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Modeling Attitudes Toward Science: Development and Validation of the Credibility of Science Scale

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ABSTRACT
We present the Credibility of Science Scale (CoSS), an efficient 6-item scale demonstrating excellent reliability and validity. CoSS scores exhibit criterion validity in predicting beliefs across a host of contemporary science topics, over and above previously documented predictors (Study 2). Further, we present evidence for the convergent and discriminant validity of the instrument, which correlates as expected with several variables previously implicated in scientific belief (e.g., political ideology, religious identity, conspiracist thinking; Study 2) and also with measures of cognitive ability (Study 3). Finally, we discuss possible uses of the CoSS as a tool for understanding science-related beliefs, behavior, and communication.

Some of the most controversial topics in contemporary public discourse concern science. The American public, and citizens of the world more broadly, are divided on critical topics like climate change, stem cell research, nuclear power, evolutionary theory, and vaccine safety (e.g., National Science Board, 2014). On many of these topics, the U.S. majority public opinion is at odds with the scientific consensus (Pew Research Center, 2015).

Recognizing the societal importance of these issues, researchers in multiple disciplines have studied people's science-related attitudes and beliefs (e.g., Evans & Evans, 2008; Gauchat, 2012; Kahan, 2015; Lewandowsky, Oberauer, & Gignac, 2013), including individual and group differences in what we call generalized perceptions about the credibility of science (PCoS) — that is, the extent to which one's default tendency is to trust in the methods and findings of science, hold positive attitudes toward the scientific enterprise, view scientists as credible, and so forth (Brewer & Ley, 2013; Earle & Cvetkovich, 1995; Hmielowski, Feldman, Myers, Leiserowitz, & Maibach, 2014; Lewandowsky & Oberauer, 2016). Despite increasing scholarly interest in PCoS, at present there is no robust, validated measure of the construct. To address this gap, we introduce the Credibility of Science Scale (CoSS).

Evaluations of science

Although Americans' attitudes toward science are generally positive (National Science Board, 2014), there is considerable variability in PCoS (see, e.g., Earle, 2010), and multiple lines of research point to their practical impact in contemporary society. For example, people's evaluations of science[1] predict their beliefs and attitudes toward specific scientific or technical topics, including genetically modified foods (Marques, Critchley, & Walshe, 2015), stem cell research (Critchley, 2008), and global warming (Hmielowski et al., 2014). Further, greater trust in scientific experts predicts relevant behavior (e.g., nutrition; Bleich, Blendon, & Adams, 2007).

Most of this research has taken a topic-centric approach, documenting predictors of *specific* scientific beliefs (e.g., Marques et al., 2015). For example, people's beliefs about the benefits of vaccination or the risks of a disease predict people's vaccination behavior (Brewer et al., 2007). More idiosyncratic predictors can be found for specific vaccines, such as a mother's history of sexually transmitted infections predicting intentions to vaccinate her daughter against HPV (Rosenthal et al., 2008).

This topic-centric approach is laudable, as specificity in measurement increases one's ability to predict specific outcomes (e.g., Fishbein & Ajzen, 1975). However, a narrow focus can lead researchers to ignore the importance of global individual differences that have explanatory power across domains (see, e.g., Hartman & Betz, 2007). In the case of people's science-related beliefs, we postulate that people's PCoS is one important variable that lends insight across a range of science-related beliefs and behaviors.[2] For example, the literature on attitude formation and persuasion shows that

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perceived source credibility can act as a heuristic, a biasing agent, or a determinant of careful thought, among other possible roles (for reviews, see Briñol & Petty, 2009; Petty & Briñol, 2014). Although past attitude formation work has assumed that scientists are regarded as high-credibility information sources by default (e.g., Hovland & Weiss, 1951), the foregoing studies suggest that PCoS is more variable.

Measuring attitudes toward science

Unfortunately, our ability to accumulate knowledge about PCoS has been hampered by measurement limitations. Most commonly, researchers rely on unvalidated ad hoc items or on post hoc measures cobbled together from items in preexisting data sets. For example, a number of studies measure the construct using single questions along the lines of "How much do you trust the things that scientists say about the environment?" (e.g., Malka, Krosnick, & Langer, 2009). Although such items are face valid, their psychometric properties are generally unknown.

Other work leverages widely available survey data sets, such as the General Social Survey (GSS; Gauchat, 2008, 2011; Johnson, Scheitle, & Ecklund, 2015; Sturgis & Allum, 2004), but such scales often display low reliability (e.g., $\alpha = .60$ in Gauchat, 2008) and lack prior scale validity evidence. Finally, these measures often confound constructs at the scale or item level, as in the item "We believe too much in science, *and not enough in feelings and faith* [emphasis added]" (from GSS; Gauchat, 2008), which explicitly confounds religious faith with attitudes toward science.

The present research

Given the societal significance of PCoS and the shortcomings of existing measures, a well-validated measure of the construct is critical for furthering knowledge in this domain. Such a measure may be useful in basic research examining scientific belief formation and communication, as well as providing educational, public health, and social programs with a key indicator of who might be more effectively reached with a particular approach or whether outreach efforts to change global science attitudes are effective. The current research develops and validates such a measure.

We conceptualize PCoS as one's base-level tendency to positively or negatively evaluate scientific methods, fields, authorities and the ideas they promote. As such, positive PCoS incline one to favorably evaluate the usefulness, accuracy, or objectivity of the scientific community's judgments. In contrast, negative PCoS manifest as a tendency to question the scientific community's motives, capabilities, and judgments. Conceptually, PCoS are likely related to but distinct from science knowledge (Allum, Sturgis, Tabourazi, & Brunton-Smith, 2008; Kahan, 2015) and issue-specific scientific beliefs. Although we predict that PCoS will be related to these and other science-oriented constructs, we are focused on modeling evaluative tendencies that are conceptually distinct from issue-specific knowledge or beliefs.

Our development and validation efforts comprise three studies. First, we utilized a combination of factor analytic and item response theory (IRT) methods to construct an efficient six-item scale with high face validity and exceptionally strong psychometric properties: the CoSS. In Studies 2 and 3, we examined the CoSS's concurrent and incremental validity in predicting respondents' beliefs across a range of specific scientific issues. We also examined the CoSS's convergent and discriminant validity in relation to numerous personality, ideology, and cognitive ability constructs implicated in past theory and research.

Study 1: Scale development

The goals of Study 1 were to evaluate a set of candidate CoSS items using classical test theory (CTT) and IRT approaches.

Method

Participants

Our sample included 525 participants gathered by Qualtrics panels ($M_{age} = 47.4$ years, range = 18–89; 72% female). Sample size targets across all studies were set to exceed typical recommendations for binary-item IRT modeling and factor analysis (i.e., $N = 500$ or more; Morizot, Ainsworth, & Reise, 2007). In this and all studies, Qualtrics delivered responses of participants for whom there were complete data. Eighteen percent had a high school degree or less, 21% had some college, 29% had a college degree, 4% had some graduate school, and 27% had a master's or doctoral degree. Eighty-one percent of the sample identified as Caucasian or White, with the next largest groups identifying as Asian (6%) and African American (5%).

Item generation

Candidate items were written with the aim of tapping respondents' *general* evaluation of science and scientists, including perceptions regarding the motives, objectivity, and competence of scientists, as well as the accuracy, objectivity, importance, and societal utility of the scientific community's theories, conclusions, and recommendations. Forty-one general evaluative items were included in this phase. Items were worded such that agreement implied more *negative* PCoS.[3] Participants responded to all items on a fully labeled 7-point Likert scale, from *disagree very strongly* to *agree very strongly*. See Table 1 and the online supplement for items included in this study.

Procedure

Participants completed several demographic questions, the candidate CoSS items, and several other short tasks in an online survey. See the online supplement for exact wording of all instructions and measures included in each study.

