

Network Embeddings to Model Science, Technology, and Economic Growth

Science, Technology, Culture & Economic growth

Lingfei Wu, 2020, liw105@pitt.edu

1. Atypicality of knowledge: Uzzi et al. 2013

2. Disruption of ideas: Wu et al. 2019

3. Localization in production: Hidalgo et al. 2007

11. Complementarity of labors: Neffke 2019

12. Polarization of skills: Alabdulkareem 2018

Geometry

9. Reduction of dimensions: Tenenbaum et al. 2000

Complex Networks

10. Encoding of complexity: Newman 2006

7. Geometry of Cultures: Kozlowski et al. 2019

8. Diffusion of attention: Tshitoyan et al. 2019

Neural-Network Embeddings

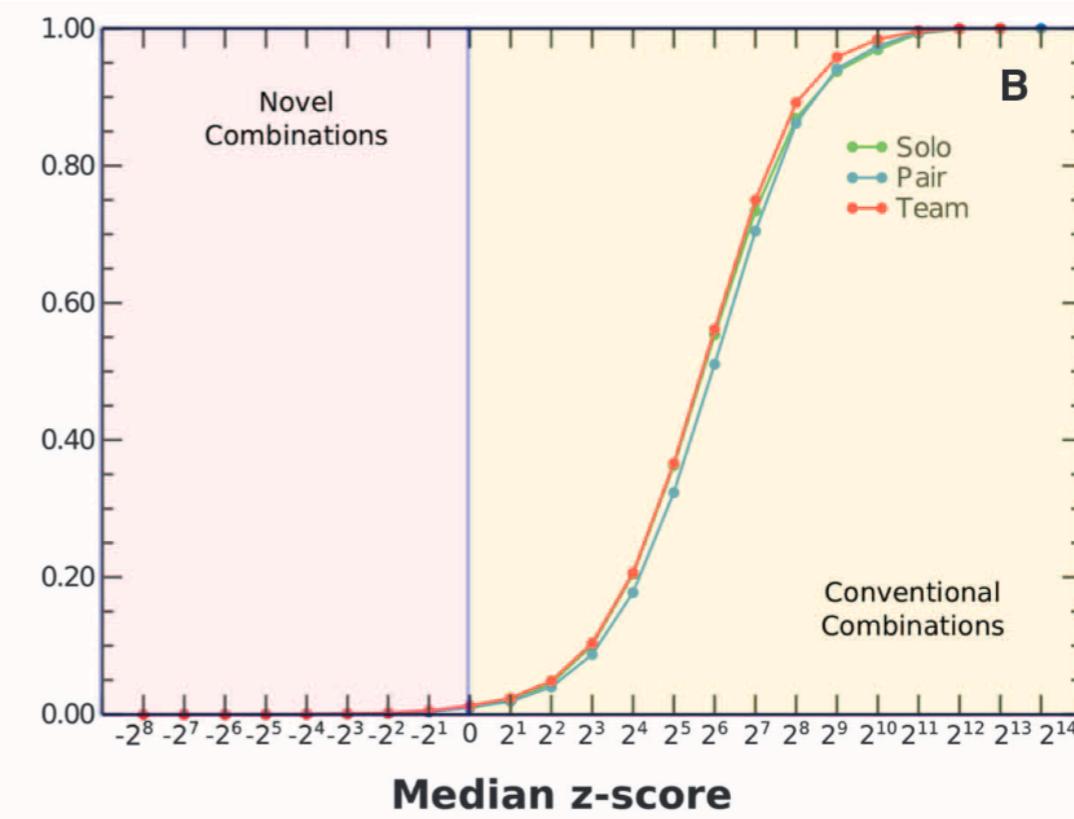
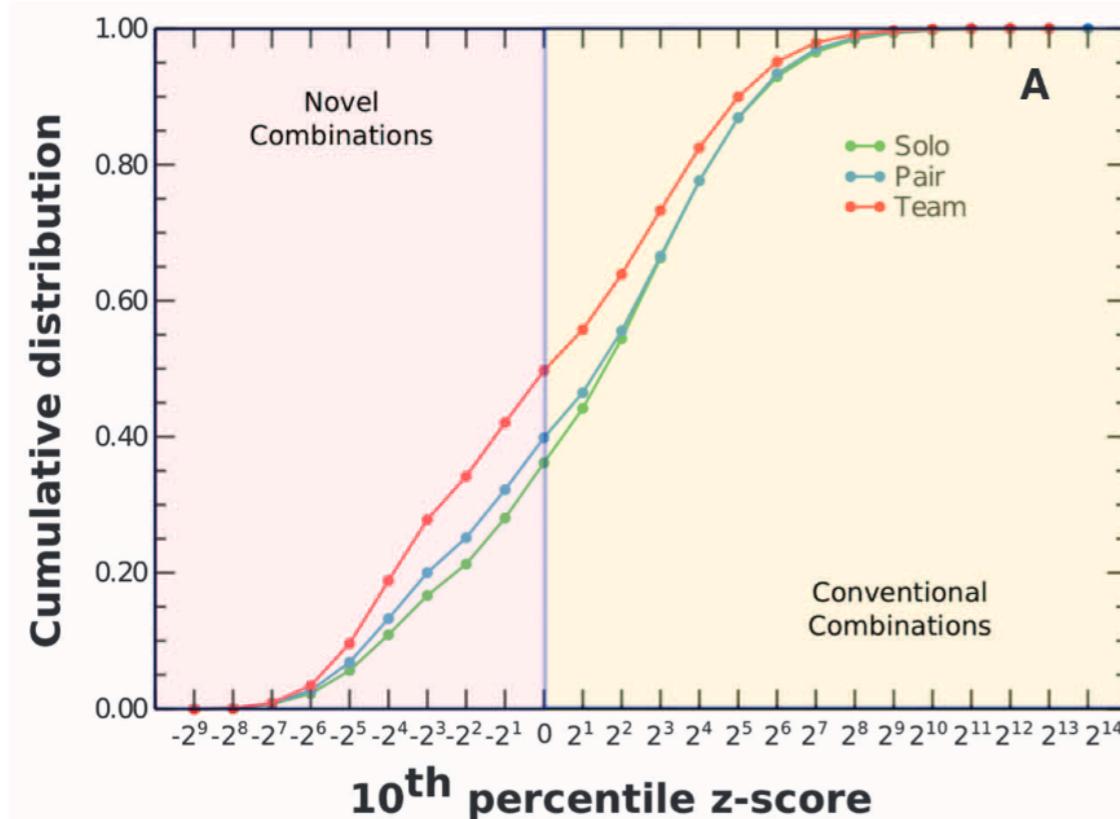
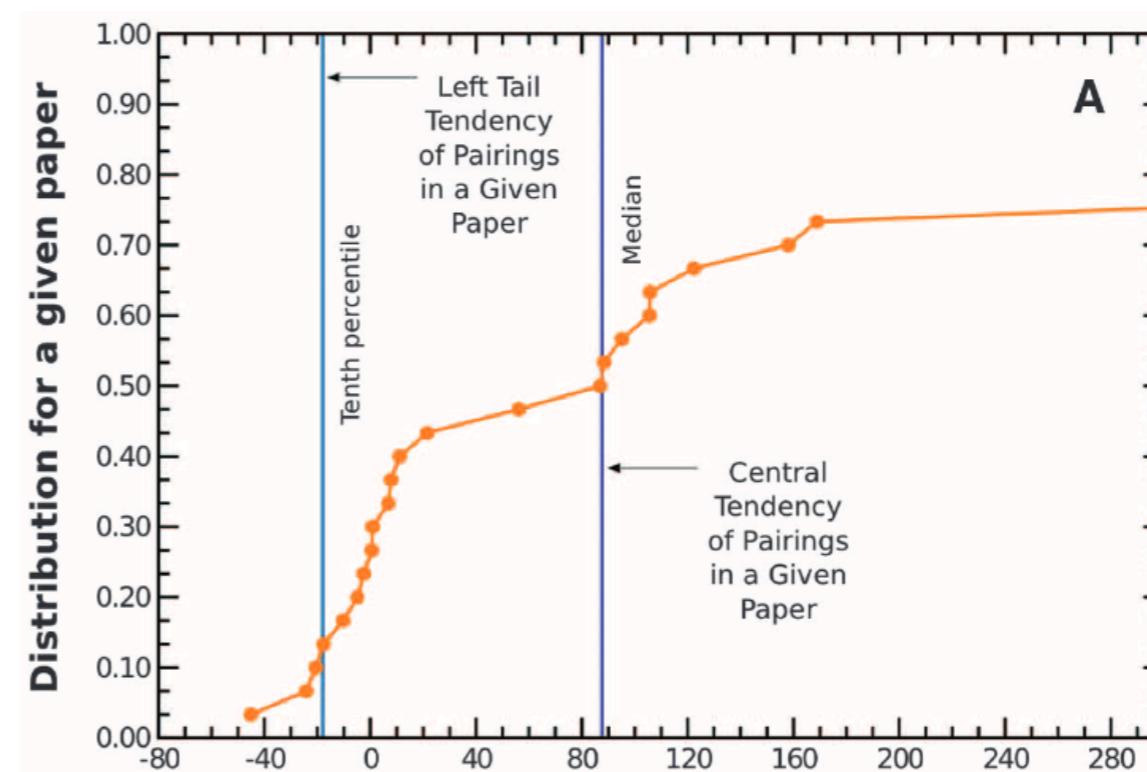
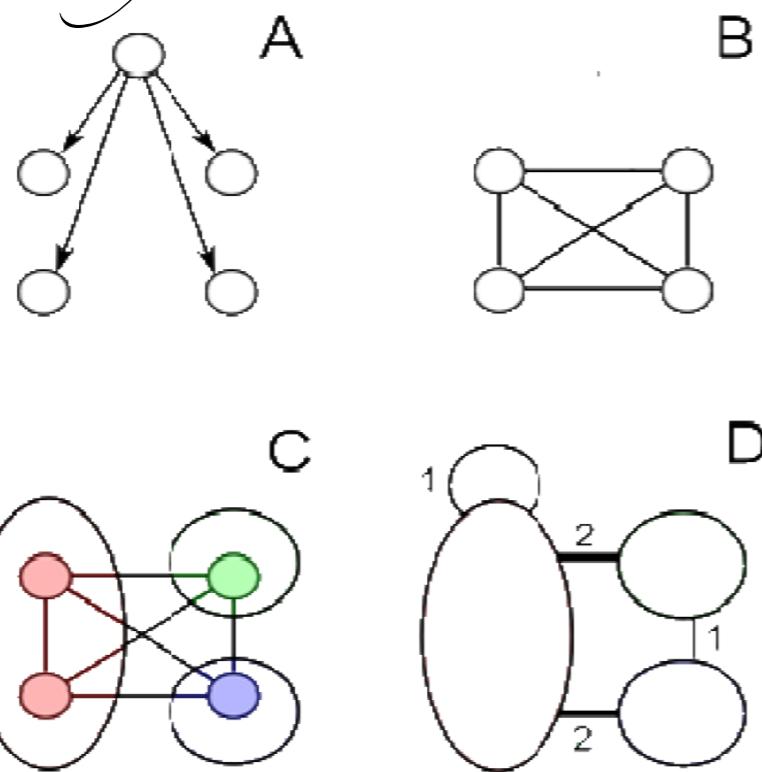
4. Compositionality of meanings: Mikolov et al., 2013

