www.sciencemag.org/content/359/6380/1094/suppl/DC1

Supplementary Materials for

The science of fake news

David M. J. Lazer,*† Matthew A. Baum,* Yochai Benkler, Adam J. Berinsky, Kelly M. Greenhill, Filippo Menczer, Miriam J. Metzger, Brendan Nyhan, Gordon Pennycook, David Rothschild, Michael Schudson, Steven A. Sloman, Cass R. Sunstein, Emily A. Thorson, Duncan J. Watts, Jonathan L. Zittrain

*These authors contributed equally to this work.
†Corresponding author. Email: d.lazer@neu.edu

Published 9 March 2018, *Science* **359**, 1094 (2018)
DOI: 10.1126/science.aao2998

This PDF file includes:

List of Author Affiliations

David M. J. Lazer,[1,2]*† Matthew A. Baum,[3]* Yochai Benkler,[4,5] Adam J. Berinsky,[6] Kelly M. Greenhill,[7,3] Filippo Menczer,[8] Miriam J. Metzger,[9] Brendan Nyhan,[10] Gordon Pennycook,[11] David Rothschild,[12] Michael Schudson,[13] Steven A. Sloman,[14] Cass R. Sunstein,[4] Emily A. Thorson,[15] Duncan J. Watts,[12] Jonathan L. Zittrain[4,5]

[1]Network Science Institute, Northeastern University, Boston, MA 02115, USA.

[2]Institute for Quantitative Social Science, Harvard University, Cambridge, MA 02138, USA

[3]John F. Kennedy School of Government, Harvard University, Cambridge, MA 02138, USA.

[4]Harvard Law School, Harvard University, Cambridge, MA 02138, USA.

[5] Berkman Klein Center for Internet and Society, Cambridge, MA 02138, USA.

[6]Department of Political Science, Massachussets Institute of Technology, Cambridge, MA 02139, USA.

[7]Department of Political Science, Tufts University, Medford, MA 02155, USA.

[8]School of Informatics, Computing, and Engineering, Indiana University, Bloomington, IN 47405, USA.

[9]Department of Communication, University of California, Santa Barbara, Santa Barbara, CA 93106, USA.

[10]Department of Government, Dartmouth College, Hanover, NH 03755, USA.

[11]Department of Psychology, Yale University, New Haven, CT 06520, USA.

[12]Microsoft Research, New York, NY 10011, USA.

[13]Graduate School of Journalism, Columbia University, New York, NY 10027, USA.

[14]Department of Cognitive, Linguistic, and Psychological Sciences, Brown University, Providence, RI 02912, USA.

[15]Department of Political Science, Boston College, Chestnut Hill, MA 02467, USA.

*These authors contributed equally to this work.

†Corresponding author. Email: d.lazer@northeastern.edu

Supporting Materials

This section provides a brief overview of literature supporting each section of "The science of fake news."

1. WHAT IS FAKE NEWS?

The term "fake news" has been in use for more than a century. An example of early use of the term appears in a piece in Harper's weekly in 1925 titled "Fake News and the Public", which bemoans the role that the newswires play in the rapid and uncritical dissemination of misinformation (*1*). For a more thorough and nuanced set of definitions regarding the various types of misinformation, see (*2*). We note that (*3*, *4*) have advocated dropping the term "fake news" because of recent efforts by political figures to use it to discredit unsympathetic news stories. Such efforts are indeed a concern, and we have no intrinsic objection to the term "false news. However, for three reasons, we have elected to retain the term "fake news." First, it has a useful scientific meaning (the intersection of misinformation and mimicry of traditional news media). Second, its very prominent recent misuse has a salutary side effect of focusing attention on the more general problem of misinformation. Third, while the term "false news" avoids the weaponization problem in the near-term, should the effort to shift the popular and scholarly nomenclature toward "false news" succeed, it would likely be subject to the same sort of weaponization that we have seen with "fake news.

