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Americans' views of scientists' motivations for scientific work

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Abstract

Scholars have not examined public views of scientific motivations directly, despite scientific authority implications. A US representative sample rated 11 motivations both descriptively (they *do* motivate scientists' work) and normatively (they *should* motivate scientists) for scientists employed by federal government agency, large business corporation, advocacy group (nonprofit seeking to influence policy), or university. Descriptive and normative ratings fell into extrinsic (money, fame, power, being liked, helping employer) and intrinsic (do good science, enjoy challenge, helping society and others) motivation factors; being independent and gaining respect were outliers. People saw intrinsic motivations as more common, but wanted intrinsic motivations to dominate extrinsic ones even more. Despite a few differences for extrinsic-motivation ratings, the lay public tended to see scientific work as similarly motivated regardless of the employer. Variance in perceived science motivations was explained by scientific beliefs (positivism, credibility) and knowledge (of facts and scientific reasoning), complemented by political ideology and religiosity.

Keywords

extrinsic motivations, intrinsic motivations, perceptions of scientists' motivations

1. Introduction

Public beliefs about motivations of scientists and/or their employers can be important for scientific authority generally, for science policy and even individual scientists (e.g. Lysaght and Kerridge, 2012). Motivations that citizens value and think provide incentives for scientific work should enhance scientific authority and scientists' credibility, while unvalued or actively opposed motivations that seem to characterize working scientists would have reverse effects. Yet little research has studied such public beliefs.

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Despite this issue's importance, we have surprisingly little evidence even on whether trust differs across scientists with potentially differing motivations. For example, there is some evidence that the public finds privately funded researchers less trustworthy than publicly funded scientists (e.g. Critchley, 2008; Hargreaves et al., 2002; Hipkins et al., 2002). Yet differences varied widely in magnitude: 14% of the public trusted scientists in private business versus 60% who trusted scientists in universities; 62% trusted privately funded versus 71% publicly funded scientists; and mean trust scores on a 0–10 scale were 5.91 for scientists in private companies versus 7.15 for public universities, respectively. Over 80% of New Zealanders agreed that a community should have some scientists linked to neither business nor government (Hipkins et al., 2002). Brewer and Ley (2013) found trust in scientific information about the environment second-highest for "university scientists," behind TV programs or channels about science, with university-scientist trust also increasing trust in other sources (Environmental Protection Agency, environmental organizations, science media, news media). They did not examine whether trust differed for scientists working for these other institutions from trust of the institutions themselves. Several US studies found majorities favored at least some policy involvement by scientists without seeing such action as diminishing individual scientists' or science's credibility, although specific policy positions might raise problems (e.g. Gray and Campbell, 2009; Kotcher et al., 2017; Lach et al., 2003; Pew Research Center, 2009).

Similar questions about this potential science motivation-trust link have been raised in the few studies on how laypeople interpret disputes among scientists, such as their causes or who is more likely correct (e.g. Dieckmann and Johnson, 2019; Johnson, 2019b; Johnson and Dieckmann, 2018). For example, conceptual discussions, focus groups, and field observations of science disputes have identified the employer or funder of scientists as indicators of potential interests that might affect scientists' behavior *and* citizens' interpretations of such behavior (Bubela et al., 2009; Collins and Evans, 2007; Irwin and Wynne, 1996; Maxim and Mansier, 2014; Wynne, 1989). However, a recent public opinion survey and subsequent experiments failed to find "employer" a subjectively or objectively strong factor in judgments of the relative credibility of scientific disputants' positions (Johnson, 2019a, 2019b). This surprising result led to the current experiment, an examination of Americans' views on scientists' motivations for scientific work across four employer types, as a necessary prelude to future work on the relation between perceived science motivations and trust in science.

2. Background

We first address the literature on scientists' motivations, and then on what the public thinks, before presenting our research questions.

Scientists' motivations

Merton (1957, 1973) asserted that reputational prizes ("ribbon") for first discovery, as an initial extrinsic reward with possible other extrinsic consequences (career advance, higher salary, better research resources), are complemented by intrinsic rewards of solving the "puzzle." Roe (1953) had earlier noted the importance of independence and need to achieve as motivations for research scientists. That was the last word on scientists' motivations for several decades.

Leonard et al. (1999) proposed a meta-theory of work motivation, not exclusive to scientists' motivations. Integrating classical motivation theories with self-concept findings, it contained five factors mentioned below:

- Intrinsic process motivation: faced with alternative tasks, persons with this motivation will select the most enjoyable task and persist until it is no longer enjoyable;
- Instrumental motivation: choose task of greatest potential for extrinsic rewards, persist while likelihood is positive;
- External self-concept motivation: affirmative social feedback about how one compares to others;
- Internal self-concept motivation: affirmative task feedback about one's traits, competencies, and values in identities important to self;
- Goal internalization motivation: achieving group or organization goals.

The first instrument for empirical research on this model, the Motivational Source Inventory (MSI) of Barbuto and Scholl (1998), featured face validity and participant problems; an analysis using research academics' responses also found reliability problems (Ryan, 2004). Ryan (2004) developed a Measure of Motivational Sources (MMS) 30-item instrument as a replacement to measure work ideals, and a Measure of Motivational Provisions (MMP) instrument for scientists to report on how well their concrete experience of their work environment addresses these motivations. For example, an intrinsic process motivation item "It is important that the work I do gives me a sense of enjoyment" (MMS1) paralleled "The work I do in my current job gives me a sense of enjoyment" (MMP1).

Ryan (2004) administered the MMS to 330 scientists (37% response rate) in 27 biological and chemical research departments across 20 UK universities. Results revealed six factors: instrumental (six items; $\alpha=.84$), external self-concept (five items; $\alpha=.77$), goal internalization (four items; $\alpha=.78$), intrinsic (five items; $\alpha=.70$), internal self-concept (four items; $\alpha=.67$), and achievement need (two items; $\alpha=.60$). Reliabilities were lower than desired, but Ryan (2004) concluded that "the top three motivators for most scientists are some combination of Achievement Need Motivation, Internal Self-concept motivation, and either Intrinsic Motivation or Goal Internalization Motivation" (p. 276). Thus, scientists seemed motivated by need for achievement (Merton's "ribbon"), feeling one is meeting one's own criteria for values and competence, enjoyment, and serving collective goals.

Most contemporary literature on scientists' motivations has emphasized specific tasks within scientific work—for example, motivations for patenting their work or citing certain authors versus others—versus motivations overall. For example, Lam (2011) assessed motivations for scientists' engagement in commercialization of their research, beginning with Merton's "ribbon" versus "puzzle" distinction. The rise of entrepreneurial science has highlighted increasing potential for "gold" motivations (Stephan and Levin, 1992). Lam cited prior mixed findings and noted inadequate attention to intrinsic motivations. She based her approach on sociology of science findings about scientists' ambivalence and divergent value orientations (Box and Cotgrove, 1966; Cotgrove, 1970; Merton and Barber, 1963), and self-determination theory (Deci and Ryan, 2000; Gagne and Deci, 2005; Ryan and Deci, 2000). This latter theory posits greater or lesser emphasis on intrinsic versus extrinsic motivations depending upon how much the person has internalized related values and psychological regulatory structures. Empirically, Lam (2011) found "traditional" scientists who were extrinsically motivated ("ribbon") and "entrepreneurial" scientists intrinsically motivated by the puzzle of commercialization but also extrinsically by "gold." Nearly half in her British sample were hybrids.

