imported into a variety of statistical software programs. For example, we simply import the .csv file into SAS because SAS understands these column headers to be variable names.

Please be careful to note that several items must be reverse scored (see Appendix Tables 1 and 2 for the indicated items). Our strong preference is do this reversal in the SAS syntax as a way to systematically, consistently, and without error reverse only the items that require it, and preventing a column of items that should be reversed from slipping through the cracks (nothing ruins a perfectly good data set more quickly than having some participants on a variable reversed, but others not).

The EALS and IRB Approval

Check with your university as to whether you need full IRB approval. If you use the data for educational purposes only (e.g., tracking students in your class) and do not intend to publish this work,

then often IRB approval is not required. If you hope to publish from your data, then certainly your local IRB must approve your measures.

The Long Form

The full EALS consists of 104 self-reported items, most of which are rated on a 7 pt scale (1 = Strongly Disagree; 4 = Neither Agree Nor Disagree; 7 = Strongly Agree). The long form EALS takes participants approximately 25 minutes to complete. Appendix Table 1 displays the 104 items, the respective lower-order and higher-order construct each item measures (this structure was psychometrically validated; Hawley et al., 2011, and the scale metric used. Items that require reversal are also indicated. The long form was created as a first step to ultimately derive a validated short form with the same structure.

The Short Form

The EALS- short form (i.e., EALS-SF) consists of 62 self-reported items drawn directly from the long form, and, like the long form, most of these items are rated on a 7 point scale (1 = Strongly Disagree; 4 = Neither Agree Nor Disagree; 7 = Strongly Agree). The EALS-SF takes participants approximately 15 minutes to complete. Appendix Table 2 displays the 62 items, the respective lower-order and higher-order construct each item measures, and the scale metric used. Items requiring reversal are also indicated.

Scaling Metric Used in the EALS and EALS-SF

With a few exceptions, the majority of the scale items are measured on a seven point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree) with a midpoint of 4 (neither agree nor disagree). (A number of subscales we pulled from other authors and accordingly kept their scale of measurement because they had been validated by the original authors; for example, the Conservative Self Identity items). We strongly encourage users to keep the scaling metric used with the EALS and

EALS-SF and not change the number of scale points or their anchoring. Doing so would obstruct the ability to make meaningful comparisons across groups. Also, please resist the temptation to measure knowledge-type questions in a True/False, dichotomous format under the misguided assumption that the item in fact is either correct or incorrect. A number of unattractive consequences result; level of certainty is not assessed and information will be lost about the scale (e.g., variability will be reduced) which in turn would require larger samples. Moreover, categorical type analyses (e.g., logistic regression, item response theory) would need to be employed. Dichotomous data are best to avoid when possible, as a general rule (Butts & Ng, 2008; Cohen, 1983; MacCallum et al., 2002; Royston et al., 2006).

What can the EALS and EALS-SF be used for?

Constructs from the EALS and EALS-SF may be useful in addressing a wide variety of research areas. A few suggestions include:

- Examining curricular effectiveness in a longitudinal design.
- Examining predictors of EALS constructs (e.g., Hawley et al., 2011)
- Examining EALS constructs as predictors of other outcome variables (e.g., does one's Knowledge/Relevance of Evolution early in college predict later college major or GPA?)
- Examining cross-sectional group differences across the EALS constructs.
- Testing complex models, such as EALS constructs as potential mediators or moderators.

Are the EALS and EALS-SF better than other measures out there?

In some ways,yes. Because the EALS is more comprehensive, has a verified structure, and has been psychometrically validated.

Other scales (with unverified structures) focus on specific phenomena, like genetic literacy (Miller, Scott, & Okamoto, 2006) and knowledge (Conceptual Inventory of Natural Selection CINS;

Anderson, Fisher, & Norman, 2002)), where these processes are considered more in depth in the sense that they are represented by more items (the CINS has 20 multiple choice items). The EALS is more comprehensive, but at the same time attempts to represent each domain with fewer items. That is, the EALS reduces redundancy when tapping into specific domains. As late as 2006, Ingram and Nelson (2006) opted for an unpublished measure of evolution knowledge and attitudes because at the time there was no "suitable instrument that assessed students' attitudes towards evolution, including acceptance of evolution, and the nature of scientific knowledge" (p. 11). We believe the EALS has in the meantime has filled this gap.

Moreover, some scales attempt to assess several domains, but in the end ask the user to calculate an overall summed score. By doing so, said information about the separate domains is completely lost (e.g., MATE; Rutledge & Warden, 1999; see also Yates & Marek, 2013). Calculating sum scores for a multi-dimensional scale is not justified from a best practices perspective. One simply doesn't know what is driving the relationships in the end.

Why did we conduct a confirmatory factor analysis (CFA)?

During the creation of the EALS, we had a clearly hypothesized structure for the scale items because we were theory-guided. Thus, we conducted a CFA to test whether our hypothesized structure appropriately explained our collected data. In other words, CFA is used to verify the structure of an instrument in terms of 'what goes with what' and to evaluate how this structure should behave in terms of making predictions or group comparisons.

What is a latent construct?

Psychologists well know that our constructs - the things we are interested in - are inherently unobservable in a concrete error free measure. That is, we don't actually SEE depression, but we attempt to assess (i.e., quantify) this construct through individuals' responses to scale items. At the same time,

we know that our measure has 'error' because of the myriad of individual difference in processes (gender, mood, social desirability, interpretation of the scale, etc.) that may interfere with or influence one's responses at any given moment.

With CFA, we assume that our items share variability among them and an individual's responses on these items are caused by their shared variability. The unobservable latent construct we hypothesize consists of only this shared variability among the items. The degree to which each item is associated with this underlying construct is reflected in item loadings (which do not have to be the same for each item), and the unexplained variation (error) is reflected in the residual estimates. Because this error is systematically removed when a CFA is conducted, we can say that our subscales have had their "unreliability disattenuated" (error removed). This in turn 'cleans' the relationships among the subscales. Simpler analytic tools (e.g., Principal Components Analysis; PCA), while useful in many ways, cannot do this.