Analytic approach

We used exploratory principal axis factoring to examine the dimensionality of the candidate CoSS items. We then used IRT methods to evaluate individual item and overall test functioning, leveraging the graded response model (GRM) framework as implemented in the ltm package for the R statistical computing environment (Rizopoulos, 2006). We tested both unconstrained (discrimination parameters allowed to vary) and constrained Rasch (discrimination parameters fixed across items) GRMs and compared models with the Bayesian Information Criteria (BIC). We used the GRM results to reduce the item pool to a final scale using the following criteria: (a) Individual items must show good item response curves and superior discrimination compared to the other items, (b) the final item set should fit the constrained (Rasch) GRM model to justify summing the items to create a total score, (c) the total test information function should be roughly centered on 0, and (d) the final items chosen should be face valid and span the conceptual facets of the latent trait.

Table 1. Study 1: Credibility of Science Scale Item principal axis factoring results and discrimination parameters from graded response model (GRM).

Item	Loading	Communality	GRM Discrim.
1. A lot of so-called scientific research is pure junk.	0.8381	0.7024	2.19
2. We should not base our decisions on what scientists tell us.	0.8246	0.6800	2.08
3. Many so-called scientific facts are really just opinions.	0.8806	0.7754	2.61
4. People trust scientists a lot more than they should.	0.8727	0.7616	2.61
5. People shouldn't believe something just because scientists say it.	0.7935	0.6296	1.80
6. People don't realize just how flawed a lot of scientific research really is.	0.8582	0.7365	2.38
7. Scientists often reach the wrong conclusions on important issues.	0.8148	0.6639	1.90
8. A lot of scientific theories are dead wrong.	0.8532	0.7280	2.33
9. Scientists are always making claims that aren't backed up by facts.	0.8403	0.7060	2.19
10. It's hard to know whether I should trust what scientists say on a given issue.	0.8057	0.6491	1.93
11. We shouldn't necessarily believe what scientific organizations tell us.	0.8688	0.7549	2.45
12. A lot of what passes for science is pure idiocy.	0.8314	0.6912	2.27
13. A lot of scientific theories are nothing more than garbage.	0.8392	0.7043	2.36
14. Just because scientific experts say something, that doesn't make it true.	0.7931	0.6290	1.71
15. For every scientific expert who tells you one thing, there is another expert who says just the opposite.	0.7596	0.5770	1.55
16. A lot of scientific research is a big waste of time and money.	0.7987	0.6379	1.91
17. A lot of scientific research is causing more harm than good.	0.8367	0.7001	2.32
18. It's hard for me to believe a lot of scientific claims.	0.7559	0.5713	2.97
19. There seems to be very little agreement among scientists on many issues.	0.6965	0.4851	1.40
20. I don't believe a lot of things that scientists claim.	0.7572	0.5734	2.37
21. Scientists are sometimes too confident in their conclusions.	0.8298	0.6885	1.51
22. We should rely less on scientists and think more for ourselves.	0.8451	0.7141	1.31
23. I sometimes worry that our political leaders rely too much on the guidance of scientists.	0.8446	0.7134	1.58
24. We place too much emphasis on science as a society.	0.8337	0.6951	2.18
25. I have doubts about certain scientific claims.	0.7068	0.4996	2.20
26. I find it difficult to believe some scientific theories.	0.8822	0.7783	2.30
27. People should have less trust in science.	0.8898	0.7918	2.26
28. We should take what scientists say with a healthy grain of salt.	0.8604	0.7403	1.44
29. Sometimes I think we put too much faith in science.	0.8716	0.7596	2.85
30. There are good reasons to doubt many popular scientific theories.	0.6783	0.4600	2.86
31. People might be better off if they didn't listen to scientists as much.	0.8731	0.7624	2.56
32. There are times when I find it hard to believe scientific claims.	0.7668	0.5880	2.46
33. Science is just one way of looking at things.	0.8755	0.7665	1.30
34. Our society places too much emphasis on science.	0.8743	0.7644	2.65
35 Scientists disagree a lot, even on very fundamental issues.	0.7345	0.5395	1.62
36. I sometimes doubt the trustworthiness of scientific evidence.	0.8159	0.6657	2.63
37. I am concerned by the amount of influence that scientists have in society.	0.8047	0.6475	2.66
38. If I ruled the world, we would spend less money on science.	0.8919	0.7955	1.64
39. I sometimes think we trust scientists more than we should.	0.8701	0.7571	2.11
40. I am skeptical of some scientific claims.	0.7134	0.5089	1.83
41. I sometimes doubt scientific conclusions.	0.8563	0.7333	2.39

Note: Items selected for final six-item scale are in bold.

Results

Exploratory factor analysis

EFA of the candidate CoSS items revealed a clear single factor solution accounting for 67% of the variance in the individual items (eigenvalue = 27.72, next largest eigenvalue = 1.08). Cronbach's alpha for the 41-item scale was .99. Table 1 shows the factor loadings and communalities for the 41 items. Although all items loaded well on this factor (factor loadings > .67), the GRM analyses described next revealed that not all items were equally informative.

GRM

Constrained (Rasch) and unconstrained GRMs were fit to the 41-item scale. The unconstrained model fit significantly better than the constrained model (BICΔ = 426.05), suggesting that some items were better than others at discriminating between participants along the latent trait. Table 1 shows the discrimination parameter estimates for each item from the unconstrained GRM. We initially examined the discrimination estimates, item information curves, and item response curves for each item and removed 22 "poorer" items. From the remaining 19 items, we sought to find a subset of items that discriminated well along the full range of the PCoS latent trait while maximizing discrimination of each item.

We reduced the remaining items one at a time by examining the overall fit to the Rasch model, overall test information, item information, and item discrimination at each step. Figure 1 shows the item characteristic curves, item information functions, and total test information for our final six-item scale (see the appendix). A constrained (Rasch) GRM fit these data better than an unconstrained model (BICΔ = 71.96). The discrimination parameter estimate for the six items was 3.49, suggesting a very strong item discrimination (Baker, 2001). The total test information function was centered on 0, suggesting equal discrimination at both the high and low ends of the trait. The final six-item CoSS had a Cronbach's alpha of .95 (average interitem correlation = .77). All six items were reverse coded such that higher total scores reflected more positive PCoS. The mean CoSS sum score was 24.96 (SD = 9.45, Mdn = 24) out of a 42 possible and was symmetrically distributed (skewness = −.02).

Discussion

We reduced the candidate items to a final set of six items, composing the CoSS. Despite its brevity, this efficient scale showed excellent psychometric properties, including high reliability and the ability to discriminate well among people across the full range of the latent construct. Our remaining studies focused on the *validity* of the CoSS.

Study 2: Construct validity

Study 2 examined the convergent and discriminant validity of the CoSS by examining its relationship to other individual difference measures of interest, as well as incremental criterion-related correlations with science-related beliefs. Further, we examined the robustness of the psychometric properties of the CoSS across potentially meaningful demographic groups.

Method

Participants

Our sample included 1,436 participants gathered by Qualtrics (M_{age} = 48.6 years, range = 18–84, 46% female). Thirty-one percent had a high school degree or less, 23% had some college, 21% had a college degree, 4% had some graduate school, and 20% had a master's or doctoral degree. Forty-five percent of the sample identified as Caucasian or White, 27% as African American, and 25% as Latino/Hispanic, with 2.5% identifying as other ethnicity/race. To examine differential item function (DIF) by education level (at least some high school, at least some college, and at least some graduate school), sex, and ethnicity/race (White, Hispanic, African American), we recruited a sample that included at least 50 participants in each combination of these demographic characteristics.

Procedure

Participants completed several demographic questions, the CoSS, and the scales described next in an online survey. Participants completed materials in the order described next.