2. THE HISTORICAL SETTING

For historical background on the rise of journalistic norms in the U.S. after World War I, see (*5*). Popular treatments of the geographic polarization of partisanship are offered by (*6*, *7*); see (*8*) for a more detailed statistical analysis of geographic polarization of presidential voting behavior. Literature on the consequences of homogeneous social networks on tolerance, attitudinal polarization, uncritical acceptance of ideologically compatible news, and closure to new information includes (*9*–*13*). For a detailed review of social and political conditions giving rise to the spread of fake news, see Rand's recent report on "truth decay" (*14*)

3. PREVALENCE AND IMPACT

Fake news has received substantial media attention in the last year; an example is (*15*), which examines examples of fake news stories that received widespread attention through sharing on Facebook. Qiu *et al.* (*16*) is a scholarly examination of virality of low-quality information online. There is empirical evidence that misinformation is as likely to go viral as reliable news on both Facebook (*16*) and Twitter (*17*), as well as be retweeted more frequently and more rapidly than true information, especially when the information involves politics (*4*)*;* (*18*) discusses the spread

of emotional information. Once misinformation is believed to be true, it is difficult to correct (*19*).

The problem may be disproportionately attributable to the activities of a few hundred sites—330 by one conservative estimate (*20*).

The magnitude of the impact of fake news is currently uncertain. By way of analogy, there is an energetic debate in the political science literature on the role that campaigns play. Vavreck (*21*) highlights the role that messaging in political campaigns play and (*22*) catalyzed a large literature on the effectiveness of get-out-the-vote efforts. However, (*23*), in a meta-analysis, examines 49 field experiments, suggesting generally small to nonexistent persuasive effects from campaign contact.

Examples from the literature on the impact of media on cynicism, apathy, and encouraging extremism include (*24–26*).

4. EMPOWERING INDIVIDUALS

Foundational literature on the use of media consumption for "gratification" includes (*27*, *28*). There is a vast literature on selective exposure and confirmation bias (*29*); examples that focus on news consumption are (*30*, *31*).

The role of familiarity and fluency in cognition has been examined in (*32*, *33*) for evidence that familiarity (via repetition) increases the perceived accuracy of fake news see (*34*). In terms of literature regarding fact-checking see (*35*, *36*), and in a political context (*37*, *38*). The possibility that presenting misinformation alongside the correction hinders is presented in (*39*, *40*), while (*41*) suggests that repeating misinformation can enhance the cognitive impact of a retraction.

Examples of training of critical information skills in primary and secondary schools includes (*42–45*), while (*46*) highlights the possibility that emphasis on fake news risks undermining the credibility of real news outlets. The broader concept of media literacy is treated well in (*47–49*).

The role of incentives in confronting preconceptions is examined in (*50*). The importance of peers in cognition is explored in (*51*, *52*).

5. PLATFORM-BASED DETECTION AND INTERVENTION: ALGORITHMS AND BOTS

Media reports on fake news that highlight the relatively low cost of producing fake news sites include (*15*, *53*, *54*). Markiness *et al.* (*55*) examines the monetization of fake news content through online ads and social media.

The role that algorithms play in determining the information we see is examined in (*56*, *57*). There is a large emerging literature on the vulnerability of platforms to manipulation (*58–63*), including evidence of the role played by social bots in the spread of misinformation (*17*). The effects of social bots in the 2016 American presidential election are discussed in (*64*) and for the French presidential election in (*65*, *66*).

Examples of posts by platforms about steps they have taken to counter fake news include (*67–*70). Levin (*71*) critically evaluates Facebook's efforts in this domain. Jasny *et al.* (*72*) examines the challenges of industry-academic collaboration.

Critical examinations of the role that media oligopolies played in the 20th century include (*73–75*).

CONCLUSION

Exemplary post-World War II research on propaganda includes (*76–78*); subsequent research revealing media effects on agenda setting, framing, and priming includes (*79–85*).

We note that our call to create a focal point of research around solving the problem of fake news is consistent with Watts's call for a solution-oriented social science (*86*) and Neblo *et al.*'s call for a translational science of democracy (*87*).