5. Factorization of connections: Levy & Goldberg 2014

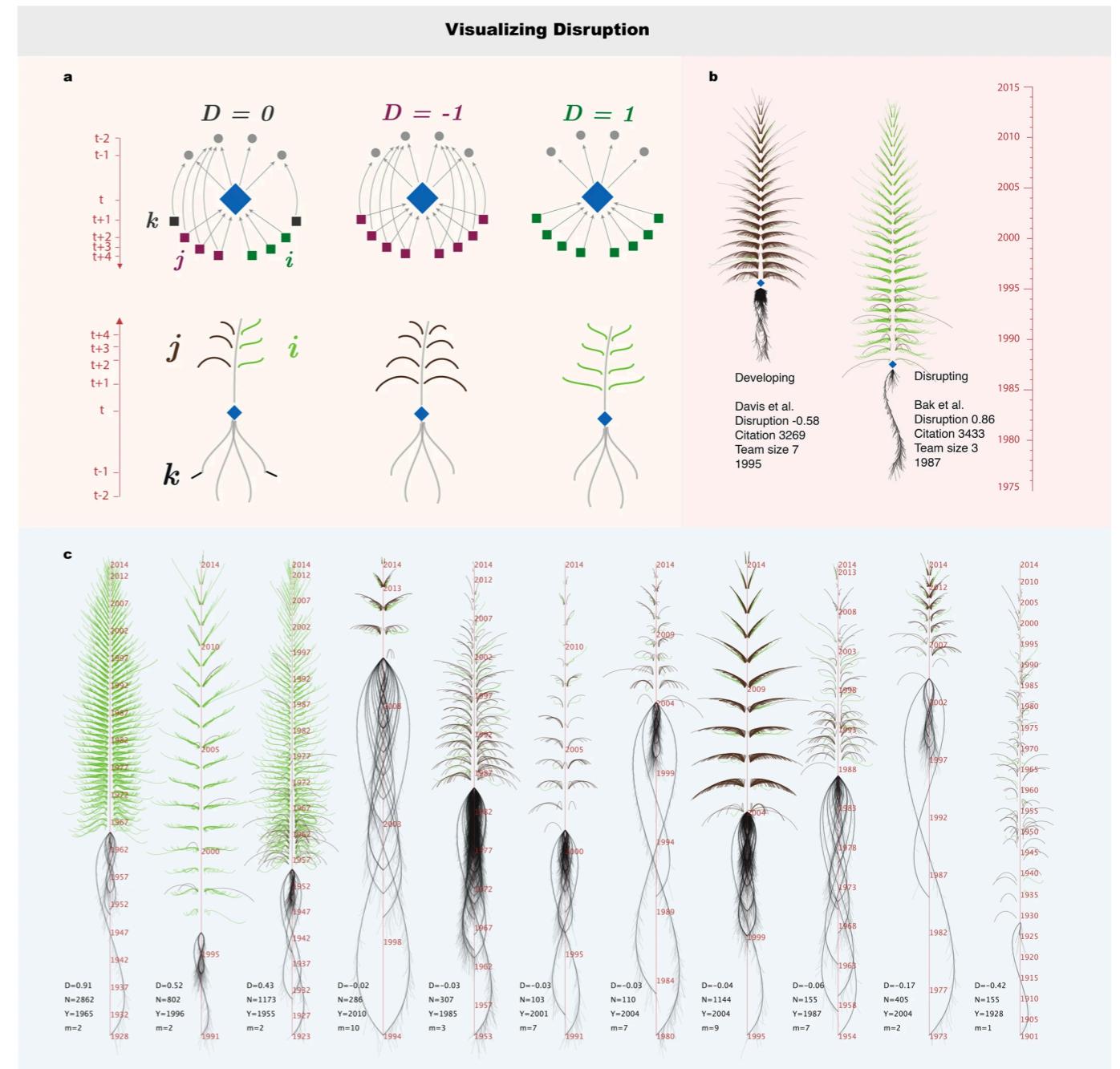