Public perception of scientists' motivations

Compared to the decades-old scholarly attention to scientists' motivations, direct attention to public views on scientific motivations is even rarer, more recent, and less comprehensive. Wellcome

Trust (1999) found British adults in qualitative research saw scientists as driven by both academic and self-interests (e.g. glory). They were also perceived as under external pressures, particularly commercial ones, that could corrupt research. Critchley (2008) found an Australian sample deemed publicly funded (here, university) stem cell scientists motivated more by benevolence (e.g. want to make life better for ordinary people using ethical research methods and being honest about research results). In contrast, privately funded scientists were deemed more self-interested (e.g. to gain money or awards). Competence (e.g. interest in discovery, passion for their work, being highly trained) did not distinguish the two groups. Perceived self-interest did not explain the lower trust of private stem cell research, but private scientists' lower perceived benevolence and perceived lower public access to benefits of private stem cell research did.

In a 2014 representative sample of UK residents, 83% agreed that scientists aim to better life for the average person. Qualitative results suggested that participants assumed money did not drive government or university scientists, unlike those in private firms. However, the survey's probing of observed versus desired traits for scientists was not on motivations but personal characteristics: honesty, ethical behavior, open-mindedness, creativity, communicative skill, being interesting, and open. Descriptive ratings on these attributes were not reported directly, but net scores showed positive views dominated, excluding scientists' perceived secretiveness. Trust in scientists "to follow any rules and regulations which apply to their profession" was generally high, although varying across employer: universities (90%), charities (88%), environmental groups (79%), government (74%), private companies (60%) (Castell et al., 2014).

The Science Barometer representative survey of Germans ($n=1008$) in August 2018 explored what the public thought made for a good "scientist," which included all academic research (humanities, social sciences, natural sciences). A mix of motivations and other attributes was probed, including "skills" such as "must not be guided by the interests of third parties" (63% "completely agree") and "think about the common good" (58%). Among reasons for why one might trust scientists, motivations included 48% who completely or somewhat agreed with "scientists work according to rules and standard procedures," and 47% with "scientists do research in the public interest." Among motivational reasons for distrust, 67% agreed with "scientists are strongly dependent on the funders of their research" and 18% with "scientists often make mistakes." Some 69% considered the influence of business on science as too strong (Wissenschaft im Dialog/Kantar Emnid, 2018).

Less directly, reasons imputed by laypeople for scientific disputes have included some—self-interest and values among other potential sources of bias (e.g. Dieckmann et al., 2015)—that imply motivations, although these are not always clearly defined by lay participants or researchers (Johnson and Slovic, 1998; Kajanne and Pirttila-Backman, 1999; Thomm et al., 2015, 2017). Another line of research, on cues that might affect lay judgments of the relative validity of different scientific positions, found employer—a potential motivation, through coercion or self-interest of scientists—and other self-interest cues ranked low in both a survey and experiments (Johnson, 2019a, 2019b).

It is difficult to directly compare motivational data from scientists and laypeople, given the small overlap in motivations explored and measures used (not to mention often non-representative samples). However, we can tentatively conclude that both groups have mixed views of scientists' motivations, including self-interest *and* collective/social interests. In addition, several hypothesized elements in theoretical and empirical studies of scientists have yet to be studied regarding public views, most notably the joy that scientists can gain from tackling their ignorance and learning new things.

The 11 motivation types for doing scientific work that we produced were generated primarily from studies of scientists' motivations or perceptions of them, as discussed earlier (see "Sources (direct or implied)" in Table 1). Most were directly expressed in the stated sources, with others

Table 1. Scientist motivation items.

Motivation items (definitions)	Sources (direct or implied)
Make money (high income, good job benefits, avoid unemployment)	Roe (1953), Stephan and Levin (1992), Leonard et al. (1999), Critchley (2008), Lam (2011), and Castell et al. (2014)
Gain power (authority over other people, influence others' behavior)	Roe (1953) and Haynes (2016)
Help employer (increase employer's money, fame, and/or power)	Leonard et al. (1999), Maxim and Mansier (2014), and Wissenschaft im Dialog/Kantar Emnid (2018)
Be independent (manage own time, choose own research topics)	Roe (1953)
Enjoy challenge (to keep learning, puzzle-solving, intellectual achievement)	Merton (1957, 1973), Leonard et al. (1999), and Critchley (2008)
Gain fame (public recognition of one's work, become celebrity)	Roe (1953) and Critchley (2008)
Be liked (maintain good job environment, co-workers enjoy being with them)	Leonard et al. (1999)
Be respected (reputation as competent scientist, admired by other scientists)	Leonard et al. (1999) and Ryan (2004)
Do good science (follow rules and meet high standards of science)	Leonard et al. (1999) and Ryan (2004)
Help society (advance human knowledge, contribute to better world, do what is right)	Ryan (2004), Critchley (2008), Castell et al. (2014), and Wissenschaft im Dialog/Kantar Emnid (2018)
Help others (provide work or research opportunities, develop others' skills and confidence)	Ryan (2004)

more implicit (e.g. power as inspired by Roe, 1953, on need for achievement and by popular-culture representations of the "evil scientist" that might possibly affect some laypeople's images of scientists' motivations, although this image seems to have waned; Haynes, 2016). Motivational descriptions were fleshed out from our experience as scientists as well.

Study aims

We addressed the following specific study aims using a nationally representative sample of permanent residents of the United States:

Aim 1: Describe what laypeople think scientists' motivations for scientific work are (descriptive) and what they feel these motivations should be (normative). We posit that perceived motivations of scientists cannot threaten or reinforce scientific authority unless there is some divergence or convergence, respectively, between what laypeople want and what they think they are getting from scientists. Actual performance of scientists in delivering desired outcomes to society is hard to measure for lay observers, even if desired outcomes were stable and one-dimensional. Thus, assumptions about motivations can provide an easier benchmark to meet. We expect that intrinsic motivations will be more desired but less observed than extrinsic ones. We are also interested in the absolute difference between these ratings, that is, the size of the gap between lay descriptions of and norms for scientists.

Aim 2: Test for differences in descriptive and normative science motivation beliefs between different employer types. Besides occasional findings of perceived differences between scientists funded with public versus private monies, Americans hold shared views (stereotypes) of nonprofit advocacy groups that are more positive and less negative than stereotypes they hold about government agencies, with corporations largely rated in the middle. Positive stereotypes included such items as contributing to society and consulting with those affected by its decisions; negative stereotypes included taking resources from people like oneself (Johnson, 2019c). This holds two possible implications for attributions of motivations of scientists employed by such employers. One option is that these positive and negative stereotypes would extend to their employees' motivations, so that advocacy-group scientists' motivations would be rated more positively (e.g. higher descriptive ratings of normatively valued motivations; less absolute difference between descriptive and normative ratings) than would agency motivations, with corporations in between. Universities were not included in the stereotypes study, but they could be considered the archetypal employer of scientists in the United States, where they employ the majority of scientists and engineers with doctorates (National Science Foundation, National Center for Science Engineering Statistics, 2015). With this ostensible primary locus of knowledge and knowledge-seeking, university scientists might be rated as having the most positive motivations. An alternative option is that motivation ratings are influenced by the perceived focus of the employer. For example, as corporations are deemed profit-seekers in the United States, motivations of their employee scientists might be deemed to emphasize extrinsic motivations such as gaining money, whereas scientists working for nonprofit advocacy groups might be assumed to emphasize such intrinsic motivations as helping to improve society. Experimental manipulation of which of these institutions employed the scientists allowed us to examine effects of employer on lay perceptions of scientific motivations.