References

1. E. McKernon, Fake News and the Public: How the Press Combats Rumor, The Market Rigger, and The Propagandist. *Harper's Monthly* (1925).

2. C. Wardle, Fake News. It's Complicated. (2017), (available at https://firstdraftnews.com/fake-news-complicated/).

3. C. Wardle, H. Derakhshan, "Information Disorder: Toward an Interdisciplinary Framework for Research and Policymaking" (Council of Europe Report DGI(2017)09, Council of Europe, 2017), (available at https://firstdraftnews.com/wp-content/uploads/2017/11/PREMS-162317-GBR-2018-Report-de%CC%81sinformation-1.pdf?x29719).

4. S. Vosoughi, D. Roy, S. Aral, The Spread of True and False News Online. *Science* **359**, 1146–1151 (2018).

5. M. Schudson, *Discovering the News: A Social History of American Newspapers* (Basic Books, New York, NY, 1978).

6. B. Bishop, R. G. Cushing, *The Big Sort: Why the Clustering of Like-Minded America Is Tearing Us Apart* (Mariner Books, Boston, 2009).

7. G. Aisch, A. Pearce, K. Yourish, The Divide Between Red and Blue America Grew Even Deeper in 2016. *The New York Times* (2016), (available at https://www.nytimes.com/interactive/2016/11/10/us/politics/red-blue-divide-grew-stronger-in-2016.html).

8. R. Johnston, D. Manley, K. Jones, Spatial Polarization of Presidential Voting in the United States, 1992–2012: The "Big Sort" Revisited. *Annals of the American Association of Geographers*. **106**, 1047 (2016).

9. D. C. Mutz, Cross-Cutting Social Networks: Testing Democratic Theory in Practice. *American Political Science Review*. **96**, 111 (2002).

10. C. R. Sunstein, *Going to Extremes: How Like Minds Unite and Divide* (Oxford University Press, Oxford, 2009).

11. H. Allcott, M. Gentzkow, Social Media and Fake News in the 2016 Election. *Journal of Economic Perspectives*. **31**, 211 (2017).

12. C. J. Nemeth, Dissent as Driving Cognition, Attitudes, and Judgments. *Social Cognition*. **13**, 273 (1995).

13. E. Pariser, *The Filter Bubble: What the Internet Is Hiding from You* (Penguin Press, New York, 2011).

14. J. Kavanagh, M. D. Rich. *Truth Decay: An Initial Exploration of the Diminishing Role of Facts and Analysis in American Public Life*. Santa Monica, CA: RAND Corporation, 2018. https://www.rand.org/pubs/research_reports/RR2314.html.

15. C. Silverman, This Analysis Shows How Viral Fake Election News Stories Outperformed Real News On Facebook (2016), (available at https://www.buzzfeed.com/craigsilverman/viral-fake-election-news-outperformed-real-news-on-facebook).

16. X. Qiu, D. F. M. Oliveira, A. Sahami Shirazi, A. Flammini, F. Menczer, Limited Individual Attention and Online Virality of Low-Quality Information. *Nature Human Behaviour*. **1**, 0132 (2017).

17. C. Shao, G. L. Ciampaglia, O. Varol, A. Flammini, F. Menczer, "The Spread of Fake News by Social Bots" (arXiv Preprint 1707.07592 [cs.SI], 2017), (available at http://arxiv.org/abs/1707.07592).

18. K. Peters, Y. Kashima, A. Clark, Talking About Others: Emotionality and the Dissemination of Social Information. *European Journal of Social Psychology*. **39**, 207 (2009).

19. S. Lewandowsky, U. K. H. Ecker, C. M. Seifert, N. Schwarz, J. Cook, Misinformation and Its Correction: Continued Influence and Successful Debiasing. *Psychological Science in the Public Interest*. **13**, 106 (2012).

20. J. Gillin, Politifact's Guide to Fake News Websites. *PolitiFact* (2017), (available at http://www.politifact.com/punditfact/article/2017/apr/20/politifacts-guide-fake-news-websites-and-what-they/).