Please note that CFA is simply specific case of structural equation modeling (SEM). Because of the hierarchical structure noted above, we highly recommend interested researchers to continue to use SEM with their own studies using the EALS and EALS-SF if possible. The use of SEM for data analysis with the EALS and EALS-SF has several advantages, including the ability to model the hierarchical nature of the constructs, removing measurement error from constructs, and subsequently, creating larger and more representative effect sizes.

Do I need to do a CFA or know how to use structural equation modeling to use the EALS?

No.

If desired, researchers can still use more traditional statistical analyses including analysis of variance (ANOVA) and regression with the EALS and EALS-SF constructs, and we detail how below.

What is a subscale?

A subscale is a set of tightly related items created to assess 'the same thing'. For example, we trawled the intelligent design literature to create items to assess people's acceptance of their fallacious talking points. Having verified with CFA, we have an Intelligent Design Fallacies subscale. We did the same thing for Young Earth Creationist Beliefs, etc.

What is a higher order factor?

A higher order factor is a construct (a concept for which there is not a single observable referent; Cronbach & Meehl, 1955) that comprises multiple subscales that have been verified to 'belong together' because scores on them tend to rise and fall together. In the EALS, the higher order factor Creationist Reasoning comprised multiple subscales - including Intelligent Design Fallacies and Young Earth Creationist Beliefs - such that for our purposes, we were comfortable looking at mean differences across Creationist Reasoning *rather than the 5 subscales defining it*.

When do I want to use higher order factors vs. subscales?

It depends. First decide what specific research question you have and how you would like to operationally define your variables. Then, consult our list of subscales to determine which best match your operational definitions. For example, perhaps a researcher is merely interested in the success of the Intelligent Design movement in his/her region. If so, then using the Intelligent Design Fallacy subscale may be sufficient for this purpose. In this case, the long form version of the subscale may be preferred because it has more items than the short form.

Alternatively, suppose a researcher is interested in examining predictors of something like creationist reasoning. If s/he wishes to define creationist beliefs as the belief that "present species diversity is explained by the Great Flood as stated in the Bible", then the items defining our Young

Earth Creationist Beliefs subscale alone may be sufficient in measuring this construct. Again, if this is the case, the perhaps the long form version is preferred.

However, if a researcher holds a broader definition of creationist reasoning that consists of not only items associated with biblical literalism as is represented by the subscale Young Earth Creationist Beliefs, but also talking points characteristic of the intelligent design movement (e.g., There is scientific evidence that humans were created by a supreme being or intelligent designer) and moral objections to the theory (e.g., People who accept evolution do not believe in God), then the higher order construct Creationist Reasoning would be more appropriate.

How do I use subscales?

If you plan to use ANOVA or regression type analyses, then simply do the following: First, measure all the items on the subscale (the item list will be longer if you are using the long form over the short form, by definition), labeling your variables/columns sensibly (e.g., IDF1-6). Next, make sure you have performed the appropriate reversal of items in your syntax (e.g., reverse score the indicated items that are indicated on the tables). Finally, simply calculate a scale score by averaging across the items. We strongly suggest calculating an average rather than a summed score.

How does one best reverse score and compute a scale score?

Because the scale is 1-7, subtract the item score from 8.

- In SAS: VariableName_rvsd = (8 - VariableName);

To, for example, calculate a scale score for Intelligent Design Fallacies using the 6 items from the short form (i.e., EALS-SF):

- In SAS: IDF = mean (of IDF1 IDF2 IDF3 IDF4 IDF5 IDF6);

  (If one uses the long form, there will be 11 items in the variable list.)

[***For advanced users:*** If you plan to use SEM, you must begin by creating a measurement model (e.g., a CFA) where all the items in a particular subscale are indicators for a single factor. As with all CFAs, the model must be identified (i.e., a scale must be set; see Brown, 2003, Kline, 2010; Little, 2013). We highly recommend against using the marker variable method of identification, where one item's factor loading is set to 1.0. Please note this method is the default method for identification in several SEM softwares. Although model fit does not change based on identification, there are implications for interpretation of results for the different methods used. We recommend identifying the model by either fixing the factor variance to 1.0 (e.g., fixed factor method of identification) or using the effects-coding method of identification (Little, Slegers, & Card, 2006). Appendix Figures 2 and 3 provide a CFA example for the construct Intelligent Design Fallacies identified by the fixed-factor and effects coding method of identification, respectively. Interested readers should refer to Gonzalez and Griffin (2001) or Little (2013) for a thorough discussion on model identification and the disadvantages of the marker variable method of identification.

Once a CFA has been conducted, you can then proceed to using this factor structure in an SEM framework (i.e., as a predictor and/or outcome variable).]

How do I use higher order factors?

How you use higher order factors will depend on the type of analysis you plan to conduct.

First and foremost, you will want to make sure you have measured completely (i.e., using all items) all of the subscales within the higher order factor you are interested in. For example, if you are interested in examining Knowledge/Relevance of evolution, then you will need to use the Relevance of Evolutionary Theory, Genetic Literacy, Evolutionary Knowledge, and Knowledge about the Scientific Enterprise subscales. Each higher order factor was developed and validated to be comprised of all of the subscales. Therefore, in order to preserve validity, all the subscales within the higher order factor must

be collected. If a subscale is left out, then the factor is no longer the same as how we originally defined and validated it. Consequently, results will not be comparable.

