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Guidelines for Science: Evidence and Checklists

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Abstract

Problem: The scientific method is unrivalled as a basis for generating useful knowledge, yet research papers published in management, economics, and other social sciences fields often ignore scientific principles. What, then, can be done to increase the publication of useful scientific papers?

Methods: Evidence on researchers' compliance with scientific principles was examined. Guidelines aimed at reducing violations were then derived from established definitions of the scientific method.

Findings: Violations of the principles of science are encouraged by: (a) funding for advocacy research; (b) regulations that limit what research is permitted, how it must be designed, and what must be reported; (c) political suppression of scientists' speech; (d) universities' use of invalid criteria to evaluate research—such as grant money and counting of publications without regard to usefulness; (e) journals' use of invalid criteria for deciding which papers to publish—such as the use of statistical significance tests.

Solutions: We created a checklist of 24 evidence-based operational guidelines to help researchers comply with scientific principles (valid inputs). Based on the definition of science, we then developed a checklist of seven criteria to evaluate whether a research paper provides useful scientific findings (valuable outputs). That checklist can be used by researchers, funders, courts, legislators, regulators, employers, reviewers, and journals.

Originality: This paper provides the first comprehensive evidence-based checklists of operational guidelines for conducting scientific research and for evaluating the scientific quality and usefulness of research efforts.

Usefulness: Journals could increase the publication of useful papers by including a section committed to publishing all relevant and useful papers that comply with science. By using the Criteria for Useful Science checklist, those who support science could more effectively evaluate the contributions of scientists.

Keywords

advocacy, econometrics, evidence - based checklists, experiments, multiple hypotheses, objectivity, regression analysis, replication, statistical significance

Disciplines

Business | Econometrics | Marketing

Guidelines for Science: Evidence and Checklists

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Keywords: advocacy; big data; checklist; experiment; incentives; multiple hypotheses; objectivity; regression analysis; regulation; replication; statistical significance

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Authors' notes: (1) Each paper we cite has been read by one or both of us. (2) To ensure that we describe the findings accurately, we are attempting to contact all authors whose research we cited as evidence. (3) We take an oath that we did our best to provide objective findings and full disclosure. (4) Estimated reading time for a typical reader is about 80 minutes.

Voluntary disclosure: We received no external funding for this paper.

Introduction

We first present a working definition of useful science. We use that definition along with our review of evidence on compliance with science by papers published in leading journals to develop operational guidelines for implementing scientific principles. We develop a checklist to help researchers follow the guidelines, and another to help those who fund, publish, or use research to assess whether a paper provides useful scientific findings.

While the scientific principles underlying our guidelines are well-established, our presentation of them in the form of comprehensive checklists of operational guidance for science is novel. The guidelines can help researchers comply with science. They are based on logic and, in some cases, on evidence about their use. We present evidence that in the absence of such an aid, researchers often violate scientific principles.

Defining Useful Science

We relied on well-accepted definitions of science. The definitions, *which apply to science in all fields*, are consistent with one another. The value of scientific knowledge is commonly regarded as being based on its objectivity (see, e.g., Reiss and Springer's 2014 "scientific objectivity" entry in the *Stanford Encyclopedia of Philosophy*).

In his 1620 *Novum Organum*, Sir Francis Bacon suggested that the scientific method involves induction from systematic observation and experimentation. In the third edition of his *Philosophiae Naturalis Principia Mathematica*, first published in 1726, Newton described four "Rules of Reasoning in Philosophy." The fourth rule reads, "In experimental philosophy we are to look upon propositions collected by general induction from phaenomena as accurately or very nearly true, *notwithstanding any contrary hypotheses that may be imagined*, till such time as other phaenomena occur, by which they may either be made more accurate, or liable to exceptions".

Berelson and Steiner's (1964, pp.16-17) research on the scientific method provided six guidelines that are consistent with the above definitions. They identified prediction as one of the primary purposes of science. Milton Friedman recommended testing out-of-sample predictive validity as an important part of the scientific method (Friedman, 1953).

The *Oxford English Dictionary* (2014) offers the following in their definition of "scientific method": "It is now commonly represented as ideally comprising some or all of (a) systematic observation, measurement, and experimentation, (b) induction and the formulation of hypotheses, (c) the making of deductions from the hypotheses, (d) the experimental testing of the deductions..."

Benjamin Franklin, the founder of the University of Pennsylvania, called for the university to be involved in the discovery and dissemination of *useful* knowledge (Franklin, 1743). He did so because he thought that universities around the world were failing in that regard.

Given Franklin's injunction and the preceding definitions, we define *useful science* as...
an objective process of studying *important problems* by *comparing multiple hypotheses using experiments* (designed, quasi, or natural). The process uses cumulative scientific knowledge and systematic measurement to obtain valid and reliable data, valid and simple methods for analysis, logical deduction that does not go beyond the evidence, tests of predictive validity using out-of-sample data, and disclosure of all information needed for replication.

The definition applies to all areas of knowledge. It does not, however, include thinking about hypotheses, or making observations and measurements; while these activities are important to science, they are not on their own sufficient to provide useful scientific findings. Following Popper (see Thornton, 2016), we reason that without empirical testing against other hypotheses,

the usefulness or otherwise of a theories and observations cannot be known and therefore cannot contribute to scientific knowledge.

Advocacy Research, Incentives, and the Practice of Science

Funding for researchers is often provided to gain support for a favored hypothesis. Researchers are also rewarded for finding evidence that supports hypotheses favored by senior colleagues. These incentives often lead to what we call “advocacy research,” an approach that sets out to gain evidence that supports a given hypothesis and that ignores conflicting evidence. That approach is contrary to the need for objectivity in science.

Incentives for scientists should encourage the discovery of useful findings, but do they? Much literature has been devoted to explaining why incentives used by universities and journals are detrimental to science. An early review led to the development of the “author’s formula” Armstrong (1982): “to improve their chances of getting their papers published, researchers should *avoid* examining important problems, challenging existing beliefs, obtaining surprising findings, using simple methods, providing full disclosure, and writing clearly.”

Advocacy Research

“The human understanding when it has once adopted an opinion draws all things else to support and agree with it. And though there be a greater number and weight of instances to be found on the other side, yet these it either neglects and despises, or else by some distinction sets aside and rejects, in order that by this great and pernicious predetermination the authority of its former conclusion may remain inviolate.”
Francis Bacon (XLVI, 1620)

“When men want to construct or support a theory, how they torture facts into their service!”
Mackay (Ch.10, para. 168, 1852)

Advocacy research occurs primarily when the topic is one about which people have strong opinions. In the 1870’s, when science was producing many benefits for society, some physicists proposed to use scientific methods to test the value of prayer. The proposal started a debate between scientists and theologians, the latter claiming that the value of prayer is a known fact that research would be of no value. Francis Galton then revealed that he had been studying the problem, finding for example, that bishops, who pray a lot, live no longer than lawyers, and that kings and queens, whose subjects pray for them, die earlier than lawyers and military officers (Brush, 1974).

Governments tend to support advocacy. Consider environmental alarms. A search identified 26 alarms over a period of two hundred years: Dangerous global cooling, and forests dying due to acid rain are two examples. None of the 26 alarms was the product of scientific forecasting procedures. Governments chose to support twenty-three of the alarms with taxes, spending, and regulations. In all cases, the alarming predictions were wrong. The government actions were harmful in 20 cases, and of no benefit in any (Green and Armstrong, 2014).

Mitroff’s (1969, 1972a, 1972b) interviews of 40 eminent space scientists led him to conclude that scientists held in the highest regard were advocates who resisted disconfirming evidence. Rather than viewing advocacy research as harmful to the pursuit of useful knowledge, Mitroff considered it a useful way to do science. Armstrong (1980a) disagreed and used advocacy research to prove that Mitroff was a fictitious name for a group of scientists who wished to demonstrate that papers that violated scientific principles could be published in a scientific journal. In doing so, Armstrong avoided mentioning disconfirming evidence—that he knew Mitroff.

Journal reviewers often act as advocates by recommending the rejection of papers that challenge their beliefs. Mahoney (1977) sent *Journal of Applied Behavior Analysis* reviewers a

paper that was, unknown to them, fictitious. One version described findings that supported the accepted hypothesis, while the other, *with the same methods*, reported opposite findings. The ten reviewers who rated the paper that supported the common belief gave an average rating of 4.2 on a 6-point scale for quality of methodology, while the 14 who rated the paper that challenged the common belief rated it 2.4. Reviewers' recommendations on whether to publish were mostly consistent with their methodology ratings. Similar experimental findings were obtained in psychology by (Smart (1964), Goodstein and Brazis (1970), Abramowitz, Gomes, and Abramowitz (1975), and Koehler (1993) reported, and in biomedical research by Young, Ioannidis, and Al-Ubaydli (2008).

Advocacy research is common in the management sciences. An audit of 120 empirical papers published in *Management Science* from 1955 to 1976 found that 64 percent selected a single favored hypothesis and sought only confirming evidence (Armstrong, 1979). An audit of 1,700 empirical papers in six leading marketing journals from 1984 to 1999 found that 74 percent used advocacy (Armstrong, Brodie, and Parsons, 2001).

From their audit of research findings from 3,500 studies in 87 areas of empirical economics, Doucouliagos and Stanley (2013) concluded that for topics about which there is a consensus, findings that challenge that consensus were less often published than would be expected by chance alone.

Distracting Incentives

Researchers in universities and many other organizations are typically subject to incentives unrelated or detrimental to useful research. In particular, grants and publications.

Grants to universities and other organizations

Grants are often awarded with an explicit or implicit requirement to conduct advocacy research, and thus to do research that is unscientific. If you obtain funding, you may lose freedom on what to study and how to do so. Most important, grants are likely to distract researchers from what they consider the most important problems that they could address.

Publication counts

The proper measure would be to reward the number and value of useful findings that are made available to the scientific literature. The mere fact of publication does not mean that a paper provides useful scientific knowledge. As we show below, few papers do. Simple counts encourage unproductive strategies such as publishing research findings in small pieces, sharing authorship with people who were only peripherally involved in the research so that more people get credit, and publishing regardless of value.

Effects on Science

In a paper titled "Why most published research findings are false," Ioannidis (2005) demonstrated how incentives, flexibility in research methods, the use of statistical significance testing, and advocacy of a favored hypothesis will *typically* lead to the publication of incorrect findings.