Aim 3: Explore whether demographic, political worldview, and science-specific knowledge and belief variables might predict perceived descriptive and normative motivations, and perceived (absolute) differences between the two motivation types beyond employer effects. Previous studies examined the extent to which lay perceptions of science are driven more by general attitudes and worldview orientations (e.g. political ideology) or by science-specific knowledge and experience (e.g. knowledge of science facts or science reasoning; Dieckmann and Johnson, 2019). By including both sets of measures here, as well as other potential factors, we can explore their relative contribution to explaining variability in lay perceptions of science motivations.

Demographic predictors (e.g. gender, age) are standard in social science research, but may have substantive associations with dependent variables. For example, to a limited degree, male, older, and more educated people offer more positive views of science and technology (Besley, 2018). Non-White, less-educated, and politically conservative respondents were more likely to oppose policy being informed by scientific evidence (Gauchat, 2015). Several studies reported on the increasing politicization of science (e.g. Dunlap et al., 2016; Gauchat, 2012; McCright et al., 2013). For example, political conservatives have reported less support for science funding (Besley, 2018). Religiosity has had mixed effects on perceptions of and support for science in research to date (e.g. Ellison and Musick, 1995; Evans, 2013; Gauchat, 2008, 2012, 2015). We would expect belief in scientific positivism (i.e. that science yields truthful knowledge about the universe) and perceived credibility of science would enhance both descriptive and normative ratings of intrinsic motivations, given our assumption that for scientists these will be deemed more desirable than extrinsic ones. Among three knowledge measures we deploy, we expect familiarity with scientific reasoning (Drummond and Fischhoff, 2017) to most influence motivation ratings because it reflects the greatest knowledge of how science and scientists operate, compared to either objective knowledge (here, of basic scientific facts, such as whether the earth circles the sun or vice versa) or subjective knowledge, the mere belief that one knows a lot about science. However, scientific knowledge usually has an overall small positive effect on S&T views outside of topic-specific knowledge (e.g. Allum et al., 2008).

3. Methods

Sampling

YouGov operates an online panel of 2 million respondents in the United States, as well as 4 million panelists in 37 other countries, who accumulate points redeemable for cash or other awards by answering surveys. YouGov can provide nationally representative samples through demographically based and other weighting. It provided a sample of 500 respondents from an initial sample of 525 randomly selected from their US panel members. These were matched to a stratified sampling frame based on gender, age, race/ethnicity, and education distributions from the 2016 American Community Survey 1-year data, with selection within strata by weighted sampling with replacement using person weights in the public use file. Matched cases were weighted to the sampling frame with propensity scores; the propensity score function included gender, age, race/ethnicity, education, and region. Post-stratification was based on deciles of the estimated propensity scores, weights due to 2016 Presidential vote choice, and four-way stratification by the demographic attributes to produce the final weight.

Instrument and measures

After indicating informed consent, and answering screener questions about being a US permanent resident, 18+ years old, and able to answer the survey in one sitting, respondents were randomly assigned to one of four "organization" conditions: "federal government agency," "large business corporation," "advocacy group" (defined for them as "a nonprofit that tries to influence policy decisions"), or "university." (The entire instrument appears in Supporting Information 1, using agency as the example.) One such label was inserted in the text of subsequent questions where (organization) appears below:

> We are interested in your opinions about the *motivations* scientists have in doing their scientific work. "Scientific work" includes all relevant decisions: which issues to study; methods to collect and analyze data; and how they report results and determine the conclusions to be drawn. You do not need to be an expert on scientific work; we are interested in your honest opinion about what you *think* motivates scientists in doing their scientific work.
>
> Next, please answer questions about each of the following goals for scientific work of scientists who work for a typical **[organization]**. We will show you one potential goal at a time and then move to the next goal. For each goal, you will make two kinds of ratings. The first ratings will show your opinions about how much this goal ***does*** impact scientific work; the second ratings will show your opinions about how much this goal ***should*** impact scientific work.

Scientist motivation ratings. Motivational ratings were made on fully labeled scales (1 = *not at all*, 5 = *extremely*) for 11 randomly ordered motivations and their associated definitions (Table 1). They responded to questions "How much do you think this goal ***motivates/influences*** scientists working for a typical **[organization]**?" and "How much do you think this goal should ***motivate/influence*** scientists working for a typical **[organization]**?" on each motivation before moving to the next. Results from subsequent questions about scientist–employer relations are reported separately (Johnson and Dieckmann, 2019).

Science-related knowledge and beliefs. Participants then completed the following measures:

- *Subjective knowledge of science*. "How much do you feel you know about how and why scientists do their scientific work the way they do?" (1 = *know nothing at all*, 5 = *know almost everything*).

- *Science fact knowledge*. Knowledge about science facts included seven true–false items (e.g. "All radioactivity is man-made") and two items about the existence and length of the Earth's solar orbit (National Science Board (NSB), 2014).
- *Science reasoning knowledge*. Familiarity with scientific reasoning (Drummond and Fischhoff, 2017) as a count of correct answers to 11 true–false items (e.g. the item probing understanding of reliability was "A researcher develops a new method for measuring the surface tension of liquids. This method is more consistent than the old method. True or False? The new method must also be more accurate than the old method").
- *Beliefs about scientific positivism*. Beliefs about scientific positivism were measured with eight items (taken from Steel et al., 2004 and Rabinovich and Morton, 2012; e.g. "Science provides objective knowledge about the world," 1 = *strongly disagree*, 5 = *strongly agree*).
- *Credibility of science*. General credibility of science and scientists, or mistrust, was measured with a six-item scale (Hartman et al., 2017; e.g. "People trust scientists a lot more than they should," 1 = *disagree very strongly*, 7 = *agree very strongly*; all items were reverse coded, so higher scores equal higher credibility of science).

Participants' subsequent responses to NSB (2014) measures on government funding of scientific research, confidence in the scientific community, and the relative benefits and harms of such research are not discussed here. Participants were then offered a space for written comments and given a short debriefing. Except for age, calculated from birth year (screener), and a yes/no question on whether the respondent was a scientist, demographic data came from YouGov's panel data (see Supporting Information 2). Median survey completion time was 20.1 minutes.

Statistical analyses

To address Aim 1, we first explored whether the 11 motivation ratings could be summarized into a smaller number of fundamental components or factors. Principal components analysis extracted orthogonal components from the motivation items for descriptive and normative item sets separately. Results were confirmed using principal axis factoring (PAF) with oblique (oblimin) rotation as an alternative factoring procedure. We then created an absolute difference score between descriptive and normative ratings on the extracted components for each participant to index the divergence between perceptions of "what exists" (descriptive) and "what one wants to exist" (normative). Multiple linear regression tested for differences on the motivation components and absolute difference scores across employers (Aim 2), and for relations between motivation ratings and demographic and science knowledge and beliefs measures (Aim 3). All inferential modeling and effect size calculations (Cohen's *d*) were sample-weight adjusted unless noted otherwise (Supporting Information 2). All analyses were conducted in the R statistical computing environment (R Core Team, 2018).