If you plan to use ANOVA or regression type analyses, then first begin by determining which subscales comprise the higher order factor(s) you are interested in measuring. As can be seen in Figure 1, three subscales (e.g., Intelligent Design Fallacies, Young Earth Creationism, and Relevance of Evolutionary Theory) are each part of two higher order factors. This situation is not a problem when CFA/SEM analyses are conducted, but it does create an issue in defining the higher order factor for ANOVA/regression analyses. If the same subscale were to be used in calculating multiple higher order factors, then a dependency would be created between these factors. To avoid this situation, we suggest that each subscale only be used in the *calculation of one of the higher order factors*. Specifically, the subscale should be included in the calculation of the higher order factor for which it has the stronger (i.e., larger in magnitude) of the two loadings because this higher order factor accounts for the most variability in the subscale. We have previously validated the higher order factor structure (see Hawley et al., 2011; Short & Hawley, 2012) and therefore suggest if ANOVA/regression analyses are to be conducted, then the subscales Intelligent Design Fallacies and Young-Earth Creationism should be used only for the higher order factor Creationist Reasoning, and the subscale Relevance of Evolutionary Theory, should be used only for the higher order factor Knowledge/Relevance.

Thus, in ANOVA/regression analyses the following subscales define each higher order factor:

Political Activity

-Political Activity

Political/Religious Conservatism

-Religious Activity

-Conservative Self Identity

-Attitudes Towards Life

Creationist Reasoning

- Intelligent Design Fallacies
- Young-Earth Creationism
- Moral Objections
- Social Objections
- Distrust of the Scientific Enterprise

Knowledge/Relevance

- Relevance of Evolutionary Theory
- Genetic Literacy
- Evolutionary Knowledge
- Knowledge About the Scientific Enterprise

Evolutionary Misconceptions

- Evolutionary Misconceptions

Exposure to Evolution

- Self Exposure to Evolution
- Youth Exposure to Evolution

An individual's score on a higher order factor can be calculated by following two steps. First, calculate the mean for each subscale that comprises the higher order factor. Again, remember to reverse the appropriate items before calculating the mean. Second, calculate the mean of these subscale means. This mean of subscale means will be the individual's score on the higher order factor. For example, suppose a researcher would like to calculate an individual's score on the higher order construct Knowledge/Relevance. First the researcher would calculate the mean across the items for each of the four subscales that comprise Knowledge/Relevance (i.e., Relevance of Evolutionary Theory, Genetic Literacy, Evolutionary Knowledge, Knowledge About the Scientific Enterprise). Second, the researcher would calculate *the mean of these four subscale means*. The resulting value would represent the individual's score on the higher order construct Knowledge/Relevance and which then be used in traditional analyses.

Finally, we would like to stress that the researcher should only calculates means for the subscales and higher order constructs and resist the desire to calculate total summed scores. A total summed score changes the variability and can create additional problems in the analysis, including interpretability of the results.

[***For advanced users***: If you plan to use SEM, then we recommend that you first create a mean score for each subscale that can be used as a parcel (see Little, Cunningham, Shahar, & Widaman, 2002; Little, Rhemtulla, Gibson, & Schoemann, 2013). Parceling has the added benefits of requiring fewer model parameter estimates, reduced sampling error, and decreasing the likelihood of correlated residuals between items (Little et al., 2002). EALS parceled indicators are computed by calculating the mean response for all items representing a particular subscale. If the researcher has administered the entire EALS or EALS-SF, then an average score can be calculated for each subscale, and these parcels can be used as indicators for the higher order factors. Figure 1 displays the CFA model for the EALS and EALS-SF that the researcher should replicate. Again, we strongly suggest the research use either the fixed-factor or effects-coding method for identifying the size higher-order constructs in the model.

When specifying the higher-order model, researchers should note two important traits of the model. First, three subscales (e.g., Intelligent Design Fallacies, Young Earth Creationism, and Relevance of Evolutionary Theory) each load onto two different higher order constructs. This state of affairs can be easily handled by any popular SEM software. Second, three higher-order factors (Political Activity, Evolutionary Misconceptions and Exposure to Evolution) do not contain three indicators (i.e., parcels). Because three indicators are not present for these constructs, additional model constraints must be specified to locally identify the model. Specifically, for Political Activity and Evolutionary Misconceptions to be identified, both the factor variance, and factor loading for the single parcel must be fixed to 1.0. Because Evolutionary Misconceptions contains two parcels (e.g., Self-Exposure to

Evolution and Youth Exposure to Evolution) the construct can be identified by constraining the factor loadings to be equal in addition to fixing the factor variance to 1.0. For a detailed discussion about why additional model constraints are required for constructs with less than three indicators researchers should refer to Brown (2006), Kline (2010), or Little (2013).]

What if I want to add items?

We would recommend adding subscales rather than items. By adding single and random items to our subscales, you would inadvertently put yourself in the position of needing to assess their fit with the existing instrument by conducting a CFA. For example, suppose you wanted to add an item to the Intelligent Design Fallacy construct such as, "Evolutionary theory is just an unfounded belief". A CFA would be required to make sure this item shares variability with our pre-existing items in the Intelligent Design Fallacies subscale.

Once you have verified that said item fit well within an existing subscale already documented by us, you have actually added an unnecessary item that duplicates information in our already represented domain space. Thus, we do not recommend adding individual items, and would suggest doing so serves little useful purpose.

What if I want to add subscales?

The more preferable scenario is that you have a subscale or construct in mind that is wholly unaddressed by our survey. That is, if you identify an area of interest unmeasured by us, we recommend going right to designing an additional subscale (or additional subscales) and use it as a correlate/covariate with the EALS constructs.

Good luck with your work!

References

Anderson, D. L., Fisher, K. M., & Norman, G. J. (2002). Development and evaluation of the conceptual inventory of natural science. *Journal of Research in Science Teaching, 39,* 952–978.

Brown, T. A. (2006). *Confirmatory factor analysis for applied research*. New York: Guilford Press.

Butts, M. M., & Ng, T. W. H. (2008). Chopped liver? OK. Chopped data? Not OK. In C. E. Lance, & Vanderberg, R. J. (Eds.), *Statistical and methodological myths and urban legends: Doctrine, verity, and fable in the Organizational and Social Sciences* (pp.361-387). New York. Routledge.

Carney, D. A., Jost, J. T., Gosling, S. D., & Potter, J. (2008). The secret lives of liberals and conservatives: Personality profiles, interaction styles, and the things they leave behind. *Political Psychology, 29*, 807-840.