Counts of publications in prestigious journals are given greater weight in determining rewards. In the social sciences, prestigious journals typically insist that empirical papers include *statistically* significant findings thereby creating an obstacle to publishing in such journals. The requirement has been increasing over the past century. By 2007, statistical significance testing was included in 98.6 percent of published empirical studies in accounting, and over 90 percent in political science, economics, finance, management, and marketing (Hubbard, 2016, Chapter 2). Unfortunately, this occurs despite the absence of evidence to support the validity of statistical significance tests (see, e.g., Hunter, 1997; Schmidt and Hunter, 1997). Hubbard (2016, pp. 232-

234) lists 19 well-cited books and articles describing why such tests are invalid. Examples of the harm are provided by Ziliak and McCloskey (2008)

Readers of scientific journals do not understand how to use statistical significance. In a real-world example, Hauer (2004) described how tests of statistical significance led decision-makers to ignore evidence that more people were killed with the “right-turn-on-red” traffic rule.

The failure to understand statistical significance is not restricted to readers. Researchers publish faulty interpretations of statistical significance in leading economics journals as shown by (McCloskey and Ziliak 1996). In addition, when leading econometricians were asked to interpret standard statistical summaries of regression analyses, they did poorly (Soyer and Hogarth, 2012).

In one study, 261 subjects were recruited from among researchers who had published in the *American Journal of Epidemiology*. They were presented with the findings of a comparative drug test, and asked which of the two drugs they would recommend for a patient. More than 90 percent of subjects presented with statistically significant drug test findings ($p < 0.05$) recommended the less effective drug, while fewer than half of those who were presented with results that were not statistically significant did so (McShane and Gal 2015).

Testing of statistical significance harms progress in science. In one study, researchers applied significance tests and claimed that they showed that two previous findings about forecasting principles had been found to be incorrect. The previous findings had been based on experiments. One claim of the debunkers was that combining forecasts was not effective in reducing accuracy. Those who do research on forecasting continue to regard combining as the most effective single method for improving forecast accuracy.

Historically, cheating has been rare in science. That said, some scientists have cheated, including famous scientists (Broad and Wade, 1982). In the past few decades, it seems that advocacy research and irrelevant criteria for evaluating researchers have increased the rate of cheating.

In particular, the pressure to obtain statistically significant findings leads researchers to practices that violate objectivity. A survey of management faculty found that 92 percent claimed to know of researchers who, within the previous year, had developed hypotheses *after* they analyzed the data (Bedeian, Taylor, and Miller’s 2010). In addition, a survey of over 2,000 psychologists, 35 percent of the respondents admitted to “reporting an unexpected finding as having been predicted from the start.” Further, 43 percent had decided to “exclude data after looking at the impact of doing so on the results” (John, Lowenstein, and Prelec, 2012.)

Another indication of cheating is that the rate of journal retractions in medical research was around one in 10,000 from the 1970s to the year 2000, and some of those retractions were due to cheating. The rate grew by a factor of 20 from the year 2000 to 2011. In addition, presumably due to the pressures to publish in those journals, papers in higher ranked journals were more likely to overestimate effect size and more likely to be found to be fraudulent (Brembs, et al. 2013).

In practice, support for a preferred hypothesis—in the form of a statistically significant difference from a senseless null hypothesis, such as the sales of a product is not affected by its price, is easily obtained by researchers who are only concerned with the requirement to publish. The practice has been used increasingly since the 1960s; in more recent times it has been referred to as “p-hacking.” For example, advocates have been able to analyze non-experimental data to support their hypothesis that competitor-oriented objectives—such as market share—lead to higher profits. In contrast, analyses of experimental studies have shown that market share objectives are detrimental to the profitability and survival of firms (Armstrong and Collopy, 1996; and Armstrong and Green, 2007). Similarly, analyses of non-experimental data by economists have supported the hypothesis that high payments for top corporate executives are beneficial to stockholders whereas experimental studies by organizational behavior researchers concludes that CEOs are currently overpaid such that stockholders’ interests are harmed (Jacquart and Armstrong, 2013).

The lack of specific objectives to produce useful scientific findings is perhaps the primary cause for the small percentage of such studies. Armstrong and Hubbard (1991) conducted a survey of editors of American Psychological Association (APA) journals that asked: “To the best of your memory, during the last two years of your tenure as editor of an APA journal, did your journal publish one or more papers that were considered to be both controversial and empirical? (That is, papers that presented empirical evidence contradicting the prevailing wisdom.)” Sixteen of the 20 editors replied: seven could recall none, four said there was one, while three said there was at least one and two said they published several such papers.

To assess the usefulness of academic research on consumer behavior, one study used 20 empirical papers from the *Journal of Consumer Research (JCR)*. Each paper described how the researchers’ hypotheses were based on their reviews of prior research. All of their favored hypotheses were supported by statistically significant findings. Descriptions of a sample of hypotheses from the 20 studies were presented to 16 academics randomly sampled from the membership of the Association for Consumer Research, 12 marketing practitioners, and 43 high-school students. In all, they made 1,736 directional predictions about the studies’ findings on 105 hypotheses. Given that the hypotheses were said to be based on prior cumulative knowledge, the academics should have had an advantage over the practitioners and students. Contrary to that expectation, the academics were correct on only 51 percent of their predictions while the students were correct on 57 percent, and the practitioners were on 58 percent. That finding failed to support the hypothesis that the JCR papers contributed to useful knowledge about consumer behavior. (Armstrong 1991.)

Given the above problems, with invalid criteria, Hubbard’s (2016) meta-analysis of 804 replication outcomes in 16 studies in seven areas of management science (pp. 140-141) found that the authors of the replications reported conflicts with the original study for 46 percent of the replications. The Open Science Collaboration (OSC 2015) study of 100 direct replications claimed that 36 percent of replication attempts failed. Even allowing for the fact that many of the replications were identified as failed by the researchers due to their inappropriate use of statistical significance as a criterion, the findings on reliability raise concerns.

On the Value of Checklists

Checklists are used in many fields to help ensure that the proper procedures are used. In the fields of engineering, aeronautics, and medicine, failures to follow checklists of evidence-based guidelines can be used in court cases to assign blame for bad outcomes.

Checklists are based on the method of decomposition, whereby a complex problem is analyzed in parts that can be solved more easily than the whole. Macgregor’s (2001) review provides experimental evidence on the usefulness of judgmental decomposition. In three experiments on job selection and college selection, decomposition improved judgments compared to holistic ratings (Arkes et al., 2010). An experiment to determine which research proposals should be funded by the National Institutes of Health found decomposed ratings were more reliable than holistic ratings (Arkes, Shaffer, and Dawes, 2006).

A review of 15 experimental studies in healthcare found that checklists led to substantial improvements in outcomes in all ([Hales and Pronovost 2006](#)). For example, one experiment examined the application of a 19-item checklist for surgical procedures to thousands of patients in eight hospitals around the world. Use of the checklist reduced death rates at those hospitals by half ([Haynes et al. 2009](#)).

Checklists can help even when the users are aware of proper procedures. For example, an experiment on avoiding infection in the intensive care units of 103 Michigan hospitals required physicians to follow five well-known guidelines for inserting catheters. Following this simple checklist reduced infection rates from 2.7 per 1,000 patients to zero after three months.

Checklists are expected to be most effective when experts know little about the relevant evidence-based principles. Advertising novices were asked to use a checklist with 195 evidence-based persuasion principles to rate each of 96 pairs of ads. By using the checklist, they made 44 percent fewer errors in predicting which ad was more effective than did unaided novices (Armstrong et. al, 2016).

Checklists can be harmful if the guidelines lack a basis in evidence or logic and thereby lead users to follow invalid guidelines more consistently. For example, Porter's (1980) five forces framework was based on opinions. Another example is the Boston Consulting Group's (BCG) matrix for portfolio planning: experiments by (1994) showed it to be invalid and harmful (Armstrong and Brodie 1994). Despite the lack of evidence on their predictive validity, those checklists continue to be widely taught in business schools and widely used in business.

Operational Guidelines for Scientists

We were unable to find a comprehensive evidence-based checklist of operational guidelines for conducting useful scientific research. We found helpful advice in the Operations Research Society of America report, "Guidelines by the Ad Hoc Committee on Professional Standards" (1971), and the CONSORT 2010 checklist (Schulz, Altman, and Moher, 2010, and Moher et al., 2010). As far as we were able to determine, those guidelines were the product of a consensus of expert opinions, and few of the guidelines were expressed in specific operational terms. They were, nevertheless, useful in helping to formulate our operational guidelines.

The primary bases for our guidelines were the established definitions of science that we described earlier. Most of them followed logically from the definitions. To assess whether there is a need for such guidelines, we searched the literature for evidence on the extent to which papers in academic journals currently conform to each of the guidelines. When violations were common, we developed guidelines for complying with scientific principles.

While we searched the Internet, our primary sources were references from key books and articles. For example, Hubbard (2016) provided a review of 900 studies, many of which deal with non-compliance with science in published research. Nosek and Bar-Anan (2012) and Nosek, Spies and Motyl (2012) provided reviews that, between them, covered 250 publications. Munafò, *et al.* (2017) provided 85 references, of which 71 were published since 2006; the paper also noted that over 2,000 such papers are published each year now. In addition, the first author has published dozens of papers on research practice since the early-1970s, many of them involving research reviews.

To ensure accuracy in our summaries of prior research, we are contacting all researchers whose substantive findings we cite asking whether our summary is correct and whether it can be improved. We also ask what papers we might have overlooked, stressing that we are looking for evidence that would challenge our findings. At the time of writing, this survey is still ongoing.

Exhibit 1 presents the checklist of 24 guidelines for scientists that we developed. We describe the guidelines under the six headings shown in Exhibit 1: Selecting a problem, Designing a study, Collecting data, Analyzing data, Writing a scientific paper, and Disseminating the findings.

Selecting a Problem

Research will only lead to useful findings when the topic of the research is important. An important problem is one for which new knowledge could substantively improve forecasting or decision-making, develop or improve useful techniques, identify and estimate the magnitude of causal relationships, or develop principles.

Exhibit 1: Guidelines for Scientists

Selecting a problem

1. Seek an important problem
2. Be skeptical about findings, theories, policies, methods, data, especially absent experimental evidence
3. Consider replications and extensions of useful papers that examine experimental evidence
4. Ensure that you can address the problem objectively
5. If you need funding, ensure that you will nevertheless have control over all aspects of your study

Designing a study

6. Acquire existing knowledge about the problem
7. Develop multiple reasonable hypotheses
8. Design experiments with specified conditions to test hypotheses against data from other situations

Collecting data

9. Obtain all valid data
10. Ensure that the data are reliable

Analyzing data

11. Use validated methods
12. Use simple methods
13. Use methods that incorporate cumulative knowledge
14. Estimate effect sizes and confidence
15. Draw logical conclusions on the practical implications of findings from the tests of hypotheses

Writing a scientific paper

16. Disclose research hypotheses, procedures, and data
17. Cite all relevant scientific papers when presenting evidence
18. Ensure summaries of prior findings that you cite are correct
19. Explain why your findings are useful
20. Write clearly and succinctly for the audience for whom the findings might be useful
21. Obtain extensive peer review and editing *before* submitting a paper for publication

Disseminating the findings

22. Provide thorough responses to journal reviewers, and challenge if your paper has useful findings
23. Consider alternative ways to publish your findings
24. Inform those who can use your findings

J. Scott Armstrong and Kesten C. Green, January 19, 2017

1. Seek an important problem

Creativity is essential for identifying important problems. There is much evidence that working in groups depresses creativity and productivity, especially if the group meets face-to-face (Armstrong, 2006). Thus, there is little reason to believe that committees of officials in governments, corporations, or foundations can identify problems that would lead to useful scientific findings.