4. Results

Demographics

Unweighted (weighted) demographic data for the 500 respondents include 57% (51.1%) female, 71.8% (64.4%) non-Hispanic White, 38.0% (29.2%) college graduates, 38.8% (37.5%) political liberals, and 37.7% (35.7%) political conservatives; full demographic data appear in Supporting Information 2. The 4% who said they were scientists included chemists, biologists, social scientists, and an engineer. A weighted Religiosity index of four religiosity questions (attend church at

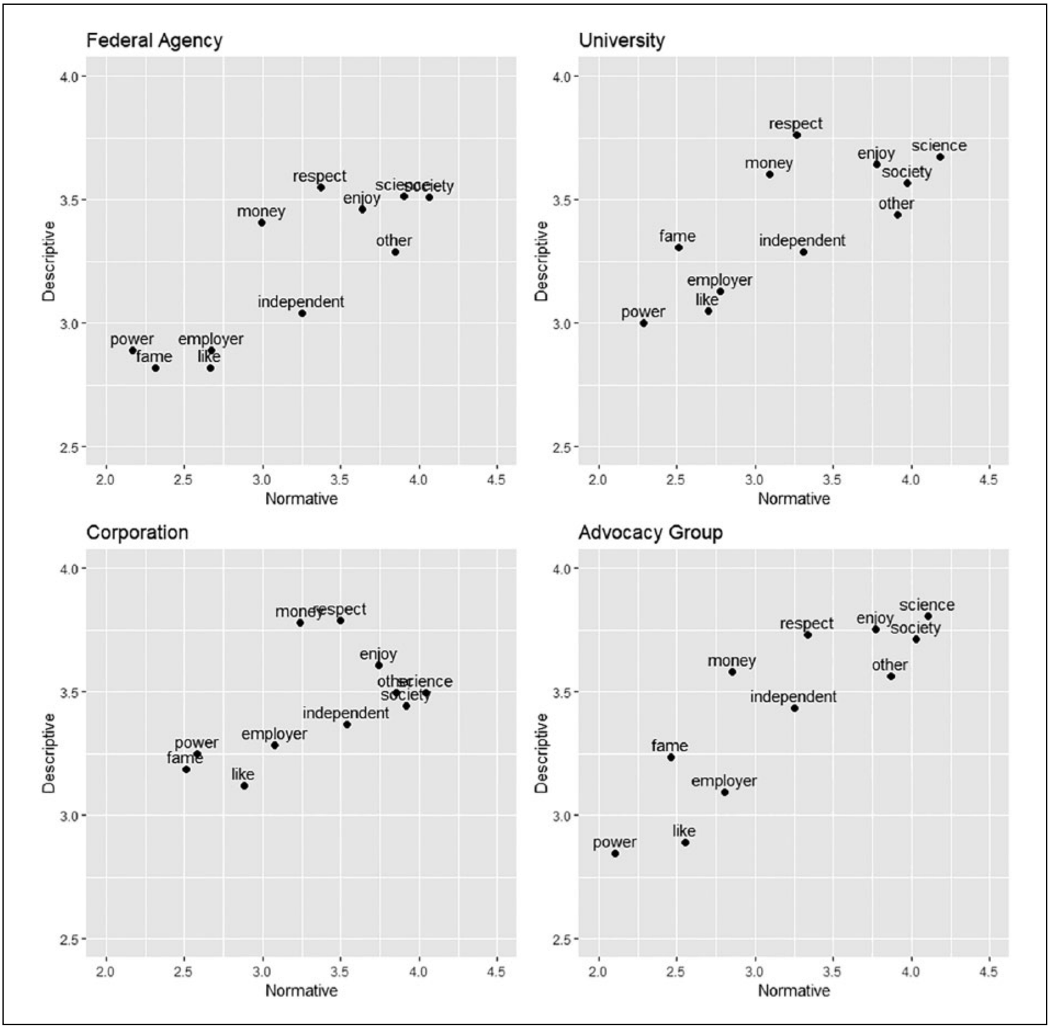

Figure 1. Mean descriptive and normative ratings for each motivation by employer type.

least once a week, born again, religion very important, and pray at least once a day) was calculated. Items were recoded so that higher scores on a standardized 1–6 scale indicated higher religiosity (Cronbach's $\alpha = .86$).

Random assignment to treatment group resulted in 128 (25.6%) in the agency condition, 117 (23.4%) in the corporation condition, 129 (25.8%) in the advocacy group condition, and 126 (25.2%) in the university condition.

Principal components analysis of motivation ratings

Plotting descriptive by normative mean ratings for each motivation by employer type (Figure 1) shows relatively stable patterns across employers. There is a clear trend for more intrinsic motivations to be rated higher normatively and more extrinsic motivations being rated lower normatively, compared to their respective descriptive ratings. The university and advocacy group appear to

Table 2. Principal components analyses of motivations ($n = 500$).

	Descriptive		Normative	
	Component 1	Component 2	Component 1	Component 2
Make money	0.05	**0.77**	**0.79**	0.04
Gain power	–0.19	**0.74**	**0.78**	–0.11
Gain fame	–0.06	**0.76**	**0.79**	–0.05
Be liked	0.21	**0.62**	**0.71**	0.13
Help employer	0.22	**0.57**	**0.64**	0.21
Be respected	0.48	0.52	0.59	0.39
Be independent	0.58	0.31	0.37	0.45
Do good science	**0.79**	–0.06	–0.09	**0.76**
Enjoy challenge	**0.72**	0.11	0.09	**0.70**
Help society	**0.77**	–0.04	0.02	**0.78**
Help others	**0.80**	–0.02	0.09	**0.76**
Eigenvalue	3.06	2.81	3.30	2.68
Cumulative variance explained	27.8%	53.4%	30.2%	54.4%

Boldface indicates high-loading items used for four motivations indices.

receive higher ratings on intrinsic motivations than the others, with money rating higher both descriptively and normatively for corporations than other employers.

Principal components analysis (PCA) results for both descriptive and normative motivation ratings (Table 2) show the same two-component structure (extracting a third component resulted in an eigenvalue ~ 1 for both item sets without yielding a better fitting model by the root mean square residual). The first component comprised extrinsic motivations of money, power, fame, being liked, and helping one's employer; the second component comprised intrinsic motivations of doing good science, enjoying challenge, and helping society and others. The respect and independence motivations were less clearly distinguished, each cross-loading on extracted components for descriptive and normative ratings, respectively. PAF with oblique rotation (results omitted) yielded the same extracted factors with nearly identical loadings and very small estimated correlations between the factors ($r = .15$ and .16 for descriptive and normative analyses, respectively). This lack of substantial correlation between PAF factors supports the plausibility of assuming orthogonal (uncorrelated) factors in the PCA.

