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## **Arbeiten mit Twitter-Daten (WS 2016/7)**

### **Time:**

October 14, 2016 Friday—10:00 to 17:00  
October 15, 2016 Saturday—09:00 to 16:00  
November 18, 2016 Friday—10:00 to 17:00  
November 19, 2016 Saturday—09:00 to 16:00

### **Place:**

October 14/15: Raum 4.B54  
November 18/19: Raum 3.B55

**Description:** Kommentar: Die zunehmende Nutzung digitaler Dienste öffnet Sozialwissenschaftlern eine neue Datenquelle für die Analyse gesellschaftlicher Phänomene. Digitale Spurendaten dokumentieren das Verhalten von Nutzern digitaler Dienste im Zeitverlauf und in großem Detail. Die Potentiale dieser Datensätze werden in der öffentlichen Diskussion mit den Begriffen Computational Social Science, Big Data und Digital Methods verbunden. In dieser Übung werden einige der populärsten Methoden der Analyse digitaler Spurendaten vorgestellt und exemplarisch eingeübt, wie zum Beispiel die Datensammlung über APIs, Grundtechniken der Zeitreihen- und Netzwerkanalyse. Für die Analyse werden die Programme R und Python genutzt. In dem Kurs werden wir unterschiedliche Methoden der computergestützten Datenanalyse lernen. Vorkenntnisse in der Nutzung von R und Python sind für die Teilnahme nicht notwendig aber sicherlich hilfreich.

**Prüfungsmodus:** Aktive Teilnahme (kurze eigenständige Datenanalyse) 4 Cr (für alle Module ohne anderslautende Angabe)

# Syllabus

**Course Overview and Session Details (Will be posted and updated over the course of the seminar):**

<http://andreasjungherr.net/>

**Textbook:**

- Pascal Jürgens and Andreas Jungherr. 2016. *A Tutorial for Using Twitter Data in the Social Sciences: Data Collection, Preparation, and Analysis*. Social Science Research Network (SSRN). doi: 10.2139/ssrn.2710146. Available at [http://papers.ssrn.com/sol3/papers.cfm?abstract\\_id=2710146](http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2710146)

**Code Repository:**

<https://github.com/trifle/twitterresearch>

**Background Readings:**

*Using Digital Trace Data in the Social Sciences:*

- David Donoho. *50 Years of Data Science*. Paper presented at the *Tukey Centennial workshop*, Princeton, NJ. Sept. 18 (2015).
- Bradley Efron and Trevor Hastie. *Computer Age Statistical Inference: Algorithms, Evidence, and Data Science*. Cambridge, UK: Cambridge University Press. 2016.
- James Howison, Andrea Wiggins, and Kevin Crowston. “Validity issues in the use of social network analysis with digital trace data”. In: *Journal of the Association for Information Systems* 12.12 (2011), pp. 767–797.
- Andreas Jungherr. *Analyzing Political Communication with Digital Trace Data: The Role of Twitter Messages in Social Science Research*. Cham, CH: Springer, 2015.
- Andreas Jungherr, Harald Schoen, and Pascal Jürgens. “The mediation of politics through Twitter: An analysis of messages posted during the campaign for the German federal election 2013”. In: *Journal of Computer-Mediated Communication* 21.1 (2016), pp. 50.68. doi: 10.1111/jcc4.12143.
- Andreas Jungherr, Harald Schoen, Oliver Posegga, and Pascal Jürgens. “Digital Trace Data in the Study of Public Opinion: An Indicator of Attention Toward Politics Rather Than Political Support”. In: *Social Science Computer Review*. (2016). doi: 10.1177/0894439316631043
- Matthew J. Salganik. *Bit By Bit: Social Research in the Digital Age*. Princeton, NJ: Princeton University Press. 2017.