Researchers should work on their own to find important problems. Make a list of problems that affect people in important ways. Show the list to people who face the problems that you propose to study. Would they regard findings that might arise from the research as useful? The question is not whether the findings would be interesting, clever, or entertaining.

It helps if researchers work in an organization that has important and obvious problems that need to be solved. Gordon and Marquis (1966), in their analysis of 245 research projects, found that academic researchers in social science departments produced less innovative research than those in organizations closer to important problems, such as hospitals.

The way a problem is described can limit the search for solutions. To avoid that, state the problem in different ways, a technique known as “problem storming.” Then search for solutions for each statement of the problem. For example, politicians who are concerned that higher education is not effective usually state the problem as “how can we improve teaching?” An alternative statement is, “how can we improve learning?” The latter approach yields recommendations that are different from those of the first, as was shown in Armstrong (2012a).

One way to present your problem statement is to write a press release that describes possible findings from your study. Show it to people who might benefit and ask them how they could use the findings.

Hal Arkes, who has a history of important discoveries in the management sciences, uses his “Aunt Mary test.” At Thanksgiving each year, his Aunt Mary would ask him to tell her about his important new research. When Aunt Mary was skeptical about a research idea, he said, “I didn't always abandon it, but I always reevaluated it, usually resulting in some kind of modification of the idea to make it simpler or more practical” (Arkes, personal communication, 2016).

2. *Be skeptical about findings, theories, policies, methods, and data, especially absent experimental evidence*

“I would rather have questions that can't be answered than answers that can't be questioned.” Attributed to Richard Feynman

Skepticism drives progress in science. Unfortunately, researchers have the normal human, preference for associating with those who have similar beliefs. That tendency has grown over the past half century, such that political conservatives—in the U.S. sense of the term—have become rare in social science departments at leading U.S. universities (Duarte *et al.*, 2015, and Langbert, Quain, and Klein 2016). The near uniformity of political beliefs on campus threatens scientific skepticism toward fashionable beliefs.

Research is more likely to be useful if it addresses problems that have been the subject of few, if any, *experimental* studies. There seems to us to be many important problems lacking experimental evidence. For example, does game theory improve the accuracy of forecasts of decisions made in conflict situations? We were unable to find any scientific support for the claim by game theory proponents. Our experiments found that game theorists' forecasts of decisions in conflicts were no more accurate than unaided guesses by naïve subjects. In addition, the methods of structured analogies and simulated interaction provided forecasts that were much more accurate than those from game theory (Green, 2002 and 2005, and Green and Armstrong, 2007 and 2011).

Ignaz Semmelweis's experiments provide a classic example of a researcher taking a skeptical approach to then current beliefs and practices—which had not previously been tested—and making a life-saving discovery as a result. He found that when doctors washed their hands after dissecting cadavers and before visiting the maternity ward, deaths among expectant mothers fell from 14 percent in 1846 to 1.3 percent in 1848 (Routh, 1849).

3. *Consider replications and extensions of useful papers that examine experimental evidence*

Replications—direct replications and extensions—of scientific studies that influence policies and decisions are important regardless of whether they support or conflict with the original study. Replications of useless studies, are of no value; nor are replications of non-scientific studies, such as advocacy studies.

Direct replications are helpful when there are reasons to be suspicious about findings relating to an important problem, such as with claims of “cold fusion.” Otherwise, extensions are more important as they can provide evidence about the conditions under which the findings apply.

Unfortunately, replications are often difficult to conduct due to a lack of sufficient disclosure in published papers and uncooperative authors (Hubbard, 2016, p.149; Iqbal et al., 2016). In addition, a replication that fails to support the original findings might not be welcomed by editors and reviewers at the journal that published the original paper (Hubbard, 2016, section 5.5.8). There is, however, reason for optimism as some journals have recently adopted policies encouraging replications, and some have published special issues of replications. Further, if you are engaged in an important and well-designed study, consider doing an extension of your study.

For an example of how replications can help, consider Iyengar and Lepper’s (2000) study. When shoppers were offered a choice of 24 jams, fewer than 3 percent made a purchase, whereas when offered a choice of six jams, 30 percent purchased. They concluded that customers should not be offered too many choices. An attempt to replicate the jam study failed, and a meta-analysis of 50 related empirical studies failed to find the “too-many-choices” effect (Scheibehenne, Greifeneder, and Todd, 2010). Extension studies have revealed that the number of choices that consumers prefer is affected by various conditions (Armstrong, 2010, pp. 35-39).

Another important replication tested Hirschman’s (1967) influential “hiding hand” study of 11 public works projects financed by the World Bank. Hirschman concluded that while planners underestimated costs, they underestimated benefits as well, so that public-works projects were beneficial. Flyvbjerg (2016) replicated Hirschman’s research by analyzing 2,062 projects involving eight types of infrastructure in 104 countries during the period 1927 to 2013. On average, costs overran by 39 percent and forecast benefits were 10 percent greater than actual.

4. Ensure that you can address the problem objectively

Once you have a list of important problems, choose those that you could address without bias. Aversion to disconfirming evidence is a common human trait. It was shown in Festinger, Riecken, and Schacter’s (1956) research about a cult that predicted the end of the world. When it did not end, cult members became more confident in their belief that they could predict the end of the world. In a related experiment, when subjects who believed that Jesus Christ was God were given *what they believed to be authentic evidence* that he was not God, they increased their belief that Christ was God; That is, stronger disconfirming evidence increased resistance to change (Batson, 1975).

It does little good to *try* to be as objective as possible. Instead, list reasons why your preferred hypothesis might be wrong. Laboratory experiments by Koriat, Lichtenstein and Fischhoff (1980), and Lord, Lepper and Preston (1984) found that approach led to a more realistic view of subjects’ confidence that a proposition was correct. Then list alternative hypotheses that others would consider reasonable. If you cannot think of information that would defeat your preferred hypothesis, work on a different problem.

5. If you need funding, ensure that you will nevertheless have control over all aspects of your study

Researchers should take responsibility for all aspects of their research. That includes ensuring that the study is important, free of bias, truthful, cost effective, and that it poses little harm to subjects. In cases where harm might occur, researchers should take steps to protect subjects. See Milgram’s (1974) Appendix 1 for the steps he took to ensure ethical treatment in his blind obedience studies at a time when there were no government regulations for the treatment of research subjects.

Scientists who need funding and who prefer to have full control of their research might consider working for organizations that are not covered by the various government review boards. That would include employment in a university that does not accept government funding, private foundations, or in countries where the government does not try to control scientists’ research.

Some universities and departments, such as ours, provide faculty members with research budgets to be allocated as they see fit. That arrangement reduces the pressure to obtain findings that please a funder. If you require external funding to complete the research, explain to potential funders that you must retain responsibility for the design of the research, and accept funding only if you have the final say. Failure to do so could lead to ethical breaches as was explicitly shown by the obedience to authority studies, begun by Milgram (1969), in which some subjects (acting in the role of “experimenters”) believed that they were killing “subjects” when the responsibility for was in the hands of a higher authority. Subjects acted in ways they would not have had they regarded themselves as being personally responsible for ethical treatment. This study was extended by many researchers (see Armstrong 1977 for a review and an application to an actual corporate decision).

Designing a Study

The next three guidelines describe how to design experiments to ensure objectivity.

6. *Acquire existing knowledge about the problem*

“If I have seen further, it is by standing on the shoulders of giants.” Isaac Newton

To contribute to useful scientific knowledge, researchers must first become knowledgeable about what is already known; a process sometimes referred to as *a priori* analysis. To help objectivity, we suggest the use of meta-analysis, the primary rules being that the search procedures should be established before doing the search, all papers that a skeptic would consider should be included in the search, and only studies that comply with scientific principles should be included in the analysis. Avoid studies that rely on non-experimental data. Thus, we suggest that the search should include the term “experiment.”

Beamon (1991) showed that meta-analyses are more valid and objective than traditional (narrative) reviews. The relatively unstructured nature of traditional reviews allows researchers to obtain support for their preferred hypotheses by including advocacy studies, avoiding disconfirming evidence, and incorrectly summarizing findings.

Advocacy research is especially a problem in the policy sciences. For example, Gigerenzer (2015) found that the literature referred to by those urging governments to “nudge” citizens to adopt preferred behaviors—such as requiring people to actively opt out of an alternative that the government has chosen for them—overlooked an extensive body of evidence that conflicts with the recommendation that *governments* nudge citizens.

Consider the case of research on the minimum wage: For centuries, people have observed that buyers prefer a lower price to a higher one, all else being equal. A meta-analysis of price elasticities for 1,851 products and services from 81 studies, found an average price elasticity across studies of -2.62, with a range from -0.25 to -9.5 (Bijmolt *et al.* 2005, Table 1). Contrast that with the review by Doucouliagos and Stanley (2009, p. 412) from which they concluded that the price elasticity for low-priced labor services was -0.2 from 1, 474 elasticity estimates.

In recent years, researchers have turned to Internet searches to find prior knowledge. Given the enormous pool of academic works available online, it is common to find many that *seem* promising. In our many reviews, however, we have found this to be expensive because, of the papers that seem promising, few provide useful evidence. Moreover, many relevant papers are overlooked. For example, a search for studies on forecasting methods found that the Social Science Citation Index identified only one-sixth of the papers cited (Armstrong and Pagell 2003).

The most effective way to find relevant publications is to ask leading scientists in the area of investigation to suggest relevant experimental papers. Use the citations in those papers to find

additional papers, and so on, a process referred to as snowballing. Additional suggestions on doing meta-analysis are provided in Ones, Viswesvaran, and Schmidt (2017)..

The availability of inexpensive regression analysis software and of “big data” has led researchers to ignore cumulative knowledge on causal relationships, and instead choose variables on the basis of statistically significant correlations in the data. Armstrong (1970) showed how easy it is to get statistically significant findings from random numbers by using stepwise regression with standard search rules. The review in Armstrong (2012b) concludes that variables should *not* be selected on that basis. A review of empirical papers published in the *American Economic Review* in the 1980s found, unfortunately, that 32 percent used statistical significance tests to select causal variables. By the 1990s, the situation was worse, as the proportion had increased to 74 percent (Ziliak and McCloskey 2004).