Materials

Science beliefs battery

To assess criterion-related validity, we developed a set of brief multi-item scales (2–10 items each) assessing beliefs about eight science issues, with emphasis on socially significant and contentious topics, including vaccination safety and efficacy, anthropogenic climate change, and evolutionary theory. We also included two sets of items used by Lewandowsky, Gignac, and Oberauer (2013) to assess vaccine and climate change beliefs. As noted previously, evaluations of science have been implicated as one predictor of people's beliefs

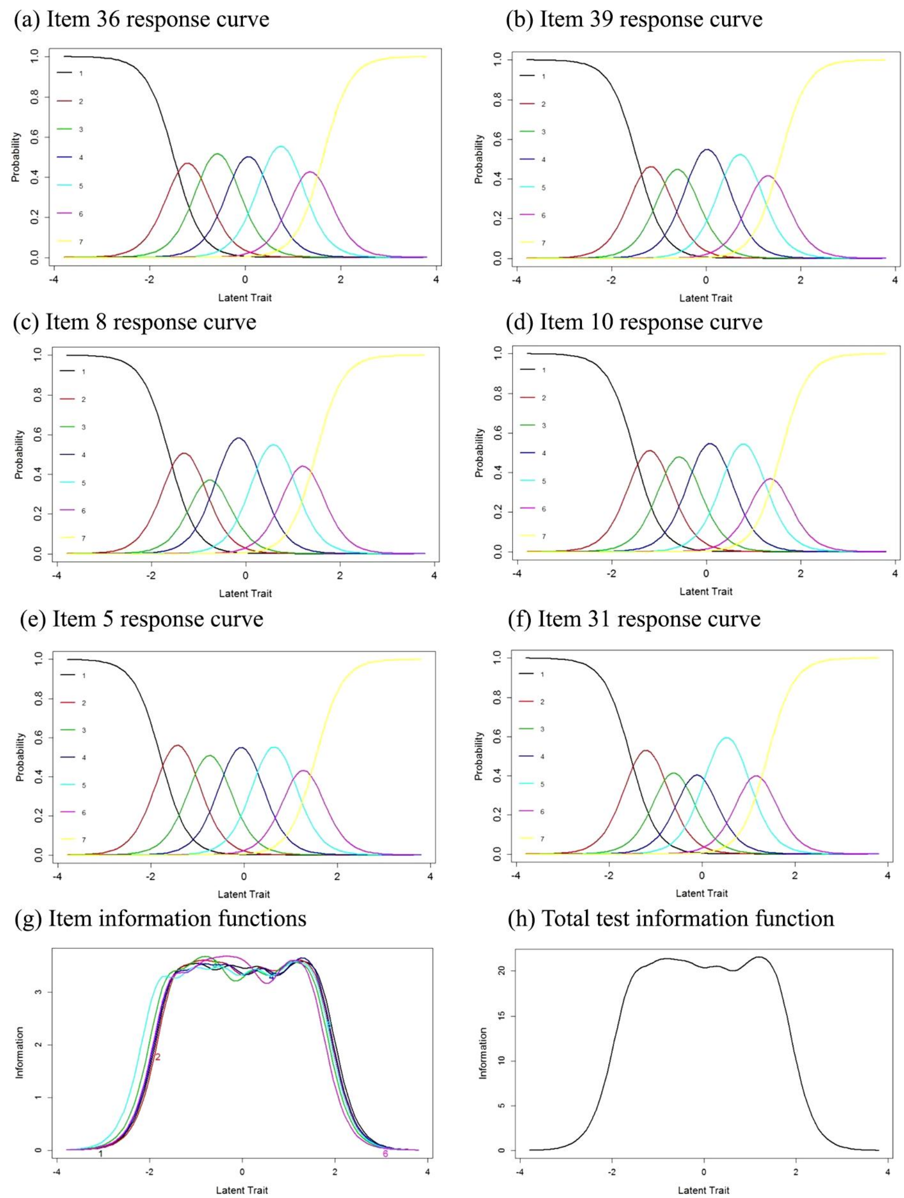

Figure 1. IRT response curves for final Credibility of Science Scale (Study 2). *Note.* Higher values indicate more agreement with the Credibility of Science Scale items, congruent with more negative generalized perceptions about the credibility of science. Note that, for ease of interpretation, we advocate reverse scoring each item so that higher scale scores are interpreted as indicating more positive attitudes.

towards many science topics (e.g., Hmielowski et al., 2014; Siegrist & Cvetkovich, 2000). However, past studies typically examined individual beliefs in isolation (but see Lewandowsky et al., 2013). Congruent with this past work, we predicted that PCoS would be positively associated with agreement with consensus scientific positions across issues.

One potential exception was a set of items assessing acceptance of less controversial science facts, such as "It is possible to split the atom" or "All planets in our solar system revolve around the sun." The noncontroversial science items may be regarded as virtually uncontested elements of collective knowledge that pose no particular policy implications or identity threat, such that positive PCoS may not be required for one to adopt such beliefs.

Science literacy

Physical and biological science literacy was measured with a series of true–false questions (e.g., Electrons are smaller than atoms) adapted from the National Science Board (2012). Previous research has found positive relationships between scientific knowledge and trust in science (Allum et al., 2008; Gauchat, 2008), and consequently we predicted a positive relationship with PCoS.

Science self-efficacy

Science self-efficacy was measured using the Science subscale of the Expanded Skills Confidence Inventory (Betz et al., 2003). Participants rate their confidence in their ability to execute various science-related activities, such as "perform a scientific experiment" or "keep up with new scientific discoveries." Items were evaluated on 5-point Likert scale anchored by *not at all confident* and *extremely confident*. We predicted science self-efficacy would be positively associated with PCoS.

Science interest

Interest in scientific occupations was measured with the Analysis subscale of the Oregon Vocational Interest Scale (Pozzebon, Visser, Ashton, Lee, & Goldberg, 2010), which asks participants to report how much they would like scientific careers and activities (e.g., being a chemist, designing a laboratory study, etc.). Items were evaluated on 7-point scales anchored by *very strongly dislike* and *very strongly like.* We predicted interest in science careers and activities would be positively associated with PCoS.

Cultural worldviews

Cultural worldviews were measured with the Kahan, Braman, Gastil, Slovic, and Mertz (2007) Cultural Cognition Worldview Scales. The Communitarian-Individualistic subscale assesses the value of the group in a person's social and political life, with higher values representing a more individualistic orientation (e.g., "The government interferes far too much in our everyday lives."). The Egalitarian-Hierarchical subscale assesses people's beliefs that some people and groups (e.g., based on race, sex, etc.) are better than others, with higher values representing greater endorsement of hierarchy (e.g., "We have gone too far in pushing equal rights in this country."). Items were evaluated on 7-point Likert scales anchored by *very strongly disagree* and *very strongly agree.* Kahan has demonstrated that people high in these dimensions are less likely to believe scientific consensus across multiple scientific domains (Kahan et al., 2007; Kahan, Jenkins-Smith, & Braman, 2011; Kahan et al., 2012). As such, we predicted that these dimensions would be negatively related to PCoS.

Big government and free market beliefs

The next items assessed ideological positions that might be related to people's attitudes toward science: concerns about "big government" and support for free markets. The Big Government Scale consisted of items we developed to measure concern or opposition with respect to perceived government inefficiency, ineptitude, or encroachment on liberty or free markets (e.g., "The government can't do anything right"; "We need to drastically reduce government spending."). A measure of free market ideology, originally used by Lewandowsky et al. (2013), was coded such that higher values indicate greater support for the benefits of the free market (e.g., "An economic system based on free markets unrestrained by government interference automatically works best to meet human needs."). Items for both scales were evaluated on 7-point Likert scales anchored by *very strongly disagree* and *very strongly agree.* As with the related cultural worldviews measures, we predicted that people who were concerned about big government and who supported free markets would show more negative PCoS because of the implications of scientific consensus for government intervention and regulation of free markets (Kahan et al., 2011; Lewandowsky et al., 2013).

Conspiracist ideation

Conspiracist ideation was measured using the Generic Conspiracist Belief Scale (Brotherton, French, & Pickering, 2013), which assesses beliefs about the existence of conspiracies (e.g., "Evidence of alien contact is being concealed from the public"). Items were evaluated on 7-point Likert scales anchored by *very strongly disagree* and *very strongly agree.* Based on past work (Lewandowsky et al., 2013; Lobato, Mendoza, Sims, & Chin, 2014), we expected conspiracist ideation would be negatively related to PCoS.

Paranormal beliefs

Paranormal beliefs were measured with the Revised Paranormal Belief Scale (Tobacyk, 2004), which assesses people's beliefs in various paranormal entities (e.g., the devil), phenomena (e.g., reincarnation), and practices (e.g., witchcraft). Items were evaluated on 7-point Likert scales anchored by *very strongly disagree* and *very strongly agree.* At a conceptual level, belief in paranormal phenomena is in tension with a scientific perspective (Goode, 2012), and, empirically, belief in the paranormal correlate positively with conspiracist and pseudoscientific beliefs (Lobato et al., 2014). Consequently, we predicted a negative relationship between endorsement of paranormal beliefs and CoSS scores.