*Python:*

- Swaroop Chitlur: *A Byte of Python*. Available at <http://python.swaroopch.com>
- Nick Eubank (2015) *Data Analysis in Python*. Available at <http://www.data-analysis-in-python.org/index.html>
- Mark Lutz (2013) *Learning Python*, 5th Edition. O'Reilly Media, Inc.
- Wes McKinney (2012) *Python for Data Analysis*. O'Reilly Media, Inc.
- Al Sweigart (2015): *Automate the Boring Stuff with Python: Practical Programming for Total Beginners*. No Starch Press.

*R:*

- Winston Chang (2012) *R Graphics Cookbook*. O'Reilly Media, Inc.
- Richard Cotton (2013) *Learning R*. O'Reilly Media, Inc.
- Robert Kabacoff (2015) *R in Action*. 2nd ed. Manning Publications.

*Data Collection Online:*

- Matthew A. Russell (2013) *Mining the Social Web: Data Mining Facebook, Twitter, LinkedIn, Google+, GitHub, and More*, 2nd Edition. O'Reilly Media, Inc.

## Session Plan

### Day 1

#### **Session 1: Introduction and Conceptual Issues in the Use of Digital Trace Data in Social Science, Computational Social Science, Digital Methods, and Big Data**

October 14, 2016 Friday—10:15 to 11:45

#### **Session 2: Set Up and Introduction to Collecting Data on Twitter**

October 14, 2016 Friday—12:45 to 14:00

#### **Session 3: Introduction to Python**

October 14, 2016 Friday—14:15 to 15:30

#### **Session 4: Collecting Data Through Twitter's API**

October 14, 2016 Friday—15:45 to 17:00

### Day 2

#### **Session 5: Data Lab**

October 15, 2016 Saturday—9:15 to 10:30

#### **Session 6: Loading Twitter Data Into a Database**

October 15, 2016 Saturday—10:45 to 12:00

#### **Session 7: Extracting Data for Typical Analyses**

October 15, 2016 Saturday—13:00 to 14:30

#### **Session 8: Data Lab**

October 15, 2016 Saturday—14:45 to 16:00

### Day 3

#### **Session 9: Presentation and Discussion of Students' Research Projects Pt. 1**

November 18, 2016 Friday—10:15 to 11:45

#### **Session 10: Presentation and Discussion of Students' Research Projects Pt. 2**

November 18, 2016 Friday—13:00 to 14:30

#### **Session 11: Presentation and Discussion of Students' Research Projects Pt. 3**

November 18, 2016 Friday—14:45 to 16:15

#### **Session 12: Discussion of Open Questions and Potential Research Designs**

November 18, 2016 Friday—16:30 to 17:00

### Day 4

#### **Session 13: Sample Analyses: Why Count?**

November 19, 2016 Saturday—09:15 to 10:30

#### **Session 14: Sample Analyses: Time Series**

November 19, 2016 Saturday—10:45 to 12:00

#### **Session 15: Data Lab**

November 19, 2016 Saturday—13:00 to 14:30

**Session 16: Where to take it from here? Discussion of Open Questions and Paper**  
November 19, 2016 Saturday—14:45 to 16:00

## Detailed Session Plan and Suggested Readings

### Session 1: Introduction and Conceptual Issues in the Use of Digital Trace Data in Social Science, Computational Social Science, Digital Methods, and Big Data

October 14, 2016 Friday—10:15 to 11:45

#### Required Readings:

- Pascal Jürgens and Andreas Jungherr (2016) *A Tutorial for Using Twitter Data in the Social Sciences: Data Collection, Preparation, and Analysis*. *Social Science Research Network (SSRN)*. doi: 10.2139/ssrn.2710146. Available at [http://papers.ssrn.com/sol3/papers.cfm?abstract\\_id=2710146](http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2710146) (pp. 7-14)