Based on these analyses, we created two motivation indices each for intrinsic and extrinsic motivations, which showed good reliability: intrinsic descriptive ($\alpha = .80$), intrinsic normative ($\alpha = .76$), extrinsic descriptive ($\alpha = .76$), and extrinsic normative ($\alpha = .82$). Motivations of respect and independence were excluded.

Differences in descriptive and normative motivation ratings

Table 3 shows weighted descriptive statistics for descriptive and normative motivation ratings. Averaging across institutions, respondents reported intrinsic motivations as higher than extrinsic motivations both descriptively (mean difference (MD) = 0.36; 95% confidence intervals (CI) = 0.26, 0.45; Cohen's $d = 0.33$) and normatively (MD = 1.18; 95% CI = 1.08, 1.28; Cohen's $d = 1.04$). There were higher normative than descriptive intrinsic motivations (MD = 0.34; 95% CI = 0.28, 0.40; Cohen's $d = 0.49$); and higher descriptive than normative extrinsic motivations (MD = −0.48; 95% CI = −0.56, −0.41; Cohen's $d = -0.57$). Employer was not a significant predictor of raw descriptive

Table 3. Sample weighted means (*SDs*) for intrinsic and extrinsic motivation ratings by employer.

	Federal agency	Corporation	Advocacy group	University
Intrinsic motivations				
Descriptive	3.50 (0.88)	3.50 (0.82)	3.67 (0.79)	3.58 (0.74)
Normative	3.87 (0.83)	3.89 (0.79)	3.93 (0.77)	3.92 (0.66)
Individual absolute differences	0.48 (0.64)	0.49 (0.59)	0.50 (0.64)	0.46 (0.56)
Extrinsic motivations				
Descriptive	3.03 (0.84)	3.37 (0.79)	3.11 (0.79)	3.30 (0.73)
Normative	2.67 (0.98)	2.86 (0.91)	2.56 (0.89)	2.81 (0.93)
Individual absolute differences	0.56 (0.71)	0.57 (0.74)	0.67 (0.80)	0.64 (0.77)

SD: standard deviation.

versus normative differences for intrinsic ($R^2 = .006$, $p = .44$) or extrinsic ($R^2 = .008$, $p = .26$) motivations, plausible given consistent patterns across employer in Table 4. Respondents on average wanted less (normative) focus on extrinsic motivations and more (normative) focus on intrinsic motivations than they believed currently exist.

To track this gap, we examined the divergence for each individual between motivations she thinks currently exist and those she wants to exist, with higher absolute numbers indicating more divergence. Table 3 shows little difference across employers in this divergence for intrinsic motivations (.04 difference between advocacy group, with the largest average gap between descriptive and normative ratings, and university, with the smallest gap). The gap was larger across employers for extrinsic motivations (.11, between federal agency and advocacy group), and the absolute difference for each employer was greater for extrinsic than for intrinsic motivations. In short, on average, people were more satisfied with imputed performance for scientists' intrinsic motivations than they were for extrinsic motivations.

Next, we tested whether employer significantly predicted each descriptive, normative, and absolute difference outcome separately. For intrinsic motivations, there were very small nonsignificant differences between employers regarding descriptive ($R^2 = .008$, $p = .28$), normative ($R^2 = .001$, $p = .93$), or absolute difference measures ($R^2 = .001$, $p = .95$). For extrinsic motivations, there were small but statistically significant differences between employers regarding descriptive ($R^2 = .03$, $p = .001$) and normative ($R^2 = .02$, $p = .04$), but not absolute difference ratings ($R^2 = .004$, $p = .60$). Participants rated scientists with corporate and university employers significantly higher on descriptive extrinsic motivations than federal agencies (corporation Cohen's $d = 0.42$, $p = .006$, university Cohen's $d = 0.35$, $p = .001$) or advocacy groups (corporation Cohen's $d = 0.33$, $p = .009$, university Cohen's $d = 0.26$, $p = .05$). Federal agency and advocacy group did not significantly differ (Cohen's $d = 0.10$, $p = .41$). For normative extrinsic motivations, participants rated scientists working for corporate employers higher than advocacy groups (Cohen's $d = 0.34$, $p = .006$) but all other differences between employers on extrinsic motivations were small and nonsignificant.

Predicting science motivation ratings with demographics and science-related beliefs and knowledge

Overall responses for science belief and knowledge measures were close to the middle of the scale for credibility of science/scientists (1–7 scale; $M = 3.93$, standard deviation (SD) = 1.45, median = 3.83), belief in scientific positivism (1–5 scale; M = 3.39, SD = 0.60, median = 3.38), and knowledge of scientific reasoning (0–11 scale; M = 5.99, SD = 2.60, median = 6), but relatively high for knowledge of scientific facts (1–9 scale; M = 6.70, SD = 1.95, median = 7). However, when asked about their subjective knowledge of "how and why scientists do their scientific work," a majority said they "know nothing at all" (27.3%) or "a little" (36.7%).

As planned, we regressed descriptive, normative, and absolute difference scores for both extrinsic and intrinsic motivations on several demographic and science belief/knowledge measures, controlling for employer differences using three dummy variables. Demographic factors had little effect overall, with no statistically significant effects for gender or education, and few effects for age or White non-Hispanic ethnicity (Table 4). However, conservative political ideology was associated with lower intrinsic descriptive and higher extrinsic absolute difference ratings. Religiosity was linked to higher extrinsic and intrinsic descriptive ratings, and higher intrinsic normative ratings.

As for science beliefs and knowledge, belief in scientific positivism increased both descriptive and normative ratings for both extrinsic and intrinsic motivations. Greater perceived credibility of science was associated with lower extrinsic descriptive and absolute difference ratings, and lower intrinsic absolute difference ratings, but higher intrinsic descriptive ratings. Subjective knowledge was linked to lower extrinsic descriptive ratings and higher intrinsic absolute differences, while objective knowledge was associated with lower extrinsic normative ratings and greater extrinsic absolute difference, intrinsic normative, and intrinsic absolute difference ratings. Knowledge of scientific reasoning was associated with lower extrinsic normative and intrinsic descriptive motivation ratings, and higher extrinsic and intrinsic absolute difference ratings. Overall, variance explained by predictors collectively was highest for extrinsic normative (31%) and extrinsic absolute difference (23%) ratings.

5. Discussion

Aim 1: Descriptive and normative beliefs about motivations

Our investigation of lay perceptions of motivations for scientists' work revealed two orthogonal components, intrinsic and extrinsic. This finding expands upon the distinction between perceived benevolence and self-interest found by Critchley (2008). The US public tends to value intrinsic motivations, such as advancing knowledge and helping society, over extrinsic ones, such as gaining fame or money. While descriptive ratings show that intrinsic motivations are deemed more common than extrinsic ones, there is a tiny but persistent individual-level gap between what is desired and what people believe motivates scientists in practice, particularly for intrinsic motivations. This gap could provide a foundation for distrust of scientists and of science, depending upon its size and context.

Yet these findings do not suggest in the US context a major threat to scientific authority from divergence between descriptive and normative views of scientists' motivations in general. At their worst, the absolute differences average two-thirds of a point on the 5-point motivation rating scale, or less than 17% of its range. Although people preferred intrinsic over extrinsic motivations regardless of the employer, they also described the former as outweighing the latter in reality. While things as they are fall short of a perceived ideal, they are much closer to that ideal than they could be.