21. L. Vavreck, *The Message Matters: The Economy and Presidential Campaigns* (Princeton University Press, Princeton, N.J, 2009).

22. A. S. Gerber, D. P. Green, C. W. Larimer, Social Pressure and Voter Turnout: Evidence from a Large-Scale Field Experiment. *American Political Science Review*. **102**, 33 (2008).

23. J. L. Kalla, D. E. Broockman, The Minimal Persuasive Effects of Campaign Contact in General Elections: Evidence from 49 Field Experiments. *American Political Science Review*, 1 (2017).

24. J. N. Cappella, K. H. Jamieson, *Spiral of Cynicism: The Press and the Public Good* (Oxford University Press, New York, 1997).

25. M. Elenbaas, C. H. de Vreese, The Effects of Strategic News on Political Cynicism and Vote Choice Among Young Voters. *Journal of Communication*. **58**, 550 (2008).

26. M. Levendusky, *How Partisan Media Polarize America* (The University of Chicago Press, Chicago, 2013).

27. E. Katz, J. G. Blumler, M. Gurevitch, Uses and Gratifications Research. *Public Opinion Quarterly*. **37**, 509 (1973).

28. E. Katz, D. Foulkes, On the Use of the Mass Media as "Escape": Clarification of a Concept. *Public Opinion Quarterly*. **26**, 377 (1962).

29. R. S. Nickerson, Confirmation Bias: A Ubiquitous Phenomenon in Many Guises. *Review of General Psychology*. **2**, 175 (1998).

30. N. J. Stroud, *Niche News: The Politics of News Choice* (Oxford University Press, New York, 2011).

31. M. S. Levendusky, Why Do Partisan Media Polarize Viewers? *American Journal of Political Science*. **57**, 611 (2013).

32. A. L. Alter, D. M. Oppenheimer, Uniting the Tribes of Fluency to Form a Metacognitive Nation. *Personality and Social Psychology Review*. **13**, 219 (2009).

33. I. M. Begg, A. Anas, S. Farinacci, Dissociation of Processes in Belief: Source Recollection, Statement Familiarity, and the Illusion of Truth. *Journal of Experimental Psychology: General*. **121**, 446 (1992).

34. G. Pennycook, T. Cannon, D. G. Rand, "Implausibility and Illusory Truth: Prior Exposure Increases Perceived Accuracy of Fake News but Has No Effect on Entirely Implausible Statements," *Working Paper* (2017), (available at https://www.ssrn.com/abstract=2958246).

35. B. Swire, U. K. H. Ecker, S. Lewandowsky, The Role of Familiarity in Correcting Inaccurate Information. *Journal of Experimental Psychology: Learning, Memory, and Cognition*. **43**, 1948 (2017).

36. G. Pennycook, D. G. Rand, "The Implied Truth Effect: Attaching Warnings to a Subset of Fake News Stories Increases Perceived Accuracy of Stories Without Warnings," *Working Paper* (2017), (available at https://www.ssrn.com/abstract=3035384).

37. M. Lodge, K. M. McGraw, P. Stroh, An Impression-Driven Model of Candidate Evaluation. *The American Political Science Review*. **83**, 399 (1989).

38. K. M. Greenhill, B. Oppenheim, Rumor has it: The adoption of unverified information in conflict zones. *International Studies Quarterly* (2017), doi:10.1093/isq/sqx015.

39. A. J. Berinsky, Rumors and Health Care Reform: Experiments in Political Misinformation. *British Journal of Political Science*. **47**, 241 (2017).

40. I. Skurnik, C. Yoon, D. C. Park, N. Schwarz, How Warnings about False Claims Become Recommendations. *Journal of Consumer Research*. **31**, 713 (2005).

41. U. K. H. Ecker, J. L. Hogan, S. Lewandowsky, Reminders and Repetition of Misinformation: Helping or Hindering Its Retraction? *Journal of Applied Research in Memory and Cognition*. **6**, 185 (2017).

42. C. Jones, Bill Would Help California Schools Teach About "Fake News," Media Literacy. *EdSource* (2017), (available at https://edsource.org/2017/bill-would-help-california-schools-teach-about-fake-news-media-literacy/582363).