#### Background Readings:

- David Donoho. *50 Years of Data Science*. Paper presented at the Tukey Centennial workshop, Princeton, NJ. Sept. 18 (2015).
- Bradley Efron and Trevor Hastie. *Computer Age Statistical Inference: Algorithms, Evidence, and Data Science*. Cambridge, UK: Cambridge University Press. 2016.
- Deen Freelon. "On the interpretation of digital trace data in communication and social computing research". In: *Journal of Broadcasting & Electronic Media* 58.1 (2014), pp. 59–75. doi: 10.1080/08838151.2013.875018.
- Scott A. Golder and Michael W. Macy. "Digital Footprints: Opportunities and Challenges for Online Social Research". In: *Annual Review of Sociology* 40 (2014), pp. 129–152. doi: 10.1146/annurevsoc071913043145.
- James Howison, Andrea Wiggins, and Kevin Crowston. "Validity issues in the use of social network analysis with digital trace data". In: *Journal of the Association for Information Systems* 12.12 (2011), pp. 767–797.
- Andreas Jungherr. *Analyzing Political Communication with Digital Trace Data: The Role of Twitter Messages in Social Science Research*. Cham, CH: Springer, 2015.
- Andreas Jungherr and Pascal Jürgens. "Forecasting the pulse: How deviations from regular patterns in online data can identify offline phenomena". In: *Internet Research* 23.5 (2013), pp. 589–607. doi: 10.1108/IntR-06-2012-0115.
- Andreas Jungherr, Harald Schoen, and Pascal Jürgens. "The mediation of politics through Twitter: An analysis of messages posted during the campaign for the German federal election 2013". In: *Journal of Computer-Mediated Communication* 21.1 (2016), pp. 50.68. doi: 10.1111/jcc4.12143.
- Andreas Jungherr, Harald Schoen, Oliver Posegga, and Pascal Jürgens. "Digital Trace Data in the Study of Public Opinion: An Indicator of Attention Toward Politics Rather Than Political Support". In: *Social Science Computer Review*. (2016). doi: 10.1177/0894439316631043.
- David Lazer et al. "Computational social science". In: *Science* 323.5915 (2009), pp. 721–723. doi: 10.1126/science.1167742.
- David Lazer et al. "The Parable of Google Flu: Traps in Big Data Analysis". In: *Science* 343.6176 (2014), pp. 1203–1205. doi: 10.1126/science.1248506.
- Viktor Mayer-Schönberger and Kenneth Cukier. *Big Data: A Revolution that Will Transform How We Live, Work, and Think*. New York, NY: Houghton Mifflin, 2013.
- Richard Rogers. *Digital Methods*. Cambridge, MA: The MIT Press, 2013.
- Derek Ruths and Jürgen Pfeffer. "Social media for large studies of behavior". In: *Science* 346.6213 (2014), pp. 1063–1064. doi: 10.1126/science.346.6213.1063.
- Matthew J. Salganik. *Bit By Bit: Social Research in the Digital Age*. Princeton, NJ: Princeton University Press. 2017.
- Markus Strohmaier and Claudia Wagner. "Computational Social Science for the World Wide Web". In: *IEEE Intelligent Systems* 29.5 (2014), pp. 84–88. doi: 10.1109/MIS.2014.80.

### Session 2: Set Up and Introduction to Collecting Data on Twitter

October 14, 2016 Friday—12:45 to 14:00

*Required Readings:*

- Jürgens & Jungherr (2016) (pp. 15-20)

*Background Readings:*

- Nick Eubank (2015) *Data Analysis in Python*. Available at <http://www.data-analysis-in-python.org/index.html>
- Matthew A. Russell. *Mining the Social Web*. 2nd ed. Sebastopol, CA: O'Reilly Media, 2014.

**Session 3: Introduction to Python**

October 14, 2016 Friday—14:15 to 15:30

*Required Readings:*

- Nick Eubank (2015) *Data Analysis in Python*. Available at <http://www.data-analysis-in-python.org/index.html>

*Background Readings:*

- Swaroop Chitlur: *A Byte of Python*. Available at <http://python.swaroopch.com>
- Mark Lutz *Learning Python*, 5th ed. Sebastopol, CA: O'Reilly Media, 2013.
- Wes McKinney. *Python for Data Analysis*. Sebastopol, CA: O'Reilly Media, 2013.
- Sebastian Raschka. *Python Machine Learning*. 2015. PACKT Publishing.
- Al Sweigart (2015): *Automate the Boring Stuff with Python: Practical Programming for Total Beginners*. No Starch Press.