However, our focus on scientists in general may have minimized such differences between descriptive and normative ratings. As Castell et al. (2014) noted, "trust in particular scientists strongly depends on framing, and possibly the assumptions this framing creates about vested interests and personalities" (p. 87). The use of particular topics (e.g. climate change, pharmaceutical drugs) might yield more divergent judgments. For example, climate scientists were trusted less by

Table 4. Linear regression analyses of motivation indices and items.

	Extrinsic index			Intrinsic index		
	Descriptive	Normative	Absolute differences	Descriptive	Normative	Absolute differences
Gender	.08 (−0.05, 0.22)	.02 (−0.13, 0.17)	.04 (−0.09, 0.17)	.11 (−0.04, 0.25)	.06 (−0.08, 0.19)	.07 (−0.04, 0.18)
Age	−.001 (−0.005, 0.003)	.001 (−0.003, 0.006)	**−.005 (−0.009, −0.002)**	**.01 (0.001, 0.009)**	−.001 (−0.004, 0.004)	−.001 (−0.005, 0.001)
Education (HS vs higher)	−.02 (−0.18, 0.13)	.07 (−0.09, 0.24)	−.03 (−0.17, 0.12)	.03 (−0.13, 0.20)	−.02 (−0.13, 0.18)	.002 (−0.12, 0.12)
Ethnic identity (White vs other)	−.08 (−0.23, 0.07)	−.16 (−0.32, 0.005)	**.16 (0.02, 0.30)**	**−.21 (−0.37, −0.05)**	−.14 (−0.28, 0.02)	.08 (−0.04, 0.20)
Political ideology (conservative vs liberal)	.07 (−0.001, 0.14)	−.04 (−0.12, 0.03)	**.09 (0.03, 0.15)**	**−.09 (−0.16, −0.02)**	−.02 (−0.09, 0.05)	.03 (−0.02, 0.09)
Religiosity	**.05 (0.01, 0.09)**	.04 (−0.006, 0.08)	.003 (−0.03, 0.04)	**.05 (0.01, 0.09)**	**.05 (0.01, 0.09)**	.008 (−0.02, 0.04)
Positivism	**.20 (0.08, 0.33)**	.13 (−0.001, 0.26)	.09 (−0.03, 0.21)	**.22 (0.09, 0.34)**	**.18 (0.06, 0.31)**	.005 (−0.09, 0.10)
Credibility of science	**−.14 (−0.20, −0.08)**	−.05 (−0.12, 0.007)	**−.10 (−0.16, −0.04)**	**.09 (0.02, 0.15)**	.06 (−0.001, 0.12)	**−.07 (−0.12, −0.02)**
Subjective knowledge	**.07 (0.004, 0.14)**	.04 (−0.03, 0.11)	.04 (−0.02, 0.11)	−.07 (−0.14, 0.01)	−.02 (−0.09, 0.05)	**.05 (0.001, 0.11)**
Objective knowledge	−.008 (−0.05, 0.04)	**−.07 (−0.12, −0.03)**	**.06 (0.02, 0.10)**	.03 (−0.02, 0.07)	**.10 (0.06, 0.14)**	**.05 (0.02, 0.08)**
Scientific reasoning	.01 (−0.02, 0.04)	**−.13 (−0.16, −0.10)**	**.11 (0.08, 0.14)**	**−.04 (−0.07, −0.01)**	.02 (−0.02, 0.05)	**.06 (0.04, 0.09)**
Emp_D1 (Univ. vs Fed.)	.15 (−0.03, 0.34)	.04 (−0.16, 0.24)	.04 (−0.14, 0.22)	.04 (−0.15, 0.24)	−.02 (−0.20, 0.17)	−.05 (−0.20, 0.09)
Emp_D2 (Corp. vs Fed.)	**.30 (0.11, 0.49)**	.08 (−0.12, 0.29)	.05 (−0.12, 0.23)	−.06 (−0.26, 0.13)	.01 (−0.18, 0.20)	.04 (−0.11, 0.19)
Emp_D3 (Advo. vs Fed.)	.09 (−0.10, 0.27)	−.08 (−0.28, 0.13)	.08 (−0.10, 0.25)	.13 (−0.07, 0.33)	−.01 (−0.19, 0.18)	.004 (−0.14, 0.15)
R^2	.18	.31	.23	.14	.11	.16

Univ.: university; Fed.: federal government agency; Corp.: large business corporation; Advo.: advocacy group; HS: high school.
Cells show unstandardized regression coefficients (95% confidence intervals (CI)). Estimates with CIs excluding 0 are bolded.

UK residents than scientists generally (Shuckburgh et al., 2012). The distinction between "impact" (e.g. ecologists) and "production" (e.g. petroleum geologists) sciences proposed to explain why political conservatives in the US might distrust some contemporary science is another useful example (McCright et al., 2013). However, the latter's emphasis on economic implications of science does not account for public views on evolution (Hamilton et al., 2015) or the big bang theory or the nature of dark matter in the universe (Johnson, 2019b). This assessment of descriptive versus normative motivational perceptions for more specific definitions of "scientist" will be an important focus for future research.

While we are confident that our list of potential motivations is fairly comprehensive and reflects the literature, this does not mean it cannot be improved for future work on both lay views and for contrasting them with scientists' views of motivations. The pattern of item loadings for respect and independence did not support their inclusion in our present descriptive and normative indices, nor could we observe a third component on which they loaded together. Whether this indicates additional components would appear if we included motivations missing here, an appropriate change in phrasing would lead respect and independence to load with our two current dimensions, or that these results truly reflect the hybrid or outlier nature of these motivations would require new data to resolve. We also in future research should promote comparison of scientists' and citizens' views of scientists' motivations by seeing whether we can develop a measure useful with both populations. Given lay subjective and objective ignorance of how scientists work (e.g. Castell et al., 2014; Wissenschaft im Dialog/Kantar Emnid, 2018), we would expect lay distinctions among motivations to be less detailed than scientists' distinctions. The reduction of our 11 items into two indices reflects that. While the MMS and MMP instruments used with scientists (Ryan, 2004) could be adapted to generate normative and descriptive equivalents for laypeople, our suggestion is to begin by interviewing scientists using our own measures as prompts to elicit other motivations not yet made explicit. The number, factoring, and reliability of the Ryan (2004) measures in his UK scientist data, as he discusses, suggest they may not be ideal for this purpose.

Finally, these findings suggesting a generally positive attitude among Americans toward scientists' work motivations do not resolve the apparent discrepancy which motivated this study. Qualitative, survey, and experimental data point to potential self-interest or employer self-interest, such as "follow the money!" as a salient issue for laypeople (see Besley et al., 2017, 2019; Johnson, 2019a; Maxim and Mansier, 2014), while interest cues generally perform poorly in predicting the perceived relative validity of disputing scientific positions in both survey self-reports and experiments (e.g. Johnson, 2019a, 2019b). Perhaps contextual factors explain this difference, and there is no true discrepancy, or one response may be more common in real life, in which case the moderate picture presented here might be misleading. Only additional observational research can test that possibility.

Aim 2: Perceived motivations across employers

Overall, we found few differences across scientist-employing institutions. The statistically significant differences in motivations occurred for extrinsic rather than intrinsic ratings. Scientists working for corporations and universities were seen as having greater extrinsic motivations than those working for federal agencies and advocacy groups. People were significantly more likely to grant the normative value of extrinsic motivations to corporations than to advocacy groups.