Cohen, J. (1983). The cost of dichotomization. *Applied Psychological Measurement, 7*, 249-253

Cronbach, L. J., & Meehl, P. E. (1995). Construct validity in psychological tests. *Psychological Bulletin*, *52*, 281-302.

Dudley, R. L., & Cruise, R. J. (1990). Measuring religious maturity: A proposed scale. *Review of Religous Research*, *32*, 97-109.

Gonzalez, R., & Griffin, D. (2001). Testing parameters in structural equation modeling: Every "one" matters. *Psychological Methods*, *6*, 258-269.

Hawley, P. H., Short, S. D., McCune, L. A., Osman, M. R., & Little, T. D. (2011). What's the matter with Kansas?: The development and confirmation of the Evolutionary Attitudes and Literacy Survey (EALS). *Evolution: Education and Outreach*, *4*, 117-132.

Ingram, E. L., & Nelson, C. E. (2006). Relationship between achievement and students' acceptance of evolution or creation in an upper-level evolution course. *Journal of Research in Science Teaching, 43*(1), 7-24.

Kline, R. B. (2010). *Principles and practice of structural equation modeling* (3rd ed.). New York. Guilford Press.

Little, T. D. (2013). *Longitudinal structural equation modeling*. New York: Guilford Press.

Little, T. D., Cunningham, W. A., Shahar, G., & Widaman, K. F. (2002). To parcel or not to parcel: Exploring the question, weighing the merits. *Structural Equation Modeling, 9,* 151-173.

Little, T. D., Rhemtulla, M., Gibson, K., & Schoemann, A. M. (2012). Why the items versus parcels controversy needn't be one. *Psychological Methods*, *00*, 000-000.

Little, T. D., Slegers, D. W., & Card, N. A. (2006). A non-arbitrary method of identifying and scaling latent variables in SEM and MACS models. *Structural Equation Modeling, 13,* 59-72.

MacCallum, R. C., Zhang, S., Preacher, K. J., & Rucker, D. D. (2002). On the practice of dichotomization of quantitative variables. *Psychological Methods, 7*, 19-40.

Miller, J. D., Scott, E. C., & Okamoto, S. (2006). Public acceptance of evolution. *Science, 313*, 765-766.

Royston, P., Altman, D. G., & Sauerbrei, W. (2006). Dichotomizing continuous predictors in multiple regression: A Bad idea. *Statistics in Medicine, 25,* 127-141.

Rutledge, M. L., & Sadler, K. C. (2007). Reliability of the Measure of Acceptance of the Theory of Evolution (MATE) instrument with university students. *The American Biology Teacher, 69*, 332-335.

Rutledge, M. L., & Warden, M. A. (1999). The development and validation of the Measure of Acceptance of the Theory of Evolution instrument. *School Science and Mathematics, 99*, 13-18.

Short, S. D., & Hawley, P. H. (2012). Evolution Attitudes and Literacy Survey (EALS): Development and validation of a short form. *Evolution*: *Education and Outreach*, *5*, 419-428.

Yates, T. B., & Marek, E. A. (2013). Is Oklahoma really OK? A regional study of the prevalence of biological evolution-related misconceptions held by introductory biology teachers. *Evolution: Education and Outreach, 6*, 1-20.

List of Table and Figures

Table 1

Evolutionary Attitudes and Literacy Survey Long Form (EALS) Constructs and Scale Items

Lower-Order Construct	Higher-Order Construct	Items	Scale Metric
Political Activity	Political Activity		
		To what degree are you political?	I
		To what degree are you politically active?	I
		To what degree are you politically aware/up-to-date?	I
		To what degree do your political views influence your daily life?	II
		To what degree do your political views influence your decisions?	II
		To what degree do your political views influence courses you enroll in?	II
Religious Activity	Religious Conservatism		
		To what degree are you religious?	I
		To what degree does religion impact your daily life?	I
		To what degree does your religion influence your decisions?	I
		To what degree do you participate in religious activities?	I
		How much do you believe in God?	II
		Religion is especially important to me because it answers many of my questions about the meaning of life. [A]	III
Conservative Self Identity	Religious Conservatism		
		To what degree are you conservative?	I
		In general, how do you self-identify politically? [B]	IV
		In general how liberal/conservative are you on Social issues (abortion, same-sex marriage, flag burning, etc)? [C]	V
		In general how liberal/conservative are you on Economic issues (welfare, taxation, free market policies, etc)? [C]	V
		In general how liberal/conservative are you on foreign policy and defense issues (defense spending, combating terrorism, pre-emptive war)? [C]	V

Attitudes Toward Life[D]	Religious Conservatism		
		Life begins at conception.	VI
		After conception, a developing human is only a cluster of cells, and it makes no sense to discuss its moral condition. **(R)**	VI
		All stages of human life- embryo, fetus, child, adult- should have the same legal protections.	VI
Intelligent Design Fallacies	Religious Conservatism & Creationist Reasoning		
		There is scientific evidence that humans were created by a supreme being or intelligent designer.	VI
		There is no evidence that humans evolved from other animals.	VI
		The theory of evolution is a matter of faith and belief, just like religion.	VI
		Humans were specially designed.	VI
		There are no transitional fossils (remains of life forms that illustrate an evolutionary transition).	VI
		It is statistically impossible that life arose by chance.	VI
		The theory of evolution does not explain similarities or differences between chimps and humans.	VI
		Complex biological systems cannot come about by slight successive modifications (i.e., they are irreducibly complex).	VI
		Evolution is a theory in crisis.	VI
		Evolution violates the 2nd law of thermodynamics (that systems move toward *disorder*, not order). [E]	VI
		Natural selection cannot create complex structures; It is like a tornado blowing through a junkyard and creating a 747.	VI
Young Earth Creationist Beliefs	Religious Conservatism & Creationist Reasoning		
		I read the bible literally.	VI
		God created humans in their present form. (used to be: A supreme being created humans in their present image.)	VI