7. *Develop multiple reasonable hypotheses*

In 1620, Francis Bacon advised researchers to consider “*any contrary hypotheses that may be imagined.*” In 1890, Chamberlin observed that the fields of science that made the most progress were those that tested all reasonable hypotheses. Platt (1964) argued for more attention to Chamberlain’s conclusions.

A review of natural experiments supports Chamberlin’s conclusions about the importance of multiple hypotheses. For example, agriculture showed little progress for centuries. That changed in the early 1700s, when English landowners began to conduct experiments to compare the effects of alternative ways of growing crops (Kealey 1996, pp. 47-89).

Ask others to suggest alternative hypotheses relevant to your problem. Seek out people who have ideas and knowledge that differs from yours. Horwitz and Horwitz (2007) in their meta-analysis found that *task related diversity* improves the number and quality of solutions. On the other hand, they found that bio-demographic diversity had small detrimental effects.

Investigate which hypothesis provides the most cost-effective solution. If you pick an important problem, any scientific finding from tests of alternative reasonable hypotheses will be useful and deserves to be published.

An audit of 120 empirical papers published in *Management Science* from 1955 to 1976 found that only 22 percent used the method of multiple reasonable hypotheses (Armstrong, 1979).

A survey of marketing scientists concluded that the method of multiple competing hypotheses was superior to advocacy and exploratory studies. However, an audit of 1,700 empirical papers published in the period 1984 to 1999 in six leading marketing journals found that only 13 percent used multiple competing hypotheses. Of those that did, only 11 percent included conditions. Thus, only one or two percent of the papers published in leading marketing journals complied with these two aspects of the scientific method. Moreover, in some of these studies, the hypotheses did not encompass all reasonable hypotheses, and some violated other scientific principles. Finally, some failed to address important problems. Because of the violations, we expect that the percentage of useful scientific studies was a small fraction of one percent of the papers published (Armstrong, Brodie, and Parsons 2001).

8. *Design experiments with specified conditions to test hypotheses against data from other situations*

Experiments provide the only valid way to gain knowledge about causal factors. Non-experimental data is akin to using data from a poorly designed experiment. There is no way to recover valid data from a badly designed experiment. For example, non-experimental research suggests that pre-announced consumer satisfaction surveys improve consumers’ satisfaction. In contrast, a series of well-designed experiments by Ofir and Simonson (2001) showed that such surveys harm customer satisfaction. In education, they harm satisfaction *and* reduce learning (Armstrong, 2012a).

Predictive validity is the strongest test when comparing different hypotheses. It requires that the accuracy of predictions from the alternative hypotheses be compared using out-of-sample data.

Experiments can take the form of laboratory or field studies. The latter may be either controlled or natural. While laboratory experiments allow for good control over the conditions, field experiments are more realistic. A comparison of findings from laboratory and field experiments in 14 areas of organizational behavior concluded that the findings were similar Locke (1986). Both are useful.

Natural experiments are strong on validity, but weak on reliability. Researchers should assess the outcomes of natural experiments with skepticism. Is the outcome of a natural experiment consistent with prior evidence? Is it due to factors unrelated to those generally assumed to be important? Consider the following example. There is debate about which is more important to one's health: life style or health care. When Russia abruptly ended its support of Cuba's economy, an economic crisis began in 1989 and lasted until 2000. There was less money for health care, food, transportation, and so on. People had to leave their desk jobs to work in the fields to grow food. An analysis of the effects on health compared national statistics from 1980 through 2005. Food intake in calories decreased by 36%. The percentage of physically active adults increased from 30% to 67%. Obesity decreased from 14% to 7%. By 1997-2002, deaths due to diabetes dropped by half and those due to heart disease by one-third (Franco, et al 2007).

Other examples are provided by Winston's (1993) analyses of natural experiments on the effects of regulations of businesses. The conclusion from natural experiments is that such regulation harms producers and consumers. In another study, Armstrong and Green (2013) found that government programs to encourage "corporate social responsibility" were harmful to the general welfare.

Quasi-experiments are characterized by control over most, but not all, key variables. Armstrong and Patnaik (2009) examined the directional consistency of the effects of conformance with persuasion principles estimated from quasi-experimental data when compared with estimates from controlled experiments. The number of quasi-experimental studies that related to each principle ranged from 6 to 118, with an average of 31. The directional effects from quasi-experimental analyses were consistent with those from field experiments for all seven principles for which such comparisons were possible, as well as for all 26 principles when comparisons with laboratory experiments were available and with the directional effects from meta-analyses for seven principles. In contrast, directional findings from *non*-experimental analyses of the persuasion principles were consistent for only two-thirds of the experimental findings.

Specify the conditions for each experiment. For example, experiments have shown that two-sided arguments are effective for persuasion under some conditions, but not others.

Collecting Data

Scientists should ensure that their data are valid and reliable. They should describe any problems with the data. Furthermore, they should use all data that have been shown to be valid and reliable, and *nothing more*. We stress "nothing more" because with the increasing power of computers, analysts have, unfortunately, been turning to data mining with "big data," which is typically non-experimental in nature and includes many irrelevant variables.

9. Obtain all valid data

Validity is the extent to which the data measure the concept that they purport to measure. Many economic disputes arise due to differences in how to measure concepts. For example, what is the best way to measure "economic inequality"?

Explain how you searched for and obtained data, and why you chose the data that you used. Include all relevant data in your analysis and explain the strengths and weaknesses of each. When there is more than one set of valid data, use them all. This will help to control for biases.

Morgenstern's (1963) book on economic data showed that individual data sets suffer from many shortcomings. There is seldom one best data set, and all are biased in one way or another. For example, data on exports from country A to country B often differ sharply from country B's data on imports from country A. One solution is to obtain all valid data sets for a given problem, and then combine the data by calculating the average.

10. *Ensure that the data are reliable*

Given valid data, the next issue is how to ensure that the data are reliable: Do repeated measures produce the same results? For example, if the measure is based on expert judgments, are the judgments similar across judges and across time? Have the measuring instruments changed over time? Are the measurement instruments in good working order? Have any unexplained revisions been made in the data? Measurement issues have led to substantial differences among researchers on the issue of climate change, as described by Ball (2014).

Analyzing Data

Scientists are responsible for ensuring that they know and use proper methods for analyzing their data. Describe the procedures you will use to analyze the data before you start your analysis, and record any changes in the data or procedures as the project develops.

11. *Use multiple validated methods*

Scientists are responsible for providing evidence that their methods have been validated for the purpose for which they have been used—unless their validity is obvious. Analyze by using alternative methods as another way to control for bias.

Many studies are nevertheless published without evidence on the validity of the methods used by the researchers. For example, the statistical fit of a model to a set of data—a commonly used test—is not valid. One study compared the fit and out-of-sample predictions of 21 models. They found *negative* rank order correlations between model fit and the accuracy of predictions from the models: $r = -.11$ for one-period and $r = -.08$ for six-periods ahead (Pant and Starbuck 1990). Five other comparative studies reached the same conclusion (Armstrong 2000).

Data mining, a technique that generally ignores prior evidence, relies on tests of statistical significance, and includes irrelevant variables. The technique has been gaining adherents over recent decades. The first author of Keogh and Kasetty's (2003) review of research on data mining stated in personal correspondence to us recently that, "although I read every paper on time-series data mining, I have never seen a paper that convinced me that they were doing anything better than random guessing for prediction. Maybe there is such a paper out there, but I doubt it."

There is usually no one best method. The solution is to combine findings from two or more valid methods. The benefits of combining have been known for well over a century and researchers have shown much interest in testing the predictive validity of combining versus other evidence-based forecasting methods: Combining forecasts *guarantees* that the combined forecast across valid methods will never be the least accurate method and that it will be at least as accurate as 1 as the typical forecast. In addition, it is always more accurate than the typical component when they bracket the true value. Finally, it is often more accurate than the best component. Even if one knew beforehand which method would be best, it is safer to use a combined forecast.

Combining should be done *within* methods—e.g., averaging the vote predictions of several independent experts—and then combining with the combined forecasts from other methods—such as polls, econometric models, and expert judgments. In a study on predictive validity in six

U. S. presidential elections, combining across four methods yielded error reductions of between 16% and 59% compared to the average errors of the individual forecasts (Graefe *et al.*, 2014).

Combining should always be used if there are two or more methods that are valid for the problem. Unfortunately, the benefits of combining are counter intuitive—it seems reasonable that there must be a best method and that it should be known—so the method is seldom used in forecasting or in testing forecast validity in practice (Larrick and Soll, 2006).

12. Use simple methods

“There is, perhaps, no beguilement more insidious and dangerous than an elaborate and elegant mathematical process built upon unfortified premises.”
Chamberlin (1899, p. 890)

The call for simplicity in science goes back at least to Aristotle, but the 14th century formulation, Occam’s razor, is more familiar (Charlesworth, 1956). The use of complex methods reduces the ability of potential users and other researchers to understand what was done and therefore to detect mistakes and assess uncertainty.

The value of simplicity was examined by searching for published forecasting experiments that compared the out-of-sample accuracy of forecasts for simple versus complex methods. That paper defined a simple method as one about which forecast users understand the (1) procedures, (2) representation of prior knowledge in models, (3) relationships among the model elements, and (4) relationships among models, forecasts, and decisions. Simplicity improved forecast accuracy in all 32 papers encompassing 97 comparisons; on average, it decreased forecast errors by 21 percent for the 25 papers that provided quantitative comparisons. (Green and Armstrong 2015.)

Extensive comparative studies have shown the superior predictive validity of simple methods for out-of-sample tests in many different areas (see Gigerenzer, Todd and the ABC Research Group, 1999).

13. Use methods that incorporate cumulative knowledge

Prior knowledge can be used to identify causal variables and the directions of their effects, and in some cases, to estimate the likely ranges of effect sizes. Two ways to incorporate prior knowledge on causal variables into a model of the problem being studied are to specify an index model, or to decompose the problem into segments based on causal forces.

The index method was inspired by an approach to decision-making that Benjamin Franklin used. It involves identifying all of the important evidence-based—or logically obvious—causal variables, then examining which hypothesis does best on each variable, and then summing across variables to determine which hypothesis is superior. Equal weights have been found to be more accurate than regression weights for out-of-sample predictive accuracy in a number of studies (Armstrong, Du, Green, and Graefe 2016). The gains in out-of-sample predictive validity of the index method are greatest when all important variables are included, which is often far more variables than can be included in a regression model.

Segmentation models can be developed by decomposing the data on the basis of causal priorities. For example, rental demand could be analyzed segmenting the population on the basis of age, occupation, income, household composition, recency of arrival, etc. Differing causal effects can then be accounted for in each segment. The approach makes effective use of enormous samples and it avoids problems with inter-correlations and interactions (Armstrong, 1985, Chapter 9).