43. Stanford History Education Group, Reading Like A Historian, (available at https://sheg.stanford.edu/history-lessons).

44. Lesson Plan: How to Teach Your Students About Fake News. *PBS NewsHour Extra*, (available at http://www.pbs.org/newshour/extra/lessons_plans/lesson-plan-how-to-teach-your-students-about-fake-news/).

45. Stanford History Education Group, "Evaluating Information: The Cornerstone of Civic Online Reasoning," (available at https://sheg.stanford.edu/upload/V3LessonPlans/Executive%20Summary%2011.21.16.pdf).

46. P. Mihailidis, S. Viotty, Spreadable Spectacle in Digital Culture: Civic Expression, Fake News, and the Role of Media Literacies in "Post-Fact" Society. *American Behavioral Scientist*. **61**, 441 (2017).

47. E. K. Vraga, M. Tully, Effective Messaging to Communicate News Media Literacy Concepts to Diverse Publics. *Communication and the Public*. **1**, 305 (2016).

48. E. K. Vraga, M. Tully, H. Rojas, Media Literacy Training Reduces Perception of Bias. *Newspaper Research Journal*. **30**, 68 (2009).

49. M. Tully, E. K. Vraga, Who Experiences Growth in News Media Literacy and Why Does It Matter? Examining Education, Individual Differences, and Democratic Outcomes. *Journalism & Mass Communication Educator*, 107769581770657 (2017).

50. D. T. Gilbert, How Mental Systems Believe. *American Psychologist*. **46**, 107 (1991).

51. D. M. Kahan, H. Jenkins-Smith, D. Braman, Cultural Cognition of Scientific Consensus. *Journal of Risk Research*. **14**, 147 (2011).

52. S. A. Sloman, P. Fernbach, *The Knowledge Illusion: Why We Never Think Alone* (Riverhead Books, New York, 2017).

53. C. Dewey, Facebook Fake-News Writer: 'I Think Donald Trump Is in the White House Because of Me.' *Washington Post* (2016), (available at https://www.washingtonpost.com/news/the-intersect/wp/2016/11/17/facebook-fake-news-writer-i-think-donald-trump-is-in-the-white-house-because-of-me/).

54. S. Subramanian, Inside the Macedonian Fake-News Complex. *WIRED* (2017), (available at https://www.wired.com/2017/02/veles-macedonia-fake-news/).

55. B. Markines, C. Cattuto, F. Menczer, in *Proceedings of the 5th International Workshop on Adversarial Information Retrieval on the Web* (ACM Press, Madrid, 2009), pp. 41–48.

56. A. Hannak *et al.*, in *Proceedings of the Twenty-Second International World Wide Web Conference (WWW'13)* (Rio de Janeiro, Brazil, 2013).

57. D. Lazer, The Rise of the Social Algorithm. *Science*. **348**, 1090 (2015).

58. E. Ferrara, O. Varol, C. Davis, F. Menczer, A. Flammini, The Rise of Social Bots. *Communications of the ACM*. **59**, 96 (2016).

59. S. Woolley, P. Howard, Political Communication, Computational Propaganda, and Autonomous Agents. *International Journal of Communication*. **10**, 4882–4890 (2016).

60. O. Varol, E. Ferrara, C. A. Davis, F. Menczer, A. Flammini, in *Proceedings of the 11th AAAI Conference on Web and Social Media* (AAAI, Montreal, 2017), pp. 280–289.

61. D. B. Clark, The Bot Bubble: How click farms have inflated social media currency. *The New Republic* (2015), (available at https://newrepublic.com/article/121551/bot-bubble-click-farms-have-inflated-social-media-currency).

62. C. Shao, G. L. Ciampaglia, A. Flammini, F. Menczer, in *Proceedings of the 25th International Conference Companion on World Wide Web* (ACM Press, Montreal, 2016), pp. 745–750.