		Humans never could have been related to apes.	VI
		The Earth isn't old enough for evolution to have taken place.	VI
		There was a time when humans and dinosaurs lived on earth together.	VI
		Present animal diversity can be explained by the Great Flood.	VI
		A majority of present-day geological features are the result of the Great Flood.	VI
		Adam and Eve of Genesis are our universal ancestors of the entire human race.	VI
		All modern species of land vertebrates are descended from those original animals on the ark.	VI
Moral Objections	Creationist Reasoning		
		People who accept evolution do not believe in God.	VI
		People who accept evolution as fact are immoral.	VI
		If you accept evolution, you really can't believe in God.	VI
		Darwinism strips meaning from our lives.	VI
		People can be moral and believe in evolution at the same time. **(R)**	VI
Social Objections	Creationist Reasoning		
		The theory of evolution has contributed to racism.	VI
		Applying the theory of evolution to human affairs implies we are not fully in control of our behavior.	VI
		The theory of evolution has contributed to sexism.	VI
		The theory of evolution has contributed to an increase in abortion.	VI
		The theory of evolution has contributed to genocide (the deliberate killing of a group based on nationality, race, politics, or culture).	VI
		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).	VI
Distrust of the Scientific Enterprise	Creationist Reasoning		
		Contemporary methods of determining the age of fossils and rocks are untrustworthy. [D]	VI
		The data used to support evolution is untrustworthy.	VI

		The theory of evolution is capable of explaining the diversity of life. **(R)**	VI
		Evolutionary theorists believe that if something is natural then it is good or right.	VI
		Evolutionary theorists believe that inevitable inequality is morally acceptable.[F]	VI
		Evolutionary theorists believe that because the strongest survive, it's a mistake to help the weak. [F]	VI
		The available data are ambiguous as to whether evolution actually occurs. [G]	VI
Relevance of Evolutionary Theory	Religious Conservatism & Knowledge/Relevance		
		The theory of evolution helps us understand plants.	VI
		Evolutionary theory is highly relevant for biology.	VI
		The theory of evolution helps us understand animals.	VI
		The theory of evolution helps us understand human origins.	VI
		For explaining human behavior, evolutionary theory is irrelevant. **(R)**	VI
		Evolutionary theory is highly relevant for the social sciences (e.g., anthropology, psychology, sociology).	VI
		Evolutionary theory is highly relevant for the humanities (e.g., history, literature, philosophy).	VI
		Evolutionary theory is relevant to our everyday lives.	VI
		The theory of evolution helps explain the world as it is in the present.	VI
Genetic Literacy	Knowledge/Relevance		
		Humans share a majority of their genes with chimpanzees. [D]	VI
		Humans share more than half of their genes with mice. [D]	VI
		Ordinary tomatoes do not have genes, whereas genetically modified tomatoes do. [D] **(R)**	VI
		Today it is not possible to transfer genes from one species of animal to another. [D]	VI
		All plants and animals have DNA [D]	VI
		Humans have somewhat less than half of the DNA in common with chimpanzees. [D] **(R)**	VI
		You can see traces of our evolutionary past in human embryos.	VI

		Humans developed from earlier life forms.	VI
		Mutations are never beneficial. [D] **(R)**	VI
Evolutionary Knowledge	Knowledge/Relevance		
		In most populations, more offspring are born than can survive.	VI
		Individuals don't evolve, species do.	VI
		Mutations can be passed down to the next generation.	VI
		Increased genetic variability makes a population more resistant to extinction.	VI
		The more recently species share a common ancestor, the more closely related they are.	VI
		Natural selection is the only cause of evolution. **(R)**	VI
		Mutations occur all the time.	VI
Misconceptions about Evolution	Evolutionary Misconceptions		
		Natural selection is a random process.	VI
		Natural selection is synonymous (means the same) as evolution.	VI
		Characteristics acquired during the lifetime of an organism are passed down to that individual's offspring.	VI
		Species evolve to be perfectly adapted to their environments	VI
		Evolution means progression towards perfection.	VI
		Evolution is a linear progression from primitive to advanced species.	VI
Knowledge about the Scientific Enterprise	Knowledge/Relevance		
		Good theories can be proven by a single experiment **(R)**	VI
		For scientific evidence to be deemed adequate, it must be reproducible by others.	VI
		Scientific ideas can be tested and supported by feelings and beliefs. **(R)**	VI
		Scientific explanations can be supernatural. **(R)**	VI
		Theories requiring more untested assumptions are generally better than theories with fewer assumptions. **(R)**	VI
		Good theories give rise to testable predictions.	VI

Self Exposure to Evolution	Exposure to Evolution		
		I've visited evolution related websites (e.g., Science Daily, Pharyngula, Edge.org)	VII
		I've watched evolution related videos on the web (e.g., Ted.com, YouTube).	VII
		I read science magazines featuring evolution (e.g., Discover, National Geographic, Nature).	VII
		I've watched nature shows that discussed evolution (e.g., PBS/Nova, Discovery, National Geographic)	VII
		I've read evolution related books (e.g., by Richard Dawkins, EO Wilson, Steven Pinker)	VII
Youth Exposure to Evolution	Exposure to Evolution		
		I have visited natural history museums on field trips or with family.	VII
		As a child, I attended science and nature camps (e.g., Outdoor Ed Lab, local nature centers or zoos).	VII
		How many evolution related courses did you have in high school?	VIII
		How much training in evolution did you receive in high school?	IX