14. Estimate effect sizes and confidence intervals

When considering policy changes, researchers should estimate the size of the effects in causal relationships. An audit of empirical papers published in the *American Economic Review* in the

1980s found that only 30 percent of papers examined effect sizes, and that decreased to 21 percent in the 1990s. (Ziliak and McCloskey (2008, Chapter 7.)

Given good knowledge of the causal variables and their expected direction of effects, regression analysis can be used to estimate effect sizes. However, one should test the estimated effect sizes against the use of equal weights for out-of-sample predictions. In other words, it is commonly found that the most important things in using econometric methods for forecasting are to know what variables are important and the direction of their effects. When confidence intervals are needed, use the variability in the accuracy of forecasts from each hypothesis based on out-of-sample data.

15. Draw logical conclusions on the practical implications of findings from the tests of the hypotheses

The conclusions should follow logically from the evidence provided by your findings. For problems that involve strong emotions, consider rewriting your conclusions using symbols in order to check the logic without emotion. For example, following Beardsley (1950, pp. 374-375), the argument “if P, then Q. Not P, therefore not Q” is easily recognized as a logical fallacy—“denying the antecedent”—but it is hard to recognize when emotional terms are used instead of letters.

Writing a Scientific Paper

Document your prior knowledge and hypotheses by keeping electronic copies of your drafts. They should provide a record of how your hypotheses changed, such as by discoveries in new or overlooked research. Cite relevant scientific findings and check that your summaries are correct. Explain clearly why your findings are useful to those who might find them useful. Finally, obtain extensive peer review before submitting for publication.

16. Disclose research hypotheses, procedures, and data

A review of publication practices in medical journals found that many papers failed to provide full disclosure of the method and data (Iqbal et al.’s 2016). The problem of incomplete disclosure is also common in applied economics and the social sciences (Hubbard, 2016, pp.147-153). Journals should require full disclosure as a condition for publication as a scientific paper.

Describe how you searched for cumulative knowledge, designed your experiment—e.g., how you ensured that you tested alternative hypotheses that others might consider reasonable—analyzed the findings using validated methods, and so on. Describe the steps taken to find evidence that might conflict with your preferred hypothesis. Address issues that might cause concern to a reader, such as steps to ensure that no subjects would be harmed.

Researchers are responsible for deciding what to report. They best understand what information should be included in a paper for publication, and what should not. They should not include information that would be useless, harmful, confusing or misleading. For example, the insistence by some journals on mandatory disclosure of all sources of funding—while presumably intended to improve the reporting of science—is expected to be harmful in practice. A review of experimental studies on mandatory disclosures, found that mandatory disclosures in all areas for which they were able to find evidence confused the people they are intended to benefit and harmed their decision-making. (Ben-Shahar and Schneider 2014.)

Consider a scientist who needs funding to run experiments to assess the net benefit of a government policy. Donors might be willing to help, but not if doing so would lead to them being subject to censure, regulation, boycotts of their businesses, attacks on their websites, and demands for the prosecution of the scientists by politicians and interest groups.

Science has an effective alternative to mandatory disclosures. If a readers are skeptical of a study’s findings for whatever reasons, they can conduct direct replications. If the scientists

responsible for the original study fail to provide the necessary materials, report that as a failure to follow proper scientific procedure. Do not, however, publically accuse them of unethical behavior, because an omission could be due to an unintended error or to a misunderstanding on your part, and it might lead to a libel case against you, as described in Armstrong (1986).

The submission letter to a journal or your paper should include an “oath” that you have followed proper scientific methods. When people are mindful of their own standards, they try to live up to them (see Armstrong (2010, pp. 89-94 for evidence). For example, experimental subjects were paid according to the number of correct answers on a task involving a series of puzzles. In one task, subjects had an opportunity to falsify their report on how many puzzles they solved. Most of those in the control groups cheated, but of the subjects who had been asked to write as many of the Ten Commandments as they could just before taking the test, none cheated (Mazar, Amir, and Ariely 2008).

In practice, hypotheses are often developed *after* analyzing the data. Again, science provides a solution—keep a log to track important changes in your hypotheses or procedures. Doing so may also resolve disputes as to who made a discovery. For example, Alexander Graham Bell’s log for his telephone experiments had a two-week gap. The log picked up with a proposal for a new approach that was almost identical to an application to the U.S. patent office by another inventor on the same day. The inventor who had applied for the patent sued, but the courts concluded there was not sufficient evidence to convict Bell of stealing the patent. Shulman (2008) discovered the missing pages from Bell’s log, and concluded that Bell had stolen it.

17. Cite all relevant scientific papers when presenting evidence

Citations in scientific papers imply evidence. Give readers an indication of what scientific evidence they would find in the cited work. Avoid mysterious citations.

Do not cite advocacy research *as scientific evidence*. Kabat (2008) concluded that the use of the advocacy method in studies on health risks is harmful to science as such studies find many false relationships and thereby mislead researchers, doctors, patients, and the public.

If a cited paper provides only opinions, make that clear to readers. Limit the space given to opinions. By doing so, you will be able to shorten your paper, save time for readers, and add force to your findings.

18. Ensure summaries of prior findings that you cite are correct

Assure the reader that you have properly summarized prior research. For starters, include a statement in your paper verifying that at least one author has read each of the original works cited.

Harzing (2002) provided 12 guidelines for referencing papers that few researchers would disagree with. They are: reproduce the correct reference, refer to the correct publication, do not use “empty references” (i.e., those that contain no evidence), use reliable sources, use generalizable sources for generalized statements, do not misrepresent the content of the reference, make clear which references support which conclusions, do not copy someone else’s references, do not cite out-of-date references, do not be impressed by top journals, do not try to reconcile conflicting evidence, and actively search for counter-evidence. Harzing’s analysis in one research area found that many of these guidelines were ignored.

Authors often make mistakes in referencing and provide incorrect summaries of other researchers’ findings. An audit of three medical journals found that 48 percent of the references contained errors. The study concluded that, “a detailed analysis of quotation errors raises doubts in many cases that the original reference was read by the authors” (Evans, Nadjari, and Burchell 1990).

An audit of papers in public health found that authors’ descriptions of cited studies differed from the original authors’ interpretations for 30 percent of the papers. Half of those descriptions were unrelated to the authors’ contentions (Eichorn and Yankauer, 1987).

Ninety-eight percent of a sample of 50 papers citing Armstrong and Overton (1977) did so incorrectly. Only one of the thousands of researchers who cited that paper asked the authors if they had used the paper's findings correctly. (Wright and Armstrong 2008.)

Contact authors of papers that you cite in a substantive way. Send them your paper and ask if you have described their findings correctly, if your citation and reference are correct, and whether you have overlooked any relevant papers in their area. We have been following this practice for many years. Many researchers reply with important corrections or suggestions for improvements, and with references for relevant studies. They often thank us for checking with them. This process has reduced our mistakes, added clarity, and reduced omissions of key studies.

19. Explain why your findings are useful

Authors must convince readers that their findings are a useful addition to existing knowledge. In other words, your paper should answer the "so what?" question.

Use descriptive titles, rather than clever, complex, or mysterious ones. Most importantly, provide a structured abstract that describes the findings, how they were obtained, and how they can be used to improve understanding of causal factors, prediction, decision-making, policy, or methods and procedures, compared with what was already known. Report the relative effect sizes of the hypotheses in tables. The conclusions section should highlight key findings and how they can be used.

An examination of 69 papers in the *International Journal of Forecasting* and 68 in the *Journal of Forecasting*, found that only 13 percent mentioned findings in the abstract. That occurred even though the journals' instructions to authors specified that findings should be included (Armstrong and Pagell 2003).

For a scientific finding to be useful, the problem must be important (see Guideline 1). Some problems jump off the page as being important, such as Milgram's question on whether people might act irresponsibly if an authority takes responsibility from an individual. We think there are many problems that are important such as "Is there any scientific evidence that government regulations in any area have provided better long-term outcomes than a free market?" or "What level of top executive compensation would maximize a firm's long-term profitability?"

The usefulness of findings also depends on the size of the effect. For example, Milgram's (1969) obedience experiments provided evidence that the size of the obedience to authority effect is large. Knowing the effect size means that evidence-based cost-benefit analyses are possible.

Surprise is another way to demonstrate usefulness. Show the design of your experiment to people who make decisions that might be affected by your findings and ask them to predict the findings. If their predictions are wrong, the findings are more likely to be useful. Do the same with researchers in the field. However, do not ask them if they are surprised *after* the findings have been presented: Three experiments by showed that researchers seldom express surprise, no matter what the findings (Slovic and Fischhoff (1977)).

If you cannot show that the paper is useful, do not publish it. When the first author started his career, his first submission involved sophisticated statistical analyses of a large data set. It was accepted by the leading journal in the field. However, in the time from submission to acceptance, he became skeptical that the analyses, while technically correct, were of any use. As a result, he withdrew his name from the paper. The paper was published and it was of no apparent value.

20. Write clearly and succinctly for the widest audience for whom the findings might be useful

Scientists should seek a large audience of those who might be able to use the findings of their research. Clear writing helps. Use words to describe everything. Use mathematics only when it helps to explain things.

Mathematics is only a language; it has nothing to do with the scientific method. If you think complex mathematics will help some readers, put it in an appendix that is available on the

Internet. Mathematical “proofs” does not mean scientific proofs. Avoid complex mathematical notation.

Use common words. Avoid scientific jargon and complex words. If a complex word is necessary, explain it.

Round numbers make it easier to read and remember—and avoids implying a high degree of precision. Reduce the number of words without eliminating important content—Haslam (2010) found that shorter papers get more citations per page.

Only use tables for data, unless it is not possible to communicate what the data are trying to say. For example, graphs are typically needed for displaying changes over time.

Eliminate as many citations as you can. The key is whether the citation provides evidence that is needed to support the statements made in the paper.

Revise often in order to reduce errors and length, and to improve clarity. Typically, we revise our papers more than 100 times: the more important and complex the paper, the more revisions. For example, over a three-year period, we worked through 456 revisions of our paper, the “Golden Rule of Forecasting” (Armstrong, Green, and Graefe, 2015).

Use editors to improve the clarity of the writing and reduce length. We typically use several copy editors for each paper.

When revising your paper, edit printed copy. Doing so is more effective than is editing on a computer screen. Copy editors tell us that use of printed copy is common practice. While we have found no direct testing of that approach for editing papers, some experiments have found that comprehension and retention are superior for print compared to on-screen reading (Jeong, 2012; Mangen, Walgermo and Bronnick, 2013), and on-screen reading was 25% slower, with lower recall (Jones, Pentecost and Raquena, 2005).