Personality

The Big Five personality factors (Openness/Intellect, Conscientiousness, Agreeableness, Neuroticism/Emotional Stability, and Extraversion/Surgency) were measured with the "mini" (four items per Big Five dimension) International Personality Item Pool (Donnellan, Oswald, Baird, & Lucas, 2006). The

Mini-IPIP exhibits less-than-ideal reliability (αs = typically ∼.65–.70), but Donnellan et al. (2006) present substantial evidence for the measures' convergent and discriminant validity. Items were evaluated on 7-point Likert scales anchored by *very strongly disagree* and *very strongly agree*. We expected few correlations between PCoS and personality, except for the openness factor, which is partially characterized by an open-minded interest in new ideas and intellectual pursuits and has been repeatedly related to an interest in investigative pursuits, such as science (e.g., Larson, Rottinghaus, & Borgen, 2002).

Identity labels

We developed several single-item, Likert-style measures of religious and sociopolitical identities (e.g., "Christian," "agnostic," "socialist," "libertarian"; see Table 4). Participants indicated the extent to which they identified with each one on a single, fully labeled 5-point scale anchored at *not at all* and *extremely*. In addition to the identity labels, as part of the demographic questions, participants were asked to report their frequency of attendance at religious services (*from never* to *several times a week*) and the importance of religion in their life (*not at all important* to *extremely important*). Prior research indicates that differences in religious, cultural, and sociopolitical self-identifications are systematically related to differences in science-related attitudes and beliefs, including a tendency for those who self-identify as high in religiosity or conservatism to report attitudes or beliefs that are more skeptical of science (see, e.g., Allum, Sibley, Sturgis, & Stoneman, 2014; Evans, 2013; Gauchat, 2008, 2012).

Confidence in institutions

Trust in institutions was measured as confidence in the leaders of a number of different entities (e.g., scientific community, congress, religious leaders, etc.) using a measure adapted from the GSS (see Smith & Son, 2013). Participants indicated the extent to which they had confidence in each one on a single 5-point scale anchored at *not at all confident* and *extremely confident*. We expected that people with more positive PCoS would trust the scientific community. We expected relatively weaker relationships with trust in other institutions, predicting a moderately negative relationship with trust in organized religion and a moderately positive relationship with trust in the government. Note that data for this article were collected in 2014–2015, and participants' confidence in the leaders of a particular institution should at least in part be affected by who the leaders in question are (e.g., a person's trust in science might predict trust in leaders to the extent that those specific leaders are seen as making scientifically grounded policy decisions).

Analytic approach

We tested CoSS dimensionality with a confirmatory factor analysis (CFA) approach in Mplus (Muthén & Muthén, 1998–2011) software (version 7.31). Model fit was assessed with the comparative fit index, Tucker–Lewis index, and the standardized root mean square residual. The same GRM methods just described were used to examine individual item and overall test functioning. In addition, we examined DIF by education level, sex, and ethnicity/race (African American, White, Latino/Hispanic) using methods implemented in the lordif package for the R statistical computing environment (Choi, Gibbons, & Crane, 2011).

To examine validity, CoSS sum scores were correlated with the other attitude, knowledge, and personality scales to assess criterion-related (concurrent), convergent, and discriminant validity. Finally, we assessed incremental validity by fitting a series of regression models with specific science beliefs as separate outcomes. CoSS, science literacy, science interest, science self-efficacy, worldviews, conspiracist ideation, paranormal beliefs, importance of religion, and the personality scales were entered simultaneously as competing predictors in each model.

Results

CFA and GRM

CFA revealed that a single-factor model was a good fit to the data (comparative fit index = 0.98, Tucker–Lewis index = 0.97, standardized root mean square residual = 0.02). The results from the constrained (Rasch) GRM were comparable to Study 1, with a discrimination parameter estimate of 3.13, centered test information function, and item characteristic curves showing good discrimination for each item at each option on the response scale. DIF testing revealed that none of the items showed substantial differential item functioning across sex, education, or ethnic/racial groups (all models assuming DIF resulted in less than 2% additional explained variance). Each of the six items were reverse coded and added such that higher total scores reflected higher perceptions of the credibility of science ($\alpha = .94$, $M = 24.32$ out of 42, $SD = 9.34$, $Mdn = 24$).

Sociodemographic differences in PCoS

CoSS scores were relatively normally distributed across sociodemographic and ethnic/racial groups, with the exception of a negative skew for people with graduate degrees. Congruent with past work (Gauchat, 2008, 2011), people with higher levels of education reported more positive evaluations of science, although this effect accounted for only 3% of the variance in CoSS scores. Age, sex, and ethnic/racial group each accounted for less than 1% of the variance in CoSS scores.

Criterion-related validity

We examined criterion-related validity by examining correlations between the CoSS and science-related beliefs (see Table 2). The CoSS correlated as expected with medium to large correlations in each of the controversial science domains. Among the strongest correlations, those who viewed science as more credible were more likely to accept evolution or to believe that the earth is billions of years old and less likely to hold antivaccine beliefs or doubt the effectiveness of comprehensive sex education. More positive science evaluations were also associated with less doubt about climate changes or human contributions to it. Finally, as expected, the relationship with noncontroversial science facts was weaker. Thus, it appears that the CoSS is predictive of beliefs across a broad array of societally significant scientific topics.

Table 2. Study 2: CoSS convergent, discriminant, and criterion validity correlations.

Scale	Items	α	Corr. with CoSS	*SE*(*r*)
Science beliefs				
Evolution Accept	4	.90	0.46	.023
Vaccine Reject	7	.93	−0.48	.023
LGO Vaccination Support[a]	5	.79	0.39	.024
Climate Science Accept	7	.95	0.30	.025
LGO Climate Accept[a]	4	.97	0.31	.025
"Noncontroversial" science Facts	10	.86	0.18	.026
Sex Ed Effective	6	.84	0.53	.022
Old Earth Accept	2	.66	0.39	.024
Anti-Conventional Medicine	4	.73	−0.43	.024
Anti-GMO	6	.89	−0.25	.026
Science literacy, self-efficacy and interest				
Science Literacy-Phys[b]	7	–	0.31	.026
Science Literacy-Bio[b]	6	–	0.26	.026
Science Self-Efficacy	10	.95	0.05	.027
Science Career Interest	10	.94	0.06	.027
Ideology/Worldview				
Communitarian–Individualistic	17	.88	−0.43	.024
Egalitarian–Hierarchical	13	.86	−0.45	.024
LGO Free Market Support[a]	4	.70	−0.30	.025
"Big Government" Reject	6	.85	−0.47	.023
Personality–Big Five				
Extraversion	4	.77	0.02	.026
Agreeableness	4	.75	0.05	.026
Conscientiousness	4	.67	0.02	.026
Neuroticism	4	.68	−0.04	.026
Openness	4	.70	0.22	.026
Anomalous Ideation				
Conspiracist Ideation	15	.95	−0.47	.023
Paranormal Beliefs	26	.94	−0.31	.025

Note: $N = 1{,}436$. Corr. = correlation; CoSS = Credibility of Science Scale; LGO = Lewandowsky, Gignac, and Oberauer; GMO = Genetically Modified Organism(s).
[a]Beliefs labeled LGO were items taken from Lewandowsky, Gignac, and Oberauer, 2013.
[b]$N = 1{,}333$ for the Science Literacy scale.

Convergent and discriminant validity

Consistent with past research, evaluations of science were positively associated with science literacy (Allum et al., 2008; Gauchat, 2008, 2011), and negatively associated with individualistic and hierarchical cultural worldviews (Kahan et al., 2012), free market and anti-big government ideology (Lewandowsky et al., 2013), conspiracist ideation (Lewandowsky et al., 2013), and paranormal beliefs (Lobato et al., 2014; see Table 2). These effects were generally medium to large in magnitude. Also as hypothesized, openness was the only Big Five personality factor with at least a small to medium magnitude (positive) correlation with the CoSS. Unexpectedly, the CoSS was not even weakly related to science self-efficacy or interest in science as an occupation.