**Session 4: Collecting Data Through Twitter's API**

October 14, 2016 Friday—15:45 to 17:00

*Required Readings:*

- Jürgens & Jungherr (2016) (pp. 21-28)

*Background Readings:*

- Matthew A. Russell. *Mining the Social Web*. 2nd ed. Sebastopol, CA: O'Reilly Media, 2014.

**Session 5: Data Lab**

October 15, 2016 Saturday—9:15 to 10:30

**Session 6: Loading Twitter Data Into a Database**

October 15, 2016 Saturday—10:45 to 12:00

*Required Readings:*

- Jürgens & Jungherr (2016) (pp. 29-41)

*Background Readings:*

- Grant Allen and Mike Owens. *The Definitive Guide to SQLite*. 2nd. New York, NY: Apress, 2010.
- Jay A. Kreibich. *Using SQLite: Small. Fast. Reliable. Choose Any Three*. Sebastopol, CA: O'Reilly Media, 2010.
- Charles Leifer. *pewee Documentation*. 2016. Available at <http://pewee.readthedocs.io/en/latest/>

**Session 7: Extracting Data for Typical Analyses**

October 15, 2016 Saturday—13:00 to 14:30

*Required Readings:*

- Jürgens & Jungherr (2016) (pp. 42-79)

*Background Readings:*

- Winston Chang (2012) *R Graphics Cookbook*. O'Reilly Media, Inc.
- Garrett Grolemund and Hadley Wickham (2016) *R for Data Science*. O'Reilly Media, Inc. Available at <http://r4ds.had.co.nz>
- Robert Kabacoff (2015) *R in Action*. 2nd ed. Manning Publications.
- Eric D. Kolaczyk and Gábor Csárdi (2014) *Statistical Analysis of Network Data with R*. Springer.
- Janet M. Box-Steffensmeier et al. (2014) *Time Series Analysis for the Social Sciences*. New York, NY: Cambridge University Press.
- Hadley Wickham (2016) *ggplot2: Elegant Graphics for Data Analysis*. 2nd ed. Springer.

### Session 8: Data Lab

October 15, 2016 Saturday—14:45 to 16:00

### Session 9: Presentation and Discussion of Students' Research Projects Pt. 1

November 18, 2016 Friday—10:15 to 11:45

#### Required Readings:

- Andreas Jungherr. "Twitter Use in Election Campaigns: A Systematic Literature Review". In: *Journal of Information Technology & Politics* 13.1 (2016). doi: 10.1080/19331681.2015. 1132401.

#### Background Readings:

##### How to Find a Research Questions:

Howard S. Becker. *Tricks of the Trade: How to think about your research while you're doing it* (1998). Chicago, IL: University of Chicago Press.