Note. For scale metric I = seven point Likert scale ranging from 1 (Not at all) to 7 (Very)
II = seven point Likert scale ranging from 1 (Not at all) to 7 (Very much)
III = seven point Likert scale ranging from 1 (Not at all True) to 7 (Totally True) with the midpoint 4 (Moderately True)
IV = eight point Likert scale with 1 (Strong Democrat), 2 (Democrat), 3 (Independent Leaning Democrat), 4 (Independent) 5 (Independent Leaning Republican) 6 (Republican), 7 (Strong Republican), or the option "N/A or Other"
V = eight point Likert scale with 1 (Very Liberal), 2 (Liberal), 3 (Slightly Liberal), 4 (Moderate) 5 (Slightly Conservative) 6 (Conservative), 7 (Very Conservative), or the option "Don't Know"
VI = seven point Likert scale ranging from 1 (Strongly Disagree) to 7 (Strongly Agree) with the midpoint 4 (Neither Agree nor Disagree).
VII = five point Likert scale with 1 (Never), 3 (Occasionally), 5 (Frequently)
VIII = five point Likert scale with 1 (None) 2 (One or Two) 3 (Three or Four) 4 (Five or Six) 5 (Seven or More)
IX = five point Likert scale with 1(None), 2 (Very Little), 3 (Some), 4 (Quite a bit), 5 (A lot)
[A] See also Dudley and Cruise (1990) [B] cf., ANES 2009 [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) Reverse coded item**

Table 2

Evolutionary Attitudes and Literacy Survey Short Form (EALS-SF) Constructs and Scale Items

Lower-Order Construct	**Higher-Order Construct**	**Items**	**Scale Metric**
Political Activity	Political Activity		
		To what degree are you political?	I
		To what degree do your political views influence your daily life?	II
		To what degree do your political views influence your decisions?	II
Religious Activity	Religious Conservatism		
		To what degree are you religious?	II
		To what degree does religion impact your daily life?	II
		To what degree does your religion influence your decisions?	II
		Religion is especially important to me because it answers many of my questions about the meaning of life. [A]	III
Conservative Self Identity	Religious Conservatism		
		To what degree are you conservative?	I
		In general, how do you self identify politically? [B]	IV
		In general how liberal/conservative are you on Economic issues (welfare, taxation, free market policies, etc)? [C]	V
Attitudes Toward Life [D]	Religious Conservatism		
		Life begins at conception.	VI
		After conception, a developing human is only a cluster of cells, and it makes no sense to discuss its moral condition. **(R)**	VI
		All stages of human life- embryo, fetus, child, adult- should have the same legal protections.	VI

Intelligent Design Fallacies	Religious Conservatism & Creationist Reasoning		
		There is scientific evidence that humans were created by a supreme being or intelligent designer.	VI
		There is no evidence that humans evolved from other animals.	VI
		There are no transitional fossils (remains of life forms that illustrate an evolutionary transition).	VI
		Complex biological systems cannot come about by slight successive modifications (i.e., they are irreducibly complex).	VI
		Evolution is a theory in crisis.	VI
		Natural selection cannot create complex structures; It is like a tornado blowing through a junkyard and creating a 747.	VI
Young Earth Creationist Beliefs	Religious Conservatism & Creationist Reasoning		
		I read the bible literally.	VI
		The Earth isn't old enough for evolution to have taken place.	VI
		There was a time when humans and dinosaurs lived on earth together.	VI
		Present animal diversity can be explained by the Great Flood.	VI
		Adam and Eve of Genesis are our universal ancestors of the entire human race.	VI
		All modern species of land vertebrates are descended from those original animals on the ark.	VI
Moral Objections	Creationist Reasoning		
		People who accept evolution as fact are immoral.	VI
		If you accept evolution, you really can't believe in God.	VI
		Darwinism strips meaning from our lives.	VI
Social Objections	Creationist Reasoning		
		The theory of evolution has contributed to racism.	VI
		The theory of evolution has contributed to sexism.	VI
		The theory of evolution has contributed to genocide (the deliberate killing of a group based on nationality, race, politics, or culture).	VI

Distrust of the Scientific Enterprise	Creationist Reasoning		
		Contemporary methods of determining the age of fossils and rocks are untrustworthy. [E]	VI
		The data used to support evolution is untrustworthy.	VI
		The available data are ambiguous as to whether evolution actually occurs. [G]	VI
Relevance of Evolutionary Theory	Religious Conservatism & Knowledge/Relevance		
		Evolutionary theory is highly relevant for biology.	VI
		The theory of evolution helps us understand human origins.	VI
		Evolutionary theory is highly relevant for the social sciences (e.g., anthropology, psychology, sociology).	VI
		Evolutionary theory is highly relevant for the humanities (e.g., history, literature, philosophy).	VI
		Evolutionary theory is relevant to our everyday lives.	VI
Genetic Literacy	Knowledge/Relevance		VI
		Humans share a majority of their genes with chimpanzees. [D]	VI
		Humans share more than half of their genes with mice. [D]	VI
		Humans have somewhat less than half of the DNA in common with chimpanzees. [D] **(R)**	VI
		Mutations are never beneficial. [D] **(R)**	VI
Evolutionary Knowledge	Knowledge/Relevance		
		In most populations, more offspring are born than can survive.	VI
		Mutations can be passed down to the next generation.	VI
		Increased genetic variability makes a population more resistant to extinction.	VI
		The more recently species share a common ancestor, the more closely related they are.	VI
		Mutations occur all the time.	VI

Misconceptions about Evolution	Evolutionary Misconceptions		
		Characteristics acquired during the lifetime of an organism are passed down to that individual's off spring.	VI
		Evolution means progression towards perfection.	VI
		Evolution is a linear progression from primitive to advanced species.	VI
Knowledge about the Scientific Enterprise	Knowledge/Relevance		
		For scientific evidence to be deemed adequate, it must be reproducible by others.	VI
		Scientific ideas can be tested and supported by feelings and beliefs. (**R)**	VI
		Scientific explanations can be supernatural. **(R)**	VI
		Good theories give rise to testable predictions.	VI
Self Exposure to Evolution	Exposure to Evolution		
		I've watched evolution related videos on the web (e.g., Ted.com, YouTube).	VII
		I read science magazines featuring evolution (e.g., Discover, National Geographic, Nature).	VII
		I've watched nature shows that discussed evolution (e.g., PBS/Nova, Discovery, National Geographic)	VII
Youth Exposure to Evolution	Exposure to Evolution		
		I have visited natural history museums on field trips or with family.	VII
		As a child, I attended science and nature camps (e.g., Outdoor Ed Lab, local nature centers or zoos).	VII
		How much training in evolution did you receive in high school?	VIII