Consistent with past research (Allum et al., 2014; Gauchat, 2012), participants who identified as religious, conservative, and/or Republican reported more negative science evaluations (medium to large effect sizes), whereas participants who identified as atheist or agnostic, liberal, and/or Democrat reported more positive evaluations (small to medium effect sizes). The CoSS had very small correlations with socialist, nonconformist, libertarian, and politically moderate identities (see Table 3). The libertarianism finding is surprising, given the considerably stronger negative association of the CoSS with pro-free market and anti-big government ideology, two central features of libertarian ideology. This finding might reinforce proposed differences between political *ideology* and political *identity* (e.g., Huddy, Mason, & Aarøe, 2015).

As expected, the CoSS was strongly related to the one-item measure of confidence in the scientific

Table 3. Study 2: Associations between CoSS and self-reported religious and political identity labels.

Identity labels	Corr. with CoSS	SE(r)
Attend services	−0.28	.025
Importance of religion	−0.42	.024
Agnostic	0.20	.026
Atheist	0.19	.026
Christian	−0.39	.024
Religious	−0.35	.025
Conservative	−0.38	.024
Democrat	0.19	.026
Liberal	0.27	.025
Libertarian	−0.04	.026
Moderate	0.05	.026
Nonconformist	0.03	.026
Republican	−0.24	.026
Socialist	0.08	.026

Note: $N = 1{,}436$. Corr. = correlation; CoSS = Credibility of Science Scale.

Table 4. Study 2: Associations between CoSS and confidence in institutions.

Institution	Corr. with CoSS	SE(r)
Scientific community	0.53	.022
Banks and financial	−0.09	.026
Major companies	−0.10	.026
Organized religion	−0.25	.026
Education	0.10	.026
Executive branch of fed government	0.20	.026
Organized labor	0.10	.026
Press (the media)	0.11	.026
Medicine	0.18	.026
U.S. Supreme Court	0.07	.026
Congress	0.08	.026
Military	−0.08	.026
The government (in general)	0.13	.026
Political parties	−0.04	.026

Note: $N = 1,436$. Corr. = correlation; CoSS = Credibility of Science Scale.

community but showed weaker and directionally varying relationships with a range of other institutions (see Table 4). This suggests that viewing science as more credible cannot be dismissed as a mere proxy for generic social trust. Overall, the pattern of relationships observed offers convergent and discriminant support for the validity of the CoSS.

Incremental validity

Table 5 shows the incremental contribution of PCoS as a predictor of each specific science belief over other possible predictors included in this study. The CoSS remained a consistent predictor of all eight specific science beliefs after controlling for a host of other variables implicated in past research and theory. Thus, although the CoSS is related to a number of previously documented predictors of scientific belief, it shows incremental validity beyond them in the prediction of key scientific beliefs.

Discussion

Study 2 replicated the strong psychometric properties observed earlier and demonstrated that CoSS items are equally effective across sex, ethnicity, and education. Study 2 also offered strong evidence for the convergent, discriminant, and criterion validity of the CoSS across a host of theoretically important constructs. Of note, the CoSS exhibited the expected pattern of relationships with topic-specific scientific beliefs, scientific literacy, education level, openness to experience, conspiracist ideation, and a variety of political ideology/worldview variables previously implicated in studies of topic-specific science attitudes and beliefs. Unexpected findings include weaker-than-expected correlations with libertarian identity and with interest in and self-efficacy concerning science-oriented careers or activities. Finally, the CoSS demonstrated incremental validity in predicting topic-specific science beliefs above and beyond many previously documented predictors of scientific beliefs.

Study 3: Cognitive ability

Although Study 2 provided a rich database of correlational validity evidence, there was one important class of variables not included: cognitive abilities. In Study 3 we extended our validity evidence to include performance on cognitive ability tasks with objectively correct answers. Our working hypothesis was that

Table 5. Study 2: Incremental validity modeling results.

Predictor	Evol	Vacc[a,b]	Clim[a]	Noncontroversaial	Sex Ed	Old Earth	Con Med[b]	GMO[b]
CoSS	.26 (.03)	−.22 (.03)	.09 (.03)	.11 (.03)	.20 (.03)	.22 (.03)	−.21 (.03)	−.08 (.03)
Science Literacy–Phys	.15 (.02)	−.05 (.02)	.06 (.02)	—	.06 (.02)	.22 (.03)	−.01 (.03)	−.03 (.03)
Science Literacy–Bio	.14 (.02)	−.07 (.02)	−.01 (.02)	—	.11 (.02)	.07 (.03)	−.05 (.02)	−.07 (.03)
Science Self-Efficacy	.07 (.03)	.08 (.03)	.06 (.03)	.20 (.03)	−.04 (.03)	.09 (.03)	.13 (.03)	.06 (.03)
Science Career Interest	.07 (.03)	.01 (.03)	.02 (.03)	.16 (.03)	−.09 (.03)	.05 (.03)	−.01 (.03)	−.01 (.03)
Communitarian-Individualistic	.03 (.03)	−.08 (.03)	−.09 (.03)	.27 (.04)	.14 (.03)	.04 (.03)	−.07 (.03)	−.01 (.04)
Egalitarian-Hierarchical	−.21 (.03)	.07 (.03)	−.42 (.03)	−.10 (.03)	−.26 (.03)	−.22 (.03)	−.10 (.03)	−.20 (.04)
LGO Free Market Support	−.17 (.03)	−.06 (.03)	−.23 (.03)	−.19 (.03)	−.03 (.03)	−.20 (.03)	−.07 (.03)	−.14 (.03)
"Big Government" Reject	.21 (.03)	.15 (.03)	.07 (.03)	.12 (.04)	−.17 (.03)	.23 (.03)	.22 (.03)	.21 (.04)
Conspiracist Ideation	−.02 (.03)	.34 (.03)	.12 (.03)	−.05 (.03)	−.06 (.03)	.02 (.03)	.29 (.03)	.32 (.03)
Paranormal Beliefs	.15 (.02)	.11 (.03)	.02 (.03)	−.04 (.03)	−.04 (.03)	.09 (.03)	.19 (.03)	.01 (.03)
Extraversion	.04 (.02)	.01 (.02)	−.02 (.02)	−.11 (.03)	.03 (.02)	.04 (.02)	−.01 (.02)	−.01 (.03)
Agreeableness	−.07 (.02)	.01 (.02)	−.02 (.02)	.02 (.03)	.06 (.02)	−.02 (.03)	.01 (.02)	.08 (.03)
Conscientiousness	.01 (.02)	−.01 (.02)	.09 (.02)	−.03 (.03)	−.01 (.02)	.06 (.02)	.01 (.02)	.04 (.03)
Neuroticism	−.01 (.02)	−.05 (.02)	.04 (.02)	−.09 (.03)	.07 (.02)	−.03 (.02)	−.01 (.02)	−.07 (.03)
Openness	−.04 (.02)	−.12 (.02)	−.02 (.02)	.16 (.03)	.09 (.02)	−.06 (.03)	−.07 (.02)	−.04 (.03)
Importance of Religion	−.28 (.02)	−.06 (.03)	.01 (.03)	−.12 (.03)	−.18 (.02)	−.18 (.03)	−.02 (.03)	.04 (.03)

Note: Cell entries are standardized regression coefficients (standardized standard errors). The science literacy scales were not included as predictors of the noncontroversial science beliefs outcome due to strong overlap of concepts/items on these scales. Evol = Acceptance of evolutionary theory; Vacc = Rejection of vaccine safety/efficacy; Clim = Acceptance of anthropogenic climate change; Con Med = Rejection of conventional ("Western") medicine; GMO = Rejection of Genetically Modified Organism food product safety; CoSS = Credibility of Science Scale; Phys = Physical Science Literacy; Bio = Biological Science literacy; LGO = Items from Lewandowsky, Gignac, & Oberauer, 2013.
[a]Outcomes are the scales we created for this study. Using the Lewandowsky scales as outcomes result in the same substantive conclusions.
[b]Agreement indicates a belief that is contrary to the scientific consensus.

cognitive abilities would positively correlate with PCoS. This was informed by Study 2 findings concerning the CoSS's correlations with education and scientific literacy, along with the common sense observation that high levels of cognitive ability and knowledge may be required to process scientifically complex arguments and evidence. In other words, we sought to test the hypothesis that abilities and thinking styles that are most congruent with a scientific mind-set (i.e., greater cognitive sophistication) would also predict more positive *evaluations* of science.