21. Obtain extensive peer review and editing before submitting a paper for publication

Contact reviewers individually. Scientists tend to respond to requests if you are dealing with a problem that they believe to be important. Try to find reviewers who are likely to be aware of research that might dispute your findings. Send them personal messages requesting help. Mass appeals, such as posting a working paper on the Internet, have rarely led to useful reviews for us.

It is difficult to get useful suggestions during presentations. We suggest providing a form for comments, asking for comments, and stopping with five minutes left for people in the audience to write suggestions. The process of preparing and delivering the paper to an audience often proves useful by encouraging one to anticipate objections.

Ask for specific suggestions on ways to improve your paper. People in a helping role respond differently than those who are asked to *evaluate* a paper. Use many competent reviewers to reduce errors; we suggest at least ten reviewers. If that seems excessive, consider that Frey (2003) acknowledged the help of 50 reviewers for one paper. Grade yourself on how many of a reviewer’s suggestions you were able to use.

Before submitting the paper, show the final version to reviewers and ask if they would like to be acknowledged. Acknowledging reviewers will add credibility. Also, thank all who provided useful support, especially funders. If funders wish to remain anonymous, simply say “anonymous donors.” If a reader is concerned that funding might have biased the research, the proper scientific response *for the reader* is to conduct a replication to test that hypothesis.

Disseminating the Findings

Publishing in an academic journal is, on its own, insufficient. As Benjamin Franklin implied, scientists should disseminate their *useful* scientific findings to all who could use them. Do so in sufficient detail so that users are able to understand the conditions under which the findings apply.

Scientists and their funders must be patient. The lead times for adoption of useful findings are typically long in the social sciences. Paul Meehl’s (1950) finding that models are superior to

expert judgment for personnel selection was widely cited, confirmed by many other studies, and recognized as one of the most useful findings in management, but almost half a century elapsed before it gained acceptance in sports, where it was shown to be much more accurate than expert opinions. Armstrong (2012c) describes the path to implementation in baseball. As far as we are aware, universities, some of which teach Meehl's findings, seldom use them; nor do corporations or governments.

22. Provide thorough responses to journal reviewers, including reasons for not following suggestions, and appeal to editors if you are correct.

In contrast to reviews we receive when we ask people to help us improve a paper, reviewers assigned by journals seldom offer useful suggestions or provide evidence for their opinions. Bradley's (1981) survey of reviews for psychology papers report similar experiences; 43% of the authors thought that referees treated them as inferior.

On average, our papers with controversial findings took three to seven years from original submission to final publication. So why object? Because your audience is the journal editor. Editors have some incentive to publish useful papers.

In Bradley's (1981) surveys, 47% of authors reported accepting "a referee's suggestion against your better judgment". We agree with Frey (2003), who suggests that scientists should *not* make changes suggested by reviewers if they believe the changes would be harmful.

Provide detailed point-by-point responses to journal reviewers' comments and suggestions. If you believe that journal reviewers were wrong in their assessment of your paper, state your objections to the journal editor in a calm manner. For example, run new experiments to test the reviewer's opinions. The first author's experience has been that while strong evidence upsets reviewers, some editors find it convincing.

Challenge rejection by journal if your case is strong. Some research suggests that journal editors usually go along with the journal reviewers' recommendations. For example, when a decision was appealed by authors, the editors of the *American Sociological Review* agreed with the authors on only 13% of the challenges (Simon, Bakanic, & McPhail, 1986). Three other studies had similar findings (Armstrong 1997).

Nevertheless, objecting has worked well for the first author, whose most useful and surprising papers have almost all been initially rejected by journals. Despite the large number of rejections, journal editors agreed with him on many papers, and all of important papers were eventually published in respectable journals. If your paper is important, never give up.

23. Consider alternative ways to publish your findings

If you have a paper that you consider is useful, send it to editors of relevant journals and ask if they would invite your paper without deferring to reviewers' recommendations on whether or not to publish. By following this approach, you have not formally "submitted" your paper; thus, you could make the offer to a number of journals at the same time— but inform the editors that you are doing so. If the editor agrees to your proposal, it is your responsibility to obtain the best reviews that you can.

The journal ranking system creates long lead times for publishing in "top" journals in the social and management sciences, and low probabilities for acceptance. Paul Meehl was reportedly asked why he published in an obscure journal without a strong reputation as "peer reviewed." Meehl responded that "it was late in his career, and he did not have the time nor patience to deal with picky reviewers who were often poorly informed" (Lee Sechrest, as quoted in Gelman, 2015).

Scientific books offer an opportunity to provide a complete review of research on a given problem along with full disclosure and without the need to satisfy reviewers who wish to enforce their views. Books can provide readers with convenient access to the cumulative scientific knowledge on a topic. On the negative side, scientific books are time-consuming for authors. The

first author of this paper has published three books and, on average, each took about nine years to complete.

Consider writing a chapter in an edited book. It is like an invited paper and frees you of uncertainty and from having to deal with mandatory peer review.

Avoid pop-management books. In their efforts to provide simple messages, pop-management books seldom explain the conditions under which their advice applies, nor provide access to the evidence behind their conclusions. Given these limitations, we have seldom found pop-management books that have been helpful to us and we seldom cite such books. Do they help others? In his course on persuasion, Armstrong (2011) tested the prior knowledge of persuasion principles of students on their first day of class and found that students who had read pop-management books that were related to persuasion had lower scores.

Finally, you can post a working paper on the Internet and put it in repositories. In one case, we were invited to write a chapter on demand forecasting for a book. We were unwilling to modify the chapter we had written to fit the editor's preferences for the book, so we posted our working paper version on the Internet in 2005. We planned to revise and submit the chapter elsewhere as a paper, but were sidetracked with other projects. Despite not having been published, to date it has over 70 Google Scholar citations.

24. Inform those who can use your findings

The primary responsibility for disseminating research findings falls upon the researcher. You have the copyright to the working paper that you submit to a journal, and so you have the right to post it on your website and on repositories such as SSRN, Research Gate, RePEc, and Scholarly Commons. Send copies to colleagues, researchers you cited in important ways, people who helped on the paper, reviewers, and those who do research on the topic of the paper.

Make the paper easy to obtain. Consider journals that support Green Open Access policies, whereby the final accepted version of the working paper might be publishable after an embargo period. Alternatively, authors can pay for Gold Open Access whereby the paper can be freely downloaded as soon as it is published. For a useful summary on the costs and benefits of using various approaches to open access publication, see Nosek and Bar-Anan (2012).

Seek coverage for your useful findings in the mass media. Be objective in your description of the findings. When substantial changes to current procedures are involved, present the findings softly and let the data speak for you. Direct conclusions lead people to defend their current beliefs and practices. For evidence on that point, see the chapter on "Resistance" in Armstrong (2010).

Try to find a reporter who is interested in the topic and whose opinions are consistent with your findings. This is hard work, and most of our attempts to obtain media coverage are rejected.

Citations of useful papers provide a good measure of dissemination. However, do not despair when your most useful papers are cited less often than your other papers. A survey of 123 of the most-cited biomedical scientists revealed that their most innovative and surprising papers had lower citation rates than did their other papers (Ioannidis, 2014).

Criteria for Useful Scientific Findings

Without individuals who are driven to produce useful scientific findings, little will happen. Still, much of the responsibility for creating an environment in which science can advance belongs to those who review the work of scientists with the purpose of funding, hiring, promoting, or firing them, as well as for those who use the findings, such as researchers, courts, policy makers and decision-makers in organizations. For that reason, we developed the "Criteria for Useful Science Checklist" to rate the value of scientific papers.

We developed the checklist with the intention that all stakeholders, and other intelligent adults, can use it. It is not necessary that academics do the ratings.

Exhibit 2
Criteria for Useful Science Checklist^a

Paper title:	Reviewer:	Date: / /
<p>The task: You, the rater, must be convinced of the paper's usefulness by clear descriptions of the research process, findings, and conclusions^b. If you are unsure from the researchers' description whether the research complies, check False/Unclear (F/?).</p>		
<p>Assess compliance with lettered items under each criterion, below. Do not speculate. Then assess whether criterion 1-7 are true based on compliance with the associated items.</p>		<p>Complies True F/?</p>
<p>1. Findings are useful True <input type="checkbox"/> False/Unclear <input type="checkbox"/></p>		
a. Importance of problem explained by title, abstract, result tables, or conclusions		<input type="checkbox"/> <input type="checkbox"/>
b. Findings provide improved prediction, decision-making, policy, or methods		<input type="checkbox"/> <input type="checkbox"/>
c. Directional or effect size findings <i>shown</i> to be surprising to practitioners or researchers		<input type="checkbox"/> <input type="checkbox"/>
<p>2. Prior scientific knowledge was comprehensively reviewed and summarized True <input type="checkbox"/> False/Unclear <input type="checkbox"/></p>		
a. Search procedures for prior useful scientific knowledge were objective and comprehensive		<input type="checkbox"/> <input type="checkbox"/>
b. Checked with cited authors that summaries of substantive findings and references were correct		<input type="checkbox"/> <input type="checkbox"/>
c. Checked with cited authors that no key studies were overlooked		<input type="checkbox"/> <input type="checkbox"/>
<p>3. Disclosure is comprehensive True <input type="checkbox"/> False/Unclear <input type="checkbox"/></p>		
a. Prior hypotheses clearly described (e.g. directions and magnitudes of relationships; effects of conditions)		<input type="checkbox"/> <input type="checkbox"/>
b. Revisions to hypotheses and conditions are described		<input type="checkbox"/> <input type="checkbox"/>
c. Methods are fully described and easy to understand		<input type="checkbox"/> <input type="checkbox"/>
d. Data are easily accessible using information provided in the paper		<input type="checkbox"/> <input type="checkbox"/>
e. Other information needed for understanding (e.g. acknowledgements, shortcomings, potential biases) provided		<input type="checkbox"/> <input type="checkbox"/>
<p>4. Data are valid and reliable True <input type="checkbox"/> False/Unclear <input type="checkbox"/></p>		
a. Data were shown to be relevant to the problem		<input type="checkbox"/> <input type="checkbox"/>
b. All relevant data (multiple measures) were used to help ensure validity and compensate for biases		<input type="checkbox"/> <input type="checkbox"/>
c. Longest available series used when analyzing time series data		<input type="checkbox"/> <input type="checkbox"/>
d. Reliability of data was assessed		<input type="checkbox"/> <input type="checkbox"/>
<p>5. Methods were valid and simple True <input type="checkbox"/> False/Unclear <input type="checkbox"/></p>		
a. Methods were shown to be valid for the problem, unless obvious to all		<input type="checkbox"/> <input type="checkbox"/>
b. Multiple validated methods were used		<input type="checkbox"/> <input type="checkbox"/>
c. Methods used cumulative scientific knowledge explicitly		<input type="checkbox"/> <input type="checkbox"/>
d. Methods were sufficiently simple for all potential users of the findings to understand		<input type="checkbox"/> <input type="checkbox"/>
<p>6. Experimental evidence was used to test all reasonable alternative hypotheses True <input type="checkbox"/> False/Unclear <input type="checkbox"/></p>		
a. All reasonable hypotheses were compared using experimental evidence under explicit conditions		<input type="checkbox"/> <input type="checkbox"/>
b. Predictive validity of hypotheses were tested using out-of-sample data		<input type="checkbox"/> <input type="checkbox"/>
<p>7. Conclusions are consistent with the evidence True <input type="checkbox"/> False/Unclear <input type="checkbox"/></p>		
a. Conclusions are logically consistent with the evidence presented in the paper		<input type="checkbox"/> <input type="checkbox"/>
b. Conclusions contribute to cumulative scientific knowledge on the problem addressed by the paper		<input type="checkbox"/> <input type="checkbox"/>

Complied with [] out of 7 criteria, and [] out of 23 items

^aAn electronic version of this checklist, available at GuidelinesforScience.com, includes more detail.