Otherwise, there were few differences across employer types, indicating that US laypeople believe scientists' motivations do not vary much across institutional context. Again, it would be important to test whether this endures for specific topics, including those that are controversial.

Aim 3: Explaining beliefs about motivations

With respect to explanatory factors for motivation judgments, we found moderate levels of collective explanation (11%–31%) across our six dependent variables, with explanatory power concentrated in science beliefs and knowledge, although political ideology and religiosity also contributed. We found, contrary to factors in lay beliefs about reasons for scientific disputes (Dieckmann and Johnson, 2019), that knowledge outweighed generic (non-science-focused) attitudes and worldviews. Descriptive ratings for *both* motivation types were enhanced by religiosity and belief in scientific positivism. There is no obvious *post hoc* explanation for these global associations, although positivism also enhanced lay ratings for all putative reasons for scientific disputes (Dieckmann and Johnson, 2019; Johnson and Dieckmann, 2018) and beliefs about scientist–employer relations (Johnson and Dieckmann, 2019), suggesting there is some response bias or unmeasured third variable associated with these positivist beliefs that warrants qualitative study. The lower descriptive ratings for intrinsic motivations from those familiar with scientific reasoning may reflect greater familiarity with mixed motivations of scientists in practice (see literature review), although intriguingly there is no such effect on extrinsic descriptions. For normative judgments, there were fewer significant associations, mostly for intrinsic motivations. Positivism belief and objective knowledge enhanced intrinsic-rating norms, while familiarity with scientific reasoning and objective knowledge reduced extrinsic-rating norms.

The split effects for credibility of science, which decreased extrinsic descriptions and increased intrinsic ones, are harder to interpret. If credibility is a predictor, as we assumed here, these results hint at a halo effect: when scientists are favored they are assumed by lay observers to have favored characteristics. An alternative is the reverse relationship such that people trust scientists more because they see intrinsic motivations as more dominant among scientists than extrinsic ones. Our cross-sectional data do not allow us to test these alternatives.

The potentially most interesting question is what factors foster a gap between what laypeople believe they observe as motivating scientists' work and what they desire. Both motivational types show larger divergences when objective knowledge and familiarity with scientific reasoning increase—suggesting that those more familiar with science may be either more sensitive to, or more accurate about, the gap—while those who find science credible see smaller gaps than do the mistrustful, a plausible association. As noted above, the latter association may have a reverse causality: those who see a smaller gap might thereby see scientists as more credible.

Future research

Clearly this work merits replication to confirm these preliminary findings across societies and by probing their generalizability to more specific kinds of scientists and for specific topics. We also have mentioned the value theoretically of probing the mechanisms by which these responses arise, and of comparing lay and scientists' descriptive and normative views of scientists' motivations using the same measures.

Beyond that is the research needed to explore whether and how lay perceptions of motivations affect trust in science and scientists, building upon the innovative work of Critchley (2008) focusing on the comparative effect of benevolence and self-interest for stem cell research. However, in pursuing such research we must acknowledge that lay beliefs about motivations are only one component of their summary judgments about science and its value to society. For example, people may see scientists' motivations as appropriate, but their work as taking place in an employment context that distorts its content or use (Critchley, 2008; Johnson and Dieckmann, 2019). In addition, people may determine whether to support science based on criteria quite other than the fitness of individual scientists' motivations. Research that puts our motivational focus into the larger picture will greatly advance scholarly understanding.

6. Conclusion

Scholarly explorations of public understanding of science have covered many different topics over the decades. Adding the issue of scientists' motivations, as part of the web of incentives and disincentives for scientific work that influences the quality and quantity of that work's output, is a required foundation for connecting it with critical elements of science's role in society, including but not limited to trust in scientists and scientific authority. Motivations deemed inappropriate, if not illegitimate, may undermine such authority, and support for science funding and education, making it important to understand both the nature of lay perceptions of these motivations and their effects. We hope other researchers will join in probing these topics.

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Supplemental material

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References

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

Barbuto JE and Scholl RW (1998) Motivation source inventory: Development and validation of new scales to measure an integrative taxonomy of motivation. *Psychological Reports* 82: 1011–1022.

Besley JC (2018) The National Science Foundation's science and technology survey and support for science funding, 2006-2014. *Public Understanding of Science* 27: 94–109.

Besley JC, McCright AM, Zahry NR, Elliott KC, Kaminski NE and Martin JD (2017) Perceived conflict of interest in health science partnerships. *PLoS ONE* 12: e0175643.

Besley JC, Zhary NR, McCright A, Elliott KC, Kaminski NE and Martin JD (2019) Conflict of interest mitigation procedures may have little influence on the perceived procedural fairness of risk-related research. *Risk Analysis* 39: 571–585.

Box S and Cotgrove S (1966) Scientific identity, occupational selection, and role strain. *British Journal of Sociology* 17: 20–28.

Brewer PR and Ley BL (2013) Whose science do you believe? Explaining trust in sources of scientific information about the environment. *Science Communication* 35: 115–137.

Bubela T, Nisbet MC, Borchelt R, Brunger F, Critchley C, Einsiedel E, et al. (2009) Science communication reconsidered. *Nature Biotechnology* 27: 514–518.

Castell S, Charlton A, Clemence M, Pettigrew N, Pope S, Quigley A, et al. (2014) *Public Attitudes to Science 2014*. Ipsos MORI. Available at: https://www.ipsos.com/ipsos-mori/en-uk/public-attitudes-science-2014

Collins H and Evans R (2007) *Rethinking Expertise*. Chicago, IL: University of Chicago Press.

Cotgrove S (1970) The sociology of science and technology. *British Journal of Sociology* 21: 1–15.

Critchley CR (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(3): 309–327.

Deci EL and Ryan RM (2000) The "what" and "why" of goal pursuits: Human needs and the self-determination theory. *Psychological Inquiry* 11: 227–268.

Dieckmann NF and Johnson BB (2019) Why do scientists disagree? Explaining and improving measures of the perceived causes of scientific disputes. *PLoS ONE* 14(2): e0211269.

Dieckmann NF, Johnson BB, Gregory R, Mayorga M, Han PK and Slovic P (2015) Public perceptions of expert disagreement: Bias and incompetence or a complex and random world? *Public Understanding of Science* 26(3): 325–338.

Drummond R and Fischhoff B (2017) Development and validation of the scientific reasoning scale. *Journal of Behavioral Decision Making* 30: 26–38.

Dunlap RE, McCright AM and Yarosh J (2016) The political divide on climate change: Partisan polarization in the U.S. public widens. *Environment* 58(5): 4–22.

Ellison CG and Musick MA (1995) Conservative Protestantism and public opinion toward science. *Review of Religious Research* 36(3): 245–262.

Evans JH (2013) The growing social and moral conflict between conservative Protestantism and science. *Journal for the Scientific Study of Religion* 52(2): 368–385.

Gagne M and Deci EL (2005) Self-determination theory and work motivation. *Journal of Organizational Behavior* 26: 331–362.

Gauchat G (2008) A test of three theories of anti-science. *Sociological Focus* 41(4): 337–357.