Method

Participants

Participants were 600 individuals gathered by Qualtrics. The average age of the sample was 29.47 years (range = 18–84) and 65% were female. Thirty-two percent had a high school degree or less, 22% had some college, 10% had a college degree, 3% had some graduate school, and 29% had a master's or doctoral degree. Sixty-eight percent of the sample identified as Caucasian or White, 9% as African American, 6% as Latino/Hispanic, 7% as Asian, 10% as other, less than 1% American Indian or Alaska Native, and less than 1% Native Hawaiian or Pacific Islander.

Procedure

Participants completed several demographic questions, the CoSS, and the tasks described next in an online survey.

Materials

Fluid intelligence (Shipley)

Participants completed the Shipley Institute of Living Scale 2 (Shipley, Gruber, Martin, & Klein, 2009), a measure of both crystallized and fluid intelligence. The Abstraction subscale, which assesses fluid intelligence, contains alphanumeric puzzles that measure the induction and sequential reasoning aspects of fluid intelligence (e.g., Lassiter, Matthews, & Orzech, 2011; Shipley et al., 2009). The dependent variable is scaled scores based on the number of correctly-solved items.

Crystallized intelligence (Shipley)

The Shipley Institute of Living Scale 2 vocabulary test (Shipley et al., 2009) is considered a measure of crystallized intelligence (e.g., Lassiter et al., 2011; Shipley et al., 2009) that requires test-takers to view target words and select the word that is closest in meaning from four options. The dependent variable is scaled scores based on the number of correctly solved items.

Statistical numeracy

Statistical numeracy was measured with the Berlin Numeracy Scale (Cokely, Galesic, Schulz, Ghazal, & Garcia-Retamero, 2012). This measure is composed of word problems requiring probabilistic reasoning, and scores on the measure predict people's understanding of a variety of risks.

Cognitive reflection

Participants' tendency to engage in deliberative thought (Sloman, 1996) was measured with the Cognitive Reflection Test (CRT; Frederick, 2005). This measure contains questions (e.g., A bat and a ball cost $1.10 in total. The bat costs $1.00 more than the ball. How much does the ball cost?) that create opposition between an "intuitive" answer ($.10) and the more reasoned, correct answer ($.05). Frederick (2005) argued that the number of correct responses is indicative of the tendency to rely on deliberative thought. Because the original CRT is often included in news stories reporting relevant research, people may know the correct answers for reasons other than reliance on deliberative thought. Consequently, we also used a modified version of the CRT (Finucane & Gullion, 2010), which uses a similar format but with items that are likely unfamiliar to participants (e.g., Soup and salad cost $5.50 in total. The soup costs a dollar more than the salad. How much does the salad cost?).

Results and discussion

The CoSS again showed excellent reliability (Cronbach's $\alpha = .91$), and it evidenced small to medium positive correlations with all of the cognitive ability variables (see Table 6). Thus, across a broad set of cognitive ability measures (statistical numeracy, fluid and crystallized intelligence, tendency to engage in deliberative reasoning), increased cognitive abilities were associated with more positive PCoS. These findings are notable in that they extend the CoSS validity evidence from beyond the realm of self-report questionnaire measurement and into the domain of objectively measured abilities and thinking styles.

Table 6. Study 3: Associations between CoSS and cognitive ability.

Scale	Items	Corr. with CoSS	SE(r)
Fluid Intelligence	25	.28	.039
Crystallized Intelligence	40	.35	.038
Statistical Numeracy	4	.14	.040
CRT (Frederick)	3	.26	.039
CRT (Finucane)	3	.23	.040

Note: $N = 600$. CoSS = Credibility of Science Scale; Corr. = correlation; CRT = Cognitive Reflection Test.

General discussion

The CoSS is an efficient six-item measure that demonstrates excellent psychometric properties, including unidimensional structure, high reliability, the ability to discriminate between people along the full range of the latent construct, and equivalent item functioning across sex, race, and educational status. The CoSS also shows strong convergent and discriminant validity, exhibiting a pattern of correlations that bears out most of our hypotheses and dovetails with relevant literature (e.g., Kahan et al., 2011; Lewandowsky & Oberauer, 2016). Finally, the CoSS shows criterion validity in the form of correlations with domain-specific beliefs across a host of diverse science topics, even after controlling for previously documented predictors of such beliefs. Given this body of evidence, we believe that the CoSS represents a potentially powerful tool for scholars interested in modeling science-related beliefs and behaviors and for targeting messages to maximize the impact of scientific communication. Next, we discuss the implications of some of the findings, along with possible uses of this measure.

Antecedents and consequences of science credibility perceptions

One notable finding is that the CoSS significantly predicted scientific beliefs on topics as substantively diverse as evolution, vaccine safety, and climate change, among others. As such, the results support our core motivating hypothesis: There are meaningful individual differences in people's evaluations of the scientific enterprise, and these differences predict beliefs and attitudes across a wide array of specific, societally relevant science topics. Whereas past work has often focused on modeling beliefs for specific science topics (e.g., climate change, vaccine safety), our work extends the focus to a broader array of science issues and identifies perceptions of the credibility of science as a thread that links people's views across these disparate topics.

Further, consistent with hypotheses, variables previously implicated in work on scientific belief were strongly correlated with PCoS (see Tables 3 and 4). In particular, ideological variables, including individualistic and hierarchical orientations, anti-big government and pro-free market attitudes, and self-identified conservatism, predicted more negative evaluations of science (see, e.g., Kahan et al., 2007; Lewandowsky & Oberauer, 2016). Also, consistent with past work, people who are prone to conspiracist thinking and or who believe in paranormal phenomena were also particularly negative toward science (Lewandowsky et al., 2013). Finally, in keeping with prior work (e.g., Allum et al., 2014; Gauchat, 2008) and with the broader discourse surrounding perceived "science versus religion" conflicts, those who reported higher religiosity tended to report more negative PCoS.

Given this pattern of correlations with both domain-specific science views and more general ideological worldviews, we believe that perceptions of the credibility of science represents a high-level evaluative construct that may prove useful in empirical work and theory testing. Next steps in advancing a more integrative research program should include the testing of structural models of scientific beliefs to better understand the unique contribution and path "location" of PCoS relative to other predictors of issue-specific science beliefs. For example, we might hypothesize that the CoSS (partially) mediates the relationship between highly general dispositions or worldviews (e.g., conspiracist ideation, individualist ideology) and more issue-specific science beliefs. Meanwhile, we would not hypothesize that lower level issue-specific predictors (e.g., one's own history of sexually transmitted infections in the case of HPV vaccine intentions; see Rosenthal et al., 2008) would operate via general evaluations of science.

Understanding scientific communication

Another important potential use of the CoSS is as a tool to study the psychological *processes* associated with processing information from scientific sources. Most notably, CoSS should predict individual differences in perceptions of the credibility of scientific *sources*. Research suggests that the perceived credibility of a message source can play multiple roles in determining how a message recipient responds to the message (Briñol & Petty, 2009). As with other influence-related variables, such as a person's mood or the number of arguments in a message, the effects of source variables will vary depending on a number of contextual variables (Petty & Briñol, 2014). When one's ability and/or motivation to carefully process scientific information is limited, we would expect people to use message source as a heuristic cue in evaluating the message (e.g., Brewer & Ley, 2013; Hmielowski et al., 2014), with more positive PCoS predicting more message-congruent change in response to a scientist source.

But other roles of PCoS are possible. For example, PCoS might affect the extent to which people pay attention to a message from a scientist. Although work on the direction of this effect is not consistent (Bleich et al., 2007; Schul, Mayo, & Burnstein, 2008), the bulk of the existing research suggests that a message from a trustworthy source would be elaborated (i.e., scrutinized and pondered) less carefully (Priester & Petty, 1995; Schul et al., 2008).