63. V. S. Subrahmanian *et al.*, The DARPA Twitter Bot Challenge. *Computer*. **49**, 38 (2016).

64. A. Bessi, E. Ferrara, Social Bots Distort the 2016 U.S. Presidential Election Online Discussion. *First Monday*. **21** (2016), doi:10.5210/fm.v21i11.7090.

65. S. S. Ali, Facebook Shuts Down 30,000 Fake Accounts in France Ahead of Presidential Election (2017), (available at http://www.nbcnews.com/news/world/facebook-shuts-down-30-000-fake-accounts-france-ahead-presidential-n746821).

66. E. Ferrara, Disinformation and Social Bot Operations in the Run up to the 2017 French Presidential Election. *First Monday*. **22** (2017), doi:10.5210/fm.v22i8.8005.

67. A. Mosseri, News Feed FYI: Addressing Hoaxes and Fake News (2017), (available at https://newsroom.fb.com/news/2016/12/news-feed-fyi-addressing-hoaxes-and-fake-news/).

68. C. Crowell, Our Approach to Bots & Misinformation (2017), (available at https://blog.twitter.com/official/en_us/topics/company/2017/Our-Approach-Bots-Misinformation.html).

69. R. Gingras, Labeling Fact-Check Articles in Google News. *Google* (2016), (available at https://blog.google/topics/journalism-news/labeling-fact-check-articles-google-news/).

70. R. Dillet, Google and Facebook Ban Fake News Sites from Their Advertising Networks (2016), (available at https://techcrunch.com/2016/11/15/google-and-facebook-ban-fake-news-sites-from-their-advertising-networks/).

71. S. Levin, Facebook Promised to Tackle Fake News. but the Evidence Shows It's Not Working. *The Guardian* (2016), (available at https://www.theguardian.com/technology/2017/may/16/facebook-fake-news-tools-not-working).

72. B. R. Jasny *et al.*, Fostering Reproducibility in Industry-Academia Research. *Science*. **357**, 759 (2017).

73. N. Chomsky, *Media Control: The Spectacular Achievements of Propaganda* (Seven Stories Press, New York, Second., 2002).

74. B. Goldberg, *Bias: A CBS Insider Exposes How the Media Distort the News* (Regnery, Washington, DC, 2001).

75. J. Hamilton, *All the News That's Fit to Sell: How the Market Transforms Information into News* (Princeton University Press, Princeton, N.J, 2004).

76. B. Berelson, P. F. Lazarsfeld, W. N. McPhee, *Voting: A Study of Opinion Formation in a Presidential Campaign* (University of Chicago Press, Chicago, 1954).

77. A. Campbell, P. E. Converse, W. E. Miller, D. E. Stokes, *The American Voter* (University of Chicago Press, Chicago, 1960).

78. P. F. Lazarsfeld, B. Berelson, H. Gaudet, *The People's Choice: How the Voter Makes up his Mind in Presidential Campaign* (Columbia University Press, New York, 1944).

79. D. Chong, J. N. Druckman, Framing Theory. *Annual Review of Political Science*. **10**, 103 (2007).

80. J. N. Druckman, On the Limits of Framing Effects: Who Can Frame? *The Journal of Politics*. **63**, 1041 (2001).

81. J. N. Druckman, The Implications of Framing Effects for Citizen Competence. *Political Behavior*. **23**, 225 (2001).

82. A. R. Cohen, *Attitude Change and Social Influence* (Basic Books, New York, 1964).

83. S. Iyengar, D. R. Kinder, *News That Matters: Television and American Opinion* (University of Chicago Press, Chicago, 1987).

84. B. C. Cohen, *The Press and Foreign Policy* (Princeton University Press, Princeton, 1970).

85. M. A. Baum, T. Groeling, Reality Asserts Itself: Public Opinion on Iraq and the Elasticity of Reality. *International Organization*. **64**, 443 (2010).

86. D. J. Watts, Should Social Science Be More Solution-Oriented? *Nature Human Behaviour*. **1**, 0015 (2017).

87. M. A. Neblo *et al.*, The Need for a Translational Science of Democracy. *Science*. **355**, (2017).