#### Conceptual Issues in Working with Digital Trace Data:

- Fernando Diaz et al. "Online and social media data as a flawed continuous panel survey". In: *PLoS ONE* 11.1 (2016). e0145406. doi:10.1371/journal.pone.0145406.
- James Howison, Andrea Wiggins, and Kevin Crowston. "Validity issues in the use of social network analysis with digital trace data". In: *Journal of the Association for Information Systems* 12.12 (2011), pp. 767–797.
- Lilli Japiec, Frauke Kreuter, Marcus Berg, Paul Biemer, Paul Decker, Cliff Lampe, Julia Lane, Cathy O'Neil, and Abe Usher. "Big Data in Survey Research: AAPOR Task Force Report". In: *Public Opinion Quarterly* 79.4 (2015), pp. 839-880. doi: 10.1093/poq/nfv039
- Andreas Jungherr, Harald Schoen, and Pascal Jürgens. "The mediation of politics through Twitter: An analysis of messages posted during the campaign for the German federal election 2013". In: *Journal of Computer-Mediated Communication* 21.1 (2016), pp. 50.68. doi: 10.1111/jcc4.12143.
- Andreas Jungherr, Harald Schoen, Oliver Posegga, and Pascal Jürgens. "Digital Trace Data in the Study of Public Opinion: An Indicator of Attention Toward Politics Rather Than Political Support". In: *Social Science Computer Review*. (2016). doi: 10.1177/0894439316631043
- David Lazer et al. "The Parable of Google Flu: Traps in Big Data Analysis". In: *Science* 343.6176 (2014), pp. 1203–1205. doi: 10.1126/science.1248506.
- Filipe N Ribeiro, Matheus Araújo, Pollyanna Gonçalves, Marcos André Gonçalves, and Fabrício Benevenuto. "SentiBench - a benchmark comparison of state-of-the-practice sentiment analysis methods". *EPJ Data Science* 5.23 (2016) doi: 10.1140/epjds/s13688-016-0085-1
- Matthew J. Salganik. *Bit By Bit: Social Research in the Digital Age*. Princeton, NJ: Princeton University Press. 2017.
- Michael F. Schober, Josh Pasek, Lauren Guggenheim, Cliff Lampe, and Frederick G. Conrad. "Social Media Analyses for Social Measurement". *Public Opinion Quarterly* 80.1 (2016), pp. 180-211. doi: 10.1093/poq/nfv048

#### Case Studies Illustrating Different Approaches to the Use of Twitter data

- Pablo Barberá. "Birds of the same feather tweet together: Bayesian ideal point estimation using Twitter data". In: *Political Analysis* 23.1 (2015), pp. 76–91. doi: 10.1093/pan/mpu011.