^bResearchers should consult Armstrong & Green's "Guidelines for Science" and rate their paper using this checklist before submitting.

Researchers must convince those who are rating the work that they have met the criteria. Raters should *not* give the benefit of the doubt to a paper that lacks clarity or sufficient information.

All identifying information about the researchers should be removed from the paper before it is provided to raters in an effort to avoid bias. A software version of the “Criteria for Useful Scientific Findings” checklist will be provided at guidelinesforscientists.com.

Stakeholders may vary in their assessments of the weights that each criterion should be given when auditing different papers. Thus, the software provides unweighted tallies of compliance.

Ratings and comments should be made available with any paper that is published or otherwise used so that stakeholders can decide for themselves whether the ratings indicate adequate compliance. Figure 2 provides an outline of the checklist.

To improve the reliability of the ratings, we suggest using three raters, and up to five if there is little agreement among the first three. We estimate from our limited testing to date that it takes less than an hour to learn to use the Guidelines for Science checklist and about 30 minutes to rate a paper. Given that the concern is with compliance to science, it would be preferable to avoid academics as raters as they might have biases as to the conclusions. The authors should, however, get reviews from experts in the area.

Using the Criteria for Useful Scientific Findings

In this section, we make suggestions on how governments, researchers, scientific journals, universities and other research funders can help to better achieve the objective of discovering and disseminating useful scientific findings.

Researchers

Researchers can take action by using the Guidelines for Scientists checklist to guide them through the research process. They should avoid funding unless they can have control over all aspects of the research. For high-risk situations, such as medical studies, researchers or their employers should provide insurance against harm.

Researchers can show that they have been successful in discovering useful scientific findings by including their ratings from the Criteria for Useful Science Checklist when submitting a paper to a journal version on the Internet.

Fortunately, some researchers and research organizations are committed to producing useful scientific findings. As a result, one can investigate almost any topic and find useful scientific findings.

Universities and Other Funding Agencies

Who funds the useful scientific research? In many areas such as technology and medicine, useful scientific research comes primarily from researchers in private firms, and it is done for profit. That works well as there is no rational reason *for the firm* to produce biased forecasts in a free market.

In many fields, much government-funded research is produced in universities and private institutes. This encourages advocacy research.

In our literature searches in various fields, we have found that researchers in universities were responsible for the overwhelming majority of useful scientific findings. In an audit of 545 papers with useful scientific findings by Armstrong and Pagell (2003), 89% were from academic journals; working papers, books, and academic conferences made up 11%; only one paper was from a trade journal. In addition, practitioners were listed as authors on only 7% of the academic papers.

Universities should state that their objectives include the discovery and dissemination of useful scientific findings. When they hire people as scientists, they should provide explicit criteria for useful scientific findings, such as our Figure 2, as part of their contract. Current incentives—such as rewards for grants, publications that do not report useful scientific findings and citations of such publications, and media coverage that is unrelated to scientific efforts—should be abandoned.

The useful science objective of universities should lead them reject funding tied to advocacy research, whether for governments or private organizations. Instead, they should provide funding that allows researchers to work on problems that they believe will allow them to best contribute useful knowledge. Some universities do this, such as the ones that employ us. For example, the first author has published over 200 papers and the second author 34 papers. Neither of us has received grants for our research.

Checklist can help universities and other organizations hire researchers who have done scientific research, and reward those who continue to do so. Funders of scientific research programs should specify that researchers must use a checklist to ensure that they comply with scientific procedures.

Scientific Journals

According to Burnham (1990), mandatory journal peer review was not common until after World War II. Did mandatory journal peer review prove to be better than the earlier procedure of editors making decisions and seeking advice from people they thought might help? He did not report evidence that the prior system was faulty. The change seemed to be due to the increase in number of papers submitted. In addition, since the reviews confer de facto certification, they must be “fair” to all. Following this logic, researchers who have excellent reputations should not be identified lest they get an advantage. An unusual approach given that most of us choose doctors and architects, for example, at least partly based on reputation.

Useful Research: Do journals ask for useful scientific research? We reviewed the aims and instructions to authors of six journals: *Management Science*, *Journal of Consumer Research*, *Marketing Science*, *Journal of Marketing Research*, *European Journal of Marketing*, and *Interfaces*. Only two made minor attempts to explain that they were seeking papers with useful scientific findings, and none provided a checklist to ensure compliance with any aspect of science.

Do journals care if papers are useful? A survey of editors of journals in psychology, social work, and psychology rated usefulness (“the value of an article’s findings to affairs of everyday social life”) tenth out of 12 criteria (Lindsey 1978, pp. 18-21). Similar findings were obtained in a survey of journal editors. “Applicability to practical or applied problems” ranked last for the ten criteria presented to editors of physics, chemistry, and sociology journals, and next to last for political science. (Beyer 1978).

Quality of Reviewing: How good are academics as journal reviewers? In one study, reviewers for 110 social work journals received a previously published paper that was modified by adding intentional flaws. Only two journals said that the paper had already been published. The control group in the submitted paper had been omitted, but few reviewers noticed this problem. Epstein concluded that only six of the 33 reviews received were competent (Epstein 1990).

In a study involving medical research, a fictitious paper with 10 major and 13 minor errors was sent to 262 reviewers, of which 199 submitted reviews. On average, the reviewers identified only 23 percent of the errors. They missed some big errors; for example, 68 percent of the reviewers failed to notice that the results did not support the conclusions (see Baxt, *et al.* 1998.)

A similar study provided medical journal reviewers with papers containing nine major intentional errors. The typical reviewer found only 2.6 (29 percent) of the errors (Schroter *et al.* 2008).

In a real-life case, John Darsee, a medical researcher at Emory and then Harvard, admitted to fabricating a paper that he published. A committee was formed to investigate. They concluded that he had fabricated data in 109 publications, which were published with 47 other researchers. The papers were published in leading peer-reviewed journals. Many of the fabrications were preposterous, such as a paper using data on a 17-year old father who had four children, ages 8, 7, 5, and 4 (Stewart and Feder 1987).

Reviewers are often unaware of the research in the areas of the papers they are asked to review. For example, in one study twelve papers were resubmitted to the same prestigious psychology journals where they had been published a few years earlier. Only 25% of the journals detected that the paper had been previously published. When not detected, the papers were rejected 89% of the time (Peters and Ceci, 1982).

Unfortunately, complexity impresses journal reviewers. In one experiment, an abstract from a published paper was altered to make one version more complex by using longer sentences and longer words, while another version was made simpler. Academic reviewers were asked to rate the quality of the work provided by the authors. The author of the complex version was rated more competent than the author of the simpler version (Armstrong 1980b). In another experiment, reviewers gave higher ratings to papers that included irrelevant complex mathematics than to those without the irrelevant information (Eriksson 2012). Finally, an experiment found that papers with irrelevant words related to neuroscience were rated as more convincing than those without the irrelevant information (Weisberg, et al. 2008). This phenomenon has been called “bafflegab.”

Computer software (SCIgen) was created to randomly select complex words commonly used in a topic area and to then use grammar rules to produce “academic papers.” The software was written to test whether reviewers would accept complex senseless papers for conferences. The title of one such paper was “Simulating Flip-flop Gates Using Peer-to-peer Methodologies.” Interestingly, some were accepted. Later, some researchers used the program to pad their resumes by submitting SCIgen papers to scientific journals. At least 120 SCIgen papers were published in established peer-reviewed scientific journals before the practice was discovered (Lott, 2014).

Recommendations for Journals: PLOS, an online journal, resolves some problems for those doing scientific research. They offer to publish all papers that meet their explicit criteria, and to do so rapidly. Their acceptance rate of 70 percent was high relative to that of prestigious journals in the social and management sciences. Five years after its introduction, almost 14,000 articles were published in PLOS, which made it the largest journal in the world (Wikipedia). Some of their papers are important and widely read. The journal did well compared with established journals on the basis of citations, and it seems to be a financial success (Carl Straumsheim, *Inside Higher Education*, January 5, 2017.)

Acceptance by PLOS is based on “soundness”—which includes criteria that overlap with our criteria. For example, “provide enough detail to allow suitably skilled investigators to fully replicate your study,” and “the article is presented in an intelligible fashion” (PLOS ONE, 2016a & b). Most importantly, PLOS does not impose obvious barriers to publication of useful scientific findings. PLOS’s soundness requirements do *not*, however, directly assess objectivity and usefulness. Thus, “sound” but useless papers might be published, as might advocacy research. This, along with some copying of their strategy by other journals and a price increase led to a sharp decline in the number of papers published by PLOS ONE since its peak in 2013.

New Section for Journals: We suggest that traditional high-status scientific journals add a section devoted to useful scientific findings. The aim would be to publish all relevant papers that comply with science quickly and to provide the papers on the Internet at no charge to readers. Taking that step would increase the number of useful scientific papers published, reduce the cost of processing papers, and reduce the time from submission to publication. The latter can be close to two years, as noted by Nosek and Bar-Anan (2012).

Editors responsible for the useful scientific findings section of a journal could provide a trained staff for rating papers for their “compliance to science.” Their reviews would require less time than is needed for traditional reviewing. Raters could provide suggestions for improving the paper’s compliance. For papers that fall short, authors could be invited to revise their paper to achieve compliance.

Alternatively, a private company could rate compliance-to-science. Authors would receive the ratings—and be invited to revise and resubmit—or to publish as is. The paper would then be posted, along with its science-compliance ratings, and interested journals could contact the authors if they would like to publish the paper.

If a journal wishes to publish a paper that is objective and provides full disclosure, but is questionable with respect to other aspects of compliance with science, at the author’s request the paper could be published with its compliance-with-science scores and descriptions of its deficiencies. Readers could then judge how much confidence they should place in the findings.