Under conditions of effortful thought (high-elaboration), other effects are possible (Petty & Briñol, 2014). If source information precedes thought about the message, and if the message itself is sufficiently ambiguous, source evaluations could bias thought about the message (Chaiken & Maheswaran, 1994; Tormala, Briñol, & Petty, 2007), leading people to interpret the message in line with their source evaluation. Under high elaboration, the source of a message could also be processed as an "argument" for or against the advocated position (Briñol & Petty, 2009) or affect the confidence someone has in their message-relevant thoughts (Tormala et al., 2007). Given the multitude of responses that a scientist as a source of information might elicit, use of the CoSS as a potential individual difference moderator variable opens up new vistas for scholars testing basic and applied hypotheses about science communication.

Conclusions

Its strong psychometric properties, compelling validity evidence, and brief format make the CoSS appropriate for a wide variety of research applications, ranging from controlled laboratory experiments to large-scale national surveys. The scale holds particular promise building explanatory empirical models of belief and action across a wide range of scientific topics and for understanding responses to experimental studies of belief formation or response to scientific communications. More broadly, the CoSS should be of interest to a range of scholars studying science-related beliefs, attitudes, and behaviors in domains as diverse as psychology, public health, political science, communication, sociology, and education.

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Notes

1. The cited work has used different strategies to assess evaluation of science, some of which are *generalized* measures (i.e., people's attitudes toward scientists in general), but many are *topic specific* (e.g., people's trust in scientists in a particular domain). All of these measurement strategies are linked by a focus on respondents' evaluations of scientists, scientific disciplines, or their methods in favorable terms—as having or lacking credibility, expertise, trustworthiness, and so on. As described next, however, past measures are subject to a number of limitations.
2. Note also that there is an extensive literature on students' attitudes toward *studying* science or in pursuing science-related careers, particularly among children and adolescents (e.g., Osborne, Simon, & Collins, 2003). Although this literature often adopts similar terms to those we use, the focus is quite different.
3. A common strategy aimed at minimizing response biases is to use both positively and negatively worded items. However, there is little evidence that such a strategy is effective, and the mixing of positively and negatively keyed responses may create psychometric method artifacts that can prevent scales from achieving unidimensionality (Conrad et al., 2004). We specifically chose to utilize negatively worded statements because a preliminary study suggested that these items had better psychometric properties (e.g., higher discrimination coefficients in exploratory IRT models).

References

Allum, N., Sibley, E., Sturgis, P., & Stoneman, P. (2014). Religious beliefs, knowledge about science and attitudes towards medical genetics. *Public Understanding of Science*, *23*, 833–849. doi:10.1177/0963662513492485

Allum, N., Sturgis, P., Tabourazi, D., & Brunton-Smith, I. (2008). Science knowledge and attitudes across cultures: A meta-analysis. *Public Understanding of Science*, *17*, 35–54. doi:10.1177/0963662506070159

Baker, F. (2001). *The basics of item response theory*. ERIC Clearinghouse on Assessment and Evaluation, University of Maryland College Park, College Park, MD.

Betz, N. E., Borgen, F. H., Rottinghaus, P., Paulsen, A., Halper, C. R., & Harmon, L. W. (2003). The expanded skills confidence inventory: Measuring basic dimensions of vocational activity. *Journal of Vocational Behavior*, *62*, 76–100. doi:10.1016/s0001-8791(02)00034-9

Bleich, S., Blendon, R., & Adams, A. (2007). Trust in scientific experts on obesity: Implications for awareness and behavior change. *Obesity*, *15*, 2145–2156. doi:10.1038/oby.2007.255

Brewer, N. T., Chapman, G. B., Gibbons, F. X., Gerrard, M., McCaul, K. D., & Weinstein, N. D. (2007). Meta-analysis of the relationship between risk perception and health behavior: The example of vaccination. *Health Psychology*, *26*, 136–145. doi:10.1037/0278-6133.26.2.136

Brewer, P. R., & Ley, B. L. (2013). Whose science do you believe? Explaining trust in sources of scientific information about the environment. *Science Communication*, *35*, 115–137. doi:10.1177/1075547012441691

Briñol, P., & Petty, R. E. (2009). Source factors in persuasion: A self-validation approach. *European Review of Social Psychology*, *20*, 49–96. doi:10.1080/10463280802643640

Brotherton, R., French, C. C., & Pickering, A. D. (2013). Measuring belief in conspiracy theories: The generic conspiracist beliefs scale. *Frontiers in Psychology*, *4*, 279.

Chaiken, S., & Maheswaran, D. (1994). Heuristic processing can bias systematic processing: Effects of source credibility, argument ambiguity, and task importance on attitude judgment. *Journal of Personality and Social Psychology*, *66*, 460–473. doi:10.1037//0022-3514.66.3.460

Choi, S. W., Gibbons, L. E., & Crane, P. K. (2011). Lordif: An R package for detecting differential item functioning using iterative hybrid ordinal logistic regression/item response theory and Monte Carlo simulations. *Journal of Statistical Software*, *39*, 1–30.

Cokely, E. T., Galesic, M., Schulz, E., Ghazal, S., & Garcia-Retamero, R. (2012). Measuring risk literacy: The Berlin numeracy test. *Judgment and Decision Making*, *7*, 25–47.

Critchley, C. R. (2008). Public opinion and trust in scientists: The role of the research context, and the perceived motivation of stem cell researchers. *Public Understanding of Science*, *17*, 309–327. doi:10.1177/0963662506070162

Donnellan, M. B., Oswald, F. L., Baird, B. M., & Lucas, R. E. (2006). The mini-IPIP scales: Tiny-yet-effective measures of the big five factors of personality. *Psychological Assessment*, *18*, 192–203. doi:10.1037/1040-3590.18.2.192

Earle, T. C., & Cvetkovich, G. (1995). *Social trust: Toward a cosmopolitan society*. Westport, CT: Praeger Publications.

Earle, T. C. (2010). Trust in risk management: A model-based review of empirical research. *Risk Analysis*, *30*, 541–574. doi:10.1111/j.1539-6924.2010.01398.x

Evans, J. H. (2013). The growing social and moral conflict between conservative protestantism and science. *Journal for the Scientific Study of Religion*, *52*, 368–385. doi:10.1111/jssr.12022

Evans, J. H. & Evans, M. S. (2008). Religion and science: Beyond the epistemological conflict narrative. *Annual Review of Sociology*, *34*, 87–105. doi:10.1146/annurev.soc.34.040507.134702

Finucane, M. L., & Gullion, C. M. (2010). Developing a tool for measuring the decision-making competence of older adults. *Psychology and Aging*, *25*, 271–288. doi:10.1037/a0019106

Fishbein, M., & Ajzen, I. (1975). *Belief, attitude, intention, and behavior: An introduction to theory and research*. Reading, MA: Addison-Wesley.

Frederick, S. (2005). Cognitive reflection and decision making. *Journal of Economic Perspectives*, *19*, 25–42. doi:10.1257/089533005775196732

Gauchat, G. (2008). A test of three theories of anti-science attitudes. *Sociological Focus*, *41*, 337–357. doi:10.1080/00380237.2008.10571338

Gauchat, G. (2011). The cultural authority of science: Public trust and acceptance of organized science. *Public Understanding of Science*, *20*, 751–770. doi:10.1177/0963662510365246

Gauchat, G. (2012). Politicization of science in the public sphere: A study of public trust in the United States, 1974–2010. *American Sociological Review*, *77*, 167–187. doi:10.2307/23102567

Goode, E. (2012). *The paranormal: Who believes, why they believe, and why it matters*. Amherst, NY: Prometheus.

Hartman, R. O., & Betz, N. E. (2007). The five-factor model and career self-efficacy: General and domain-specific relationships. *Journal of Career Assessment*, *15*, 145–161. doi:10.1177/1069072706298011

Hmielowski, J. D., Feldman, L., Myers, T. A., Leiserowitz, A., & Maibach, E. (2014). An attack on science? Media use, trust in scientists, and perceptions of global warming. *Public Understanding of Science*, *23*, 866–883. doi:10.1177/0963662513480091

Hovland, C. I., & Weiss, W. (1951). The influence of source credibility on communication effectiveness. *Public Opinion Quarterly*, *15*, 635–650.