- Marco T. Bastos, Dan Mercea, and Arthur Charpentier. “Tents, Tweets, and Events: The Interplay Between Ongoing Protests and Social Media”. In: *Journal of Communication* 65.2 (2015), pp. 320–350. doi: 10.1111/jcom.12145.
- Michael D. Conover et al. “Political polarization on Twitter”. In: *ICWSM 2011: Proceedings of the 5th International AAAI Conference on Weblogs and Social Media*. Ed. by Nicolas Nicolov et al. Menlo Park, CA: Association for the Advancement of Artificial Intelligence (AAAI), 2011, pp. 89–96.
- Peter Sheridan Dodds, Kameron Decker Harris, Isabel M. Kloumann, Catherine A. Bliss, Christopher M. Danforth. “Temporal Patterns of Happiness and Information in a Global Social Network: Hedonometrics and Twitter”. *PLoS ONE* 6.12 (2011), e26752. doi: 10.1371/journal.pone.0026752
- Elizabeth Dubois and Devin Gaffney. “The multiple facets of Influence: Identifying political influentials and opinion leaders on Twitter”. *American Behavioural Scientist* 58.10 (2014), pp. 1260-1277. doi: 10.1177/0002764214527088
- Deen Freelon. “Analyzing online political discussion using three models of democratic communication”. *New Media & Society* 12.7 (2010), pp. 1172-1190. doi: 10.1177/1461444809357927.
- Sharad Goel et al. “The Structural Virality of Online Diffusion”. In: *Management Science* 62.1 (2015), pp. 180-196. doi: 10.1287/mnsc.2015.2158.
- Todd Graham et al. “Between broadcasting political messages and interacting with voters: The use of Twitter during the 2010 UK general election campaign”. In: *Information, Communication & Society* 16.5 (2013), pp. 692–716. doi: 10.1080/1369118X.2013.785581.
- Mark Edward Huberty. “Can we vote with our tweet? On the perennial difficulty of election forecasting with social media”. In: *International Journal of Forecasting* 31.3 (2015), pp. 992–1007. doi: 10.1016/j.ijforecast.2014.08.005.
- Andreas Jungherr. “The logic of political coverage on Twitter: Temporal dynamics and content”. In: *Journal of Communication* 64.2 (2014), pp. 239–259. doi: 10.1111/jcom.12087.
- Andreas Jungherr. *Analyzing Political Communication with Digital Trace Data: The Role of Twitter Messages in Social Science Research* (2015). Cham: Springer. doi: 10.1007/978-3-319-20319-5
- Andreas Jungherr and Pascal Jürgens. “Through a glass, darkly: Tactical support and symbolic association in Twitter messages commenting on Stuttgart 21”. In: *Social Science Computer Review* 32.1 (2014), pp. 74–89. doi: 10.1177/0894439313500022
- Pascal Jürgens, Andreas Jungherr, and Harald Schoen. “Small Worlds with a Difference: New Gatekeepers and the Filtering of Political Information on Twitter.” In *WebSci '11: Proceedings of the 3rd International Web Science Conference*. New York, NY: ACM, 2011. doi: 10.1145/2527031.2527034
- Daniel Kreiss. “Seizing the Moment: The Presidential Campaigns’ Use of Twitter During the 2012 Electoral Cycle”. *New Media & Society* (2014). (Online First). doi: 10.1177/1461444814562445
- Yu-Ru Lin et al. “Rising tides or rising stars? Dynamics of shared attention on Twitter during media events”. In: *PLoS One* 9.5 (2014), e94093. doi: 10.1371/journal.pone.0094093.
- Panagiotis Takis Metaxas, Eni Mustafaraj, and Daniel Gayo Avello. “How (not) to predict elections”. In: *SocialCom 2011: The 3rd IEEE International Conference on Social Computing*. Washington, DC: IEEE, 2011, pp. 165–171. doi: 10.1109/PASSAT/SocialCom.2011.98.
- W. Russell Neuman, Lauren Guggenheim, S. Mo Jang, and Soo Young Bae. “The Dynamics of Public Attention: Agenda-Setting Theory Meets Big Data”. *Journal of Communication* 64.2 (2014), pp. 193–214. doi: 10.1111/jcom.12088
- Richard Rogers. “Debanalizing Twitter: The transformation of an object of study”. In: *WebSci 2013: Proceedings of the 5th Annual ACM Web Science Conference*. Ed. by Hugh Davis et al. New York, NY: ACM, 2013, pp. 356–365. doi: 10.1145/2464464.2464511.
- David A. Shamma, Lyndon Kennedy, and Elizabeth F. Churchill. “Peaks and persistence: Modeling the shape of microblog conversations”. In: *CSCW 2011: Proceedings of the ACM 2011 Conference on Computer Supported Cooperative Work*. Ed. by Pamela Hinds et al. New York, NY: ACM, 2011, pp. 355–358. doi: 10.1145/1958824.195887810.1145/1958824.1958878.
- Niels Spierings, Kristof Jacobs. Getting Personal? The Impact of Social Media on Preferential Voting. *Political Behavior* 36.1 (2014), pp 215–234. doi: 10.1007/s11109-013-9228-2



- Damian Trilling. "Two Different Debates? Investigating the Relationship Between a Political Debate on TV and Simultaneous Comments on Twitter". In: *Social Science Computer Review* 33.3 (2015), pp. 259–276. doi: 10.1177/0894439314537886.
- Maurice Vergeer and Liesbeth Hermans. „Campaigning on Twitter: Microblogging and Online Social Networking as Campaign Tools in the 2010 General Elections in the Netherlands“. In *Journal of Computer-Mediated Communication* 18.4 (2013), pp 399–419. doi: 10.1111/jcc4.12023
- Maurice Vergeer, Liesbeth Hermans, and Steven Sams. „Online social networks and micro-blogging in political campaigning: The exploration of a new campaign tool and a new campaign style“. *Party Politics* 19.3 (2013), pp. 477-501. doi: 10.1177/1354068811407580.