Note.
For scale metric I = seven point Likert scale ranging from 1 (Not at all) to 7 (Very)
II = seven point Likert scale ranging from 1 (Not at all) to 7 (Very much)
III = seven point Likert scale ranging from 1 (Not at all True) to 7 (Totally True) with the midpoint 4 (Moderately True)
IV = eight point Likert scale with 1 (Strong Democrat), 2 (Democrat), 3 (Independent Leaning Democrat), 4 (Independent) 5 (Independent Leaning Republican) 6 (Republican), 7 (Strong Republican), or the option "N/A or Other"
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VI = seven point Likert scale ranging from 1 (Strongly Disagree) to 7 (Strongly Agree) with the midpoint 4 (Neither Agree nor Disagree).
VII = five point Likert scale with 1 (Never), 3 (Occasionally), 5 (Frequently)
VIII = five point Likert scale with 1 (None) 2 (One or Two) 3 (Three or Four) 4 (Five or Six) 5 (Seven or More)

[A] See also Dudley and Cruise (1990) [B] cf., ANES 2009 [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) Reverse coded item**

Figure 1

Hierarchical Structure of the EALS and EALS-SF

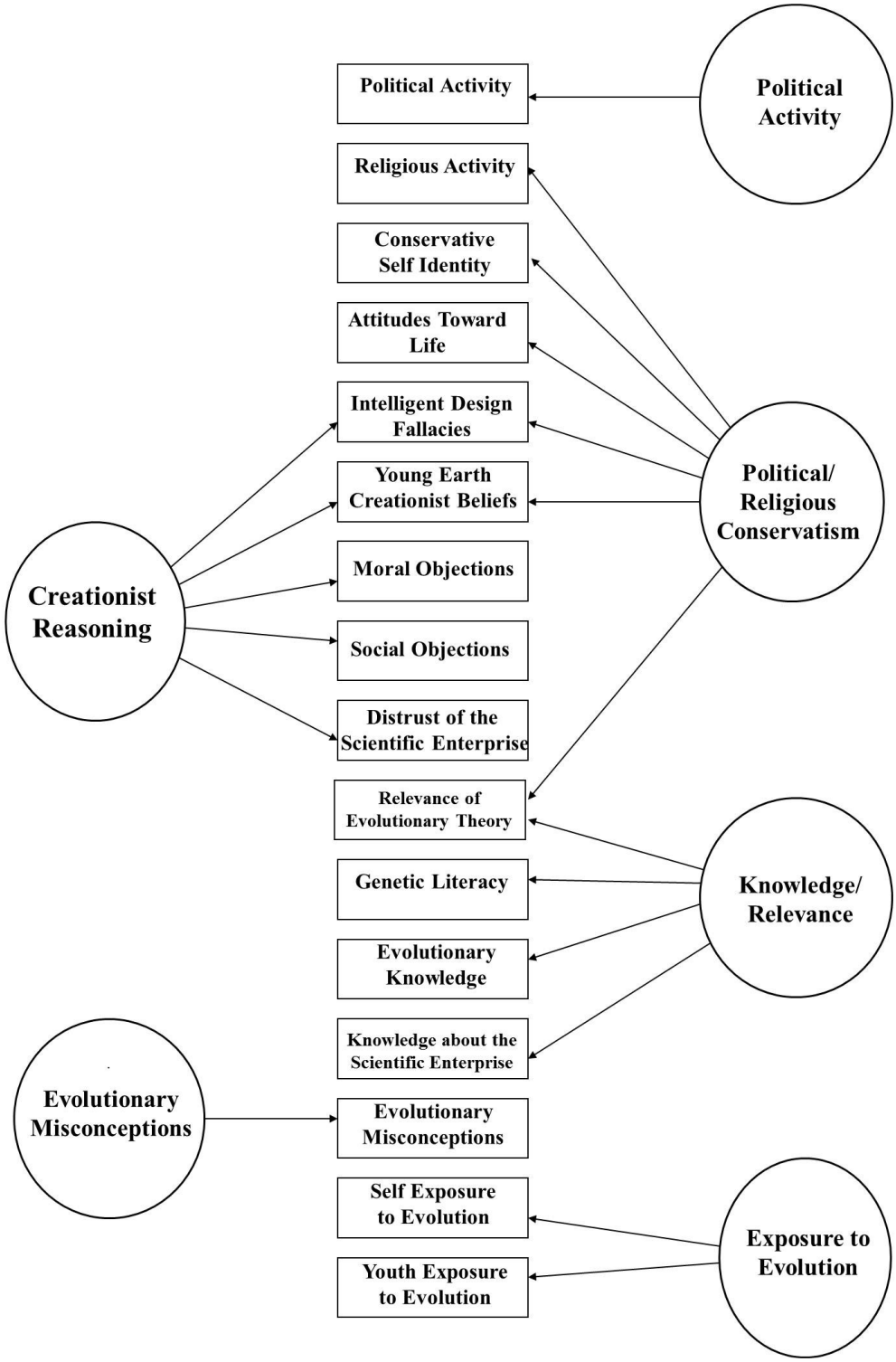
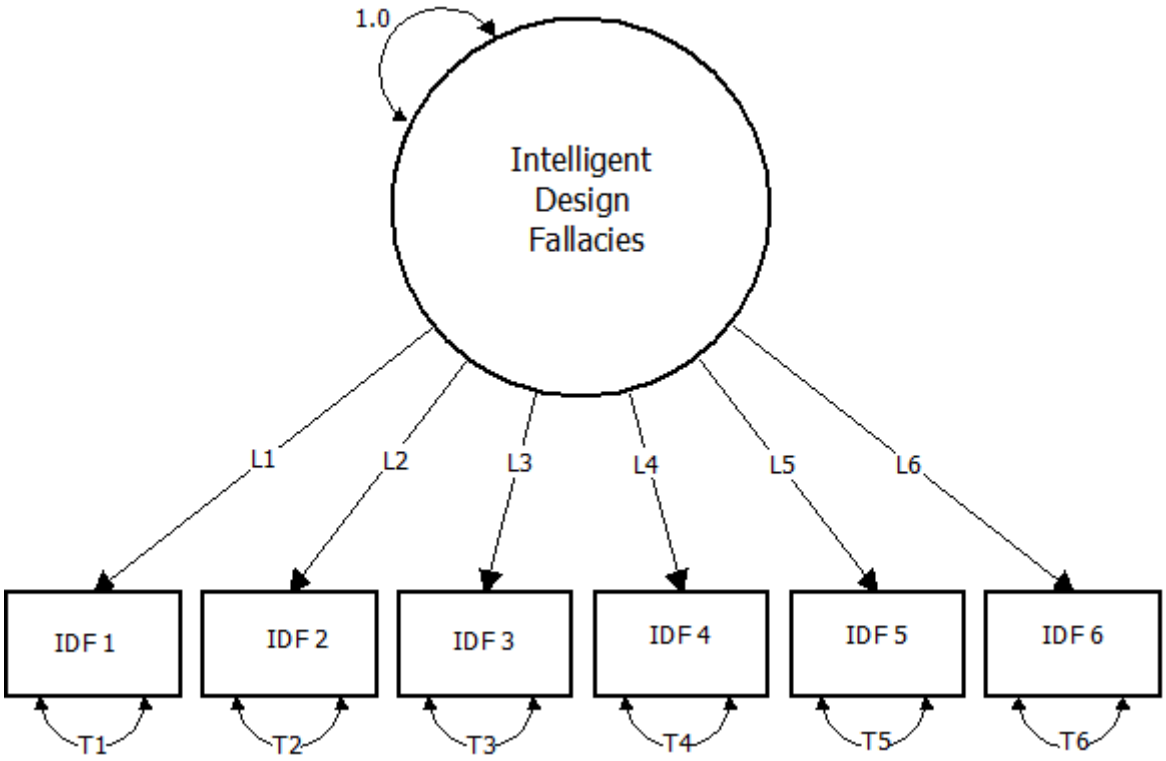
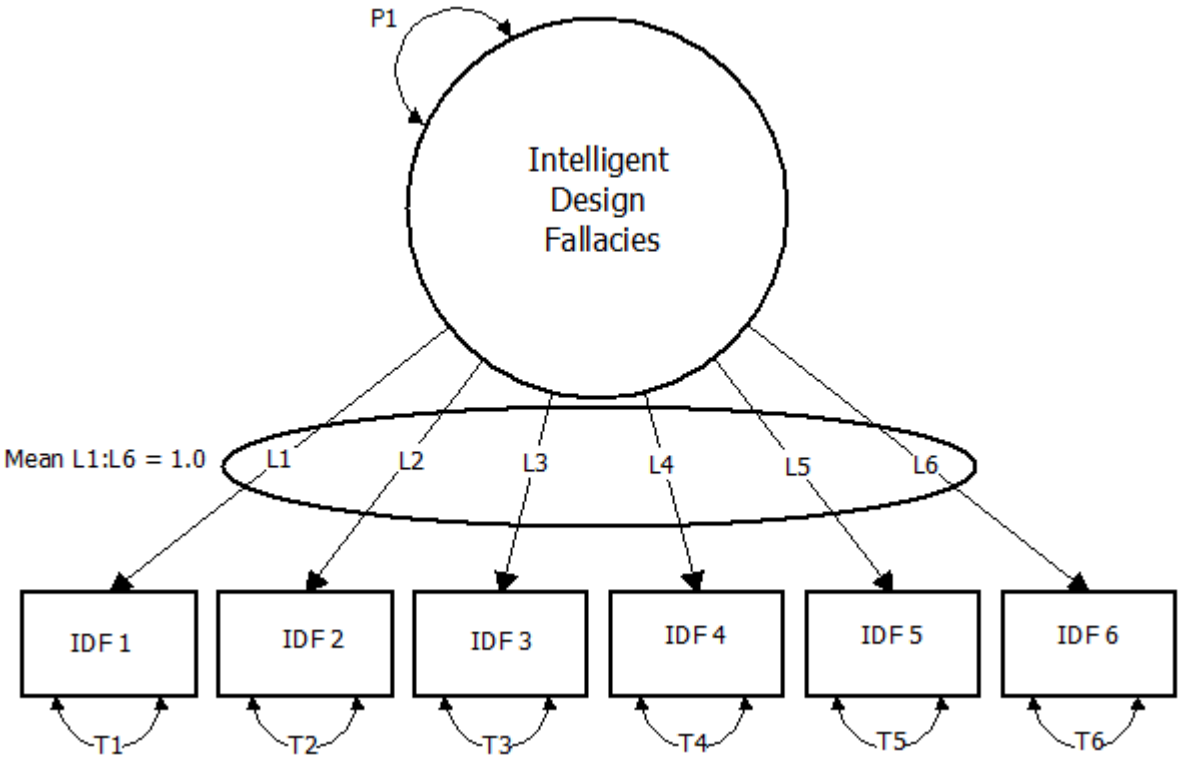


Figure 2: *Example of CFA for EALS-SF construct Intelligent Design Fallacies with fixed factor method of identification*



Note. L1—L6 = factor loadings, T1—T6 = residual variances. The variance of the construct Intelligent Design Fallacies is fixed to 1.0 to identify the model.

Figure 3: *Example of CFA for EALS-SF construct Intelligent Design Fallacies with effects coding method of identification*



Note. L1—L6 = factor loadings, T1—T6 = residual variances, and P1 = factor variance. The model is identified by fixing the mean of the factor loadings to = 1.0 (see Little, Slegers, & Card, 2006).