Other suggestions for journals:

Other changes can be made beyond the new section. We agree with most recommendations made by Nosek and Bar-Anan (2012) and we include some on them in the following list.

- 1) Require that authors provide a structured abstract. Emerald Publishers, for example, does that for its journals and it is standard practice in many physical and medical science journals.
- 2) Ask for estimates of effect sizes, confidence intervals, and costs related to each hypothesis. That would help when cost/benefit analyses are relevant.
- 3) Encourage authors and reviewers to include their names when they submit.
- 4) Invite proposals for invited papers. If accepted, the papers will be published when the authors say it is ready.
- 5) Invite papers. That means that the paper will be published when the researchers say it is ready. Inviting papers helps journals to publish more important papers than would otherwise be the case, and to do so less expensively as the authors must obtain the reviews. In audit of 545 papers, invited papers were 20 times more important—based on the papers with useful scientific findings and the citations for those papers—than traditional submissions. Inviting papers allows authors to choose topics that challenge current thinking, or to take on large tasks such as meta-analyses. By relying on that strategy for the 1982 introduction of the *Journal of Forecasting*, its impact factor for 1982 to 1983 was seventh among all journals in business, management, and planning (Armstrong and Pagell, 2003). The rankings dropped when the strategy was abandoned.
- 6) Encourage authors to seek their own reviews.
- 7) Ban statistical significance testing. There are no conditions under which statistical significance testing has been found to be helpful: it is harmful even when used properly (Armstrong 2007b).
- 8) Ask reviewers *only* for suggestions on how a paper might be improved.
- 9) Avoid asking that papers adhere to a common format unless it is necessary. For example, many readers find numbered sections bothersome when they serve no need. And when numbered sections are helpful, the author will know that.
- 10) Provide open peer review of papers on a journal’s moderated website after publication. Insist on civil discourse, and that reviewers provide their names, contact information, and brief resumes. Reviewers should verify that they read the paper in question. They should avoid emotional and *ad hominem* arguments, opinions, and inappropriate language. The reviews should be easily located, as should corrections and papers that have cited the reviewed paper.

While we are concerned in this paper with the publishing useful scientific findings, leading journals should continue to have sections for exploratory studies, thought pieces, applications,

opinions, editorials, obituaries, tutorials, book reviews, commentaries, ethical issues, logical application of existing scientific knowledge, corrections, announcements, and identification of problems in need of research. The leading journals provide a forum for cooperative efforts to improve science in a given field, and to provide repositories for cumulative knowledge.

Governments

Adam Smith wondered why Scotland's relatively few academics, who were poorly paid, were responsible for many scientific advances during the Industrial Revolution, while England's larger number of academics contributed little. He concluded that because the government provided them with generous support, academics in England had little motivation to do useful research (Kealey 1996, pp. 60-89). Modern universities around the world tend to be like those of 18th century England. Should we expect different results today?

Natural experiments have shown governments to be less effective than private enterprises at delivering services (Poole, 2008). Kealey (1996) concluded that this also applies to research. Findings of systematic analyses are consistent with those conclusions. For example, Karpoff (2001) compared 35 government and 57 private missions conducted during the great age of Arctic exploration in the 19th Century. The privately run expeditions were safer, more successful, and less expensive than the government-sponsored ones. Governments could best help to advance scientific knowledge by eliminating funding for advocacy research, by removing regulatory impediments, and by protecting scientists' freedom of speech.

While additional government funding increases the number of papers published, it seems to have little effect on the number useful scientific findings. For example, the number of papers on forecasting increased enormously over the latter half of the 20th Century, yet the number of useful papers remained steady at about one per month over that period (Armstrong and Pagell 2003).

Government-supported advocacy often leads to the suppression of speech by scientists. The response to Galileo's calculations of the movement of planets is perhaps the best-known example. In modern times, the U.S.S.R. government's endorsement of Lysenko's politically flawed theories about plant breeding led to the persecution of scientists with contrary views (Miller, 1996). More recently, scientists whose findings conflict with the U.S. government's position on the global warming alarm have been threatened, harassed, fired from government and university positions, subjected to hacking of their websites, and threatened with prosecution under racketeering (RICO) laws (see, e.g., Curry, 2015).

For centuries, scientists have been concerned about designing experimental studies that would avoid harming participants. They realize that ignoring the natural concern for the welfare of others would lead to disgrace as a scientist and to exposure to lawsuits brought by those who were harmed. Individual scientists are best able to design safeguards for their subjects, they have more at stake than regulators would have, and when they have full responsibility they would be free of the obedience to authority effects that led to serious ethical breaches in government research.

Starting in the mid-1960s, U.S. government officials decided to regulate science. How they concluded that there was a problem is a mystery: neither Schneider (2015) nor Schrag (2010) could find systematic evidence on the extent of serious harm by individual scientists. Some surveys have failed to find evidence of harm from scientific research conducted without IRB involvement. For example, only three projects, in a study of 2,039 non-biomedical studies, reported a breach of confidentiality that harmed or embarrassed a subject (Schrag, pp. 63-67).

Instead of evidence, the government relied on examples of studies that harmed subjects to justify regulations. Among the most unethical examples were the U.S. government Tuskegee syphilis experiments; a U. S. radiation study where prisoners, mentally handicapped teenagers, and newborn babies were injected with plutonium; and Germany's biomedical experiments in Nazi internment camps. We find it difficult to believe that individual scientists would conduct such unethical projects without the support and protection of government.

Regulation of scientists is now enforced by “Institutional Review Boards” (IRBs) in the U.S. They now have the power to license and monitor research using human subjects. We fail to understand why the government thought that protection for subjects would be improved by removing responsibility from researchers. It runs counter to the findings in the “blind obedience” studies initiated by Milgram (1969)—that is, while individuals are reluctant to harm others, they can be induced to do so if directed by an authority. Currently, nearly all researchers in institutions that receive federal funding must receive permission from an IRB or a member of its staff, if the study involves human subjects. In effect, researchers must get permission to study a particular topic, and obtain approval for the design and reporting of their study. The requirements apply even when the researcher does not receive government funding (Schneider, 2015, p. xix).

Many regulations seem bizarre to scientists. For example, an ordinary citizen can ask citizens about their opinions on a topic, as can journalists, but scientists at a university must receive permission from the government in order to ask people about their opinions lest someone be upset.

The Iron Law of Regulation states “There is no form of market failure, however egregious, which is not eventually made worse by the political interventions intended to fix it. For a number of years, now, we have been looking for violations of the Iron Law. While most people are sure there are conditions under which regulation helps, we have been unable to find any scientific evidence to support that belief. Our search continues at IronLawofRegulation.com.

According to Schneider, the government seems unable to provide evidence that their regulation of science is beneficial. Reviews by Schneider (2015), Schrag (2010), and Infectious Diseases Society of America (2009) provide evidence that scientific studies are abandoned or delayed, and costs are greatly increased in response to regulation. For example, disclaimers have been used since the beginning of advertising because organizations want to protect their reputations and to treat their stakeholders well. However, experimental studies on *mandatory* disclaimers find that they are confusing to people and harm their decision making (Green and Armstrong 2012). Our interpretation of the above research is that regulation has led to delays, higher costs, less scientific progress, and increased risks of harm to research participants. Most important, regulations violate scientists’ freedom of speech. On that basis alone, the regulations should be removed.

Discussion

The scientific principles that underlie the guidelines apply to all areas of science. That said, researchers might find a need to modify the operational guidelines depending on the particular field of research.

The cost of using the checklists would be low in absolute terms, and low relative to current methods for designing and evaluating research.

Getting evidence-based checklists adopted *can* be easy. In a previous study, we had no trouble convincing people to use a 195-item checklist when we paid them a small fee for doing so (Armstrong, *et al.* 2016). That experience, and the successful adoption of checklists in other fields, suggest that researchers would comply with science guidelines if universities and other funders, and journals, required them to do so in clear operational terms as part of their contract. We suggest our Exhibit 2, but organizations could tailor that list to suit their needs.

The Criteria for Useful Science Checklist could be used by universities and public policy research organizations to demonstrate that a paper produces useful scientific research; by courts to assess the quality of evidence; by researchers to apply for jobs; by governments to propose or revise policies or regulations; and by professional societies to recommend standards.

Summary and Conclusions

“The prospect of domination of the nation's scholars by Federal employment, project allocations, and the power of money is ever present – and is gravely to be regarded. Yet, in holding scientific research and discovery in respect, as we should, we must also be alert to the... danger that public policy could itself become the captive of a scientific-technological elite.”

Dwight D. Eisenhower (1961) *Farewell address to the nation*

Much can be done to improve compliance to scientific principles. The key obstacles to improvement are: (1) advocacy research; (2) irrelevant criteria such as grants, and publication and citation counts; (3) government regulation of science; (4) use of non-experimental data; and (4) statistical significance testing.

These problems can be avoided by asking researchers and other stakeholders to put their efforts into the production of useful scientific findings. This can be done by using experiments to test alternative reasonable hypotheses that address important problems and by complying with science. Given these requirements, all papers should be published.

The process must start with the researchers who are dedicated to doing useful scientific research. Exhibit 1, the Guidelines for Scientists, describes the process. Researchers should take responsibility for all aspects of scientific research. This implies that they should not engage in advocacy research, as it violates the basic principle that science should be objective.

Advocacy studies have made up a large percentage of the papers published in the social sciences. We recommend that they should not be published by journals with the implication that they are scientific nor should they be cited in scientific papers without mention of the limitations.

Governments should not be involved in research. Regulation of science should be abandoned with full responsibility placed on scientists. Government regulation of science increases costs, slows progress in science, is expected to put subjects at higher risk, and violates free speech by scientists.

Universities and other funders could improve scientific progress by providing funding that allows researchers to select useful problems suited to their interests and skills. In addition, they can arrange insurance for subjects who might be harmed.

Mandatory peer review by journals is harmful to the growth of science. Scientists should seek peer review before submitting for publication, and inform readers about their success in doing so. Journals should provide open peer review. To promote advances in scientific knowledge, journals could devote a section to papers with useful scientific findings, as judged by their compliance to science for important problems. Given the Internet, journals could publish all compliant papers that are relevant to their field. The cost for compliance-to-science reviews would be much lower than for the traditional system, and the time to publication for important papers would be cut from years to weeks.


The Criteria for Useful Science Checklist provided in this paper can be used by funders, researchers, courts, journals, government policy makers, and managers to identify papers that provide useful scientific findings. In addition, it can identify researchers to show that they have obtained useful scientific findings.

References

The references include coding of our efforts to contact authors that provided substantive findings by email to ask them to check that we have represented their work correctly and whether we overlooked important papers in their area. The codes, presented at the end of the references are:

* No response; ** Confirmed our description; *** Made useful suggestions.

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