#### *Datasets*

Lars Kaczmirek, Philipp Mayr, Ravi Vatrapsu, Arnim Bleier, Manuela Blumenberg, Tobias Gummer, Abid Hussain, Katharina Kinder-Kurlanda, Kaveh Manshaei, Mark Thamm, Katrin Weller, Alexander Wenz, and Christof Wolf. "Social Media Monitoring of the Campaigns for the 2013 German Bundestag Elections on Facebook and Twitter". [arXiv.org](http://arxiv.org/abs/1312.4476) 1312.4476 (2014). Available at <http://arxiv.org/abs/1312.4476>

#### **Session 10: Presentation and Discussion of Students' Research Projects Pt. 2**

November 18, 2016 Friday—13:00 to 14:30

#### **Session 11: Presentation and Discussion of Students' Research Projects Pt. 3**

November 18, 2016 Friday—14:45 to 16:15

#### **Session 12: Discussion of Open Questions and Potential Research Designs**

November 18, 2016 Friday—16:30 to 17:00

#### **Session 13: Sample Analyses: Why Count?**

November 19, 2016 Saturday—09:15 to 10:30

#### *Required Readings:*

- Jürgens & Jungherr (2016) (pp. 44-52)

#### **Session 14: Sample Analyses: Time Series**

November 19, 2016 Saturday—10:45 to 12:00

#### *Required Readings:*

- Jürgens & Jungherr (2016) (pp. 53-67)

#### **Session 15: Data Lab**

November 19, 2016 Saturday—13:00 to 14:30

#### **Session 16: Where to take it from here? Discussion of Open Questions and Paper**

November 19, 2016 Saturday—14:45 to 16:00

#### *Background Readings:*

#### *Using other data sources:*

- Matthew A. Russell. *Mining the Social Web*. 2nd ed. Sebastopol, CA: O'Reilly Media, 2014.

#### *Extending your analytical skill set:*

- Mario Callegaro, Katja Lozar Manfreda, and Vasja Vehovar. *Web Survey Methodology*. 2015. SAGE.
- David Donoho. *50 Years of Data Science*. Paper presented at the Tukey Centennial workshop, Princeton, NJ. Sept. 18, 2015.
- Bradley Efron and Trevor Hastie. *Computer Age Statistical Inference: Algorithms, Evidence, and Data Science*. Cambridge, UK: Cambridge University Press. 2016.

- Peter Flach. *Machine Learning: The Art and Science of Algorithms that Make Sense of Data*. 2012. Cambridge, UK: Cambridge University Press.
- Alan S. Gerber and Donald P. Green. *Field Experiments: Design, Analysis, and Interpretation*. 2012. W.W. Norton.
- Wes McKinney. *Python for Data Analysis*. Sebastopol, CA: O'Reilly Media. 2013.
- Sebastian Raschka. *Python Machine Learning*. 2015. PACKT Publishing.
- Matthew J. Salganik. *Bit By Bit: Social Research in the Digital Age*. Princeton, NJ: Princeton University Press. 2017.

*How might you employ these skills outside of academia:*

- Fred Benenson. *On to the next 2,271 days...* January 12, 2016.
- Thomas H. Davenport and D.J. Patil. "Data Scientist: The Sexiest Job of the 21st Century". In: *Harvard Business Review* (2012, October). Available at <https://hbr.org/2012/10/data-scientist-the-sexiest-job-of-the-21st-century/>
- Olivia Lau and Ian Yohai. "Using Quantitative Methods in Industry". In: *PS: Political Science & Politics* 49.3. 2016. pp. 524-526. doi: 10.1017/S1049096516000901
- David W. Nickerson and Todd Rogers. "Political Campaigns and Big Data". In: *The Journal of Economic Perspectives* 28.2. 2014. pp. 51-73. doi: 10.1257/jep.28.2.51
- Andrew Therriault. "Finding a Place in Political Data Science". In: *PS: Political Science & Politics* 49.3. 2016. pp. 531-533. doi: 10.1017/S1049096516000925