Huddy, L., Mason, L., & Aarøe, L. (2015). Expressive Partisanship: Campaign Involvement, Political Emotion, and Partisan Identity. *American Political Science Review*, *109*, 1–17. doi:10.1017/s0003055414000604

Johnson, D. R., Scheitle, C. P., & Ecklund, E. H. (2015). Individual religiosity and orientation towards science: Reformulating relationships. *Sociological Science*, *2*, 106–124. doi:10.15195/v2.a7

Kahan, D. M. (2015). Climate-science communication and the measurement problem. *Advances in Political Psychology*, *36*, 1–43. doi:10.1111/pops.12244

Kahan, D. M., Braman, D., Gastil, J., Slovic, P., & Mertz, C. K. (2007). Culture and identity-protective cognition: Explaining the white-male effect in risk perception. *Journal of Empirical Legal Studies*, *4*, 465–505. doi:10.1111/j.1740-1461.2007.00097.x

Kahan, D. M., Jenkins-Smith, H., & Braman, D. (2011). Cultural cognition of scientific consensus. *Journal of Risk Research*, *14*, 147–174. doi:10.2139/ssrn.1549444

Kahan, D. M., Peters, E., Wittlin, M., Slovic, P., Ouellette, L. L., Braman, D., & Mandel, G. (2012). The polarizing impact of science literacy and numeracy on perceived climate change risks. *Nature Climate Change*, *2*, 732–735. doi:10.1038/nclimate1547

Larson, L. M., Rottinghaus, P. J., & Borgen, F. H. (2002). Meta-analyses of Big Six Interests and Big Five Personality Factors. *Journal of Vocational Behavior*, *61*, 217–239. doi:10.1006/jvbe.2001.1854

Lassiter, K. S., Matthews, T. D., & Orzech, J. A. (2011). Does the Shipley Institute of Living Scale measure fluid and crystallized abilities? *North American Journal of Psychology*, *13*, 255.

Lewandowsky, S., Gignac, G. E., & Oberauer, K. (2013). The role of conspiracist ideation and worldviews in predicting rejection of science. *PLoS ONE*, *8*, e75637. doi:10.1371/journal.pone.0075637

Lewandowsky, S., & Oberauer, K. (2016). Motivated rejection of science. *Current Directions in Psychological Science*, *25*, 217–222. doi:10.1177/0963721416654436

Lobato, E., Mendoza, J., Sims, V., & Chin, M. (2014). Examining the relationship between conspiracy theories, paranormal beliefs, and pseudoscience acceptance among a university population. *Applied Cognitive Psychology*, *28*, 617–625. doi:10.1002/acp.3042

Malka, A., Krosnick, J. A., & Langer, G. (2009). The association of knowledge with concern about global warming: Trusted information sources shape public thinking. *Risk Analysis*, *29*, 633–647. doi:10.1111/j.1539-6924.2009.01220.x

Marques, M. D., Critchley, C. R., & Walshe, J. (2015). Attitudes to genetically modified food over time: How trust in organizations and the media cycle predict support. *Public Understanding of Science*, *24*, 601–618. doi:10.1177/0963662514542372

Morizot, J., Ainsworth, A. T., & Reise, S. P. (2007). Toward modern psychometrics: Application of item response theory models in personality research. In R. W. Robins,

R. C. Fraley, & R. F. Krueger (Eds.), *Handbook of research methods in personality psychology* (pp. 407–423). New York, NY: Guilford

Muthén, L. K., & Muthén, B. O. (1998–2011). *Mplus user's guide* (6th ed.). Los Angeles, CA: Muthén & Muthén.

National Science Board. (2012). *Science and engineering indicators*. Arlington, VA: National Science Foundation.

National Science Board. (2014). *Science and engineering indicators*. Arlington, VA: National Science Foundation.

Petty, R. E., & Briñol, P. (2014). The elaboration likelihood and meta-cognitive models of attitudes: Implications for prejudice, the self, and beyond. In J. W. Sherman, B. Gawronski & Y. Trope (Eds.), *Dual-process theories of the social mind* (pp. 172–187). New York, NY: Guilford.

Funk, C., & Rainie, L. (2015, January 29). Public and scientists' views on science and society . Available from http://www.pewinternet.org/2015/01/29/public-and-scientists-views-on-science-and-society/

Osborne, J., Simon, S., & Collins, S. (2003). Attitudes towards science: A review of the literature and its implications. *International Journal of Science Education*, *25*, 1049–1079. doi:10.1080/0950069032000032199

Pozzebon, J. A., Visser, B. A., Ashton, M. C., Lee, K., & Goldberg, L. R. (2010). Psychometric characteristics of a public-domain self-report measure of vocational interests: The Oregon Vocational Interest Scales. *Journal of Personality Assessment*, *92*, 168–174.

Priester, J. R., & Petty, R. E. (1995). Source attributions and persuasion: Perceived honesty as a determinant of message scrutiny. *Personality and Social Psychology Bulletin*, *21*, 637–654. doi:10.1177/0146167295216010

Rizopoulos, D. (2006). ltm: An R package for latent variable modeling and item response theory analyses. *Journal of Statistical Software*, *17*, 1–25.

Rosenthal, S. L., Rupp, R., Zimet, G. D., Meza, H. M., Loza, M. L., Short, M. B., & Succop, P. A. (2008). Uptake of HPV vaccine: Demographics, sexual history and values, parenting style, and vaccine attitudes. *Journal of Adolescent Health*, *43*, 239–245. doi:10.1016/j.jadohealth.2008.06.009

Schul, Y., Mayo, R., & Burnstein, E. (2008). The value of distrust. *Journal of Experimental Social Psychology*, *44*, 1293–1302. doi:10.1016/j.jesp.2008.05.003

Shipley, W. C., Gruber, C. P., Martin, T. A., & Klein, A. M. (2009). *Shipley-2 manual*. Los Angeles, CA: Western Psychological Services.

Siegrist, M., & Cvetkovich, G. (2000). Perception of hazards: The role of social trust and knowledge. *Risk Analysis*, *20*, 713–720. doi:10.1111/0272-4332.205064

Sloman, S. A. (1996). The empirical case for two systems of reasoning. *Psychological Bulletin*, *119*, 3–22.

Smith, T. W., & Son, J. (2013, May). *General Social Survey 2012—Final report: Trends in public attitudes about confidence in institutions*. Chicago, IL: NORC at the University of Chicago.

Sturgis, P., & Allum, N. (2004). Science in society: Re-evaluating the deficit model of public attitudes. *Public Understanding of Science*, *13*, 55–74. doi:10.1177/0963662504042690

Tobacyk, J. J. (2004). A revised paranormal belief scale. *The International Journal of Transpersonal Studies*, *23*, 94–98.

Tormala, Z. L., Briñol, P., & Petty, R. E. (2007). Multiple roles for source credibility under high elaboration: It's all in the timing. *Social Cognition*, *25*, 536–552. doi:10.1521/soco.2007.25.4.536

Appendix

Credibility of Science Scale (CoSS)

Your Views on the Scientific Community and Its Work

On the next few screens you will be presented with a series of statements about scientists and the scientific community. Please indicate how well each statement describes your own views—that is, how strongly you disagree or agree with each statement. Note that these statements deliberately focus on your general impressions about today's scientific community, its methods, and its conclusions. Further, note that some of the items may seem repetitive or redundant. This is intentional. Even if a statement seems very similar to a previous item, please take the time to rate each item on its own terms.

Disagree very strongly	Disagree strongly	Disagree somewhat	Neither agree nor disagree	Agree somewhat	Agree strongly	Agree very strongly
1. People trust scientists a lot more than they should.						
2. People don't realize just how flawed a lot of scientific research really is.						
3. A lot of scientific theories are dead wrong.						
4. Sometimes I think we put too much faith in science.						
5. Our society places too much emphasis on science.						
6. I am concerned by the amount of influence that scientists have in society.						

Note: All items are reverse coded, such that higher values indicate more favorable (less negative) attitudes.