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

Gauchat G (2015) The political context of science in the United States: Public acceptance of evidence-based policy and science funding. *Social Forces* 94: 723–746.

Gray NJ and Campbell LM (2009) Science, policy advocacy, and marine protected areas. *Conservation Biology* 23: 460–468.

Hamilton LC, Hartter J and Saito K (2015) Trust in scientists on climate change and vaccines. *SAGE Open* 5: 1–13.

Hargreaves I, Lewis J and Spears T (2002) *Towards a Better Mark: Science, the Public and the Media*. Swindon: Economic and Social Research Council.

Hartman R, Dieckmann NF, Stantsy B, Sprenger A and DeMarree K (2017) Modeling attitudes toward science: Development and validation of a credibility of science scale (CoSS). *Basic and Applied Social Psychology* 39: 358–371.

Haynes RD (2016) Whatever happened to the "mad, bad" scientist? Overturning the stereotype. *Public Understanding of Science* 25: 31–44.

Hipkins R, Stockwell W, Bolstad R and Baker R (2002) *Commonsense, Trust and Science: How Patterns of Beliefs and Attitudes to Science Pose Challenges for Effective Communication*. Wellington, NZ: Ministry of research Science and Technology. Available at: https://www.nzcer.org.nz/research/publications/commonsense-trust-and-science-how-patterns-beliefs-and-attitudes-science-pose-

Irwin A and Wynne B (Eds) (1996) *Misunderstanding Science? the Public Reconstruction of Science and Technology*. New York, NY: Cambridge University Press.

Johnson BB (2019a) Americans' views of cues to the relative credibility of disputing groups of scientists. *Social Science Research Network*. Available at: https://ssrn.com/abstract=3392532

Johnson BB (2019b) Experiments in lay cues to the relative validity of positions taken by disputing groups of scientists. *Risk Analysis* 39: 1657–1674.

Johnson BB (2019c) Probing the role of institutional stereotypes in Americans' evaluations of hazard-managing institutions. *Journal of Risk Research*. Epub ahead of print 1 February. DOI: 10.1080/13669877.2019.1569095.

Johnson BB and Dieckmann NF (2018) Lay Americans' views of why scientists disagree with each other. *Public Understanding of Science* 27: 824–835.

Johnson BB and Dieckmann NF (2019) *Lay beliefs about scientists' relations with their employers* Report no. 837. Eugene, OR: Decision Research.

Johnson BB and Slovic P (1998) Lay views on uncertainty in environmental health risk assessment. *Journal of Risk Research* 1: 261–279.

Kajanne A and Pirttila-Backman A-M (1999) Laypeople's viewpoints about the reasons for expert controversy regarding food additives. *Public Understanding of Science* 8: 303–315.

Kotcher JE, Myers TA, Vraga EK, Stenhouse N and Maibach EW (2017) Does engagement in advocacy hurt the credibility of scientists? Results from a randomized national survey experiment. *Environmental Communication* 11: 415–429.

Lach D, List P, Steel B and Shindler B (2003) Advocacy and credibility of ecological scientists in resource decision making: A regional study. *BioScience* 53: 170–178.

Lam A (2011) What motivates academic scientists to engage in research commercialization: "Gold," "ribbon" or "puzzle"? *Research Policy* 40: 1354–1368.

Leonard NH, Beauvais LL and Scholl RW (1999) Work motivation: The incorporation of self-concept-based processes. *Human Relations* 52(8): 969–997.

Lysaght T and Kerridge I (2012) Rhetoric, power and legitimacy: A critical analysis of the public policy disputes surrounding stem cell research in Australia (2005–6). *Public Understanding of Science* 21: 195–210.

McCright AM, Dentzman K, Charters M and Dietz T (2013) The influence of political ideology on trust in science. *Environmental Research Letters* 8: 044029.

Maxim L and Mansier P (2014) How is scientific credibility affected by communicating uncertainty? The case of endocrine disrupter effects on male fertility. *Human and Ecological Risk Assessment* 20: 201–223.

Merton RK (1957) Priorities in scientific discovery: A chapter in the sociology of science. *American Sociological Review* 22: 635–659.

Merton RK (1973) *The Sociology of Science: Theoretical and Empirical Investigations*. Chicago, IL: University of Chicago Press.

Merton RK and Barber E (1963) Sociological ambivalence. In: Tiryakian EA (ed.) *Sociological Theory, Values and Sociocultural Changes*. Glencoe, IL: The Free Press, pp. 91–120.

National Science Board (NSB) (2014) *Science and Engineering Indicators 2014* (NSB 14–01). Arlington, VA: National Science Foundation.

National Science Foundation, National Center for Science Engineering Statistics (2015) National Survey of college graduates. Available at: https://www.nsf.gov/statistics/srvygrads/

Pew Research Center (2009) *Public Praises Science; Scientists Fault Public, Media*. Washington, DC: Pew Research Center for People & the Press.

R Core Team (2018) *R: A Language and Environment for Statistical Computing*. Vienna: R Foundation for Statistical Computing. Available at: https://www.R-project.org/

Rabinovich A and Morton TA (2012) Unquestioned answers or unanswered questions: Beliefs about science guide responses to uncertainty in climate change in risk communication. *Risk Analysis* 32: 992–1002.

Roe A (1953) A psychological study of eminent psychologists and anthropologists, and a comparison with biological and physical scientists. *Psychological Monographs: General and Applied* 67(2): 1–55.

Ryan JC (2004) An examination of the role of scientists' motivations and the influence of the organizational environment on scientific research effectiveness. PhD Dissertation, Dublin City University, Dublin.

Ryan RM and Deci EL (2000) Intrinsic and extrinsic motivations: Classic definitions and new directions. *Contemporary Educational Psychology* 25: 54–67.

Shuckburgh E, Robison R and Pidgeon N (2012) *Climate Science, the Public and the News Media: Summary Findings of a Survey and Focus Groups Conducted in the UK in March 2011*. Swindon, UK: Living with Environmental Change.

Steel B, List P, Lach D and Shindler B (2004) The role of scientists in the environmental policy process: A case study from the American West. *Environmental Science and Policy* 7: 1–13.

Stephan PE and Levin SG (1992) *Striking the Mother Lode in Science: The Importance of Age, Place, and Time*. New York, NY: Oxford University Press.

Thomm E, Barzilai S and Bromme R (2017) Why do experts disagree? The role of conflict topics and epistemic perspectives in conflict explanations. *Learning and Instruction* 52: 15–26.

Thomm E, Hentschke J and Bromme R (2015) The explaining conflicting scientific claims (ECSC) questionnaire: Measuring laypersons' explanations for conflicts in science. *Learning and Individual Differences* 37: 139–152.

Wellcome Trust (1999) Public perspectives on human cloning. Available at: https://wellcome.ac.uk/search?search=cloning

Wissenschaft im Dialog/Kantar Emnid (2018) *Science Barometer 2018*. Berlin: Wissenschaft im Dialog/Kantar Emnid. Available at: https://www.wissenschaft-im-dialog.de/en/our-projects/science-barometer/science-barometer-2018/

Wynne B (1989) Sheepfarming after Chernobyl: A case study in communicating scientific information. *Environment: Science and Policy for Sustainable Development* 31: 10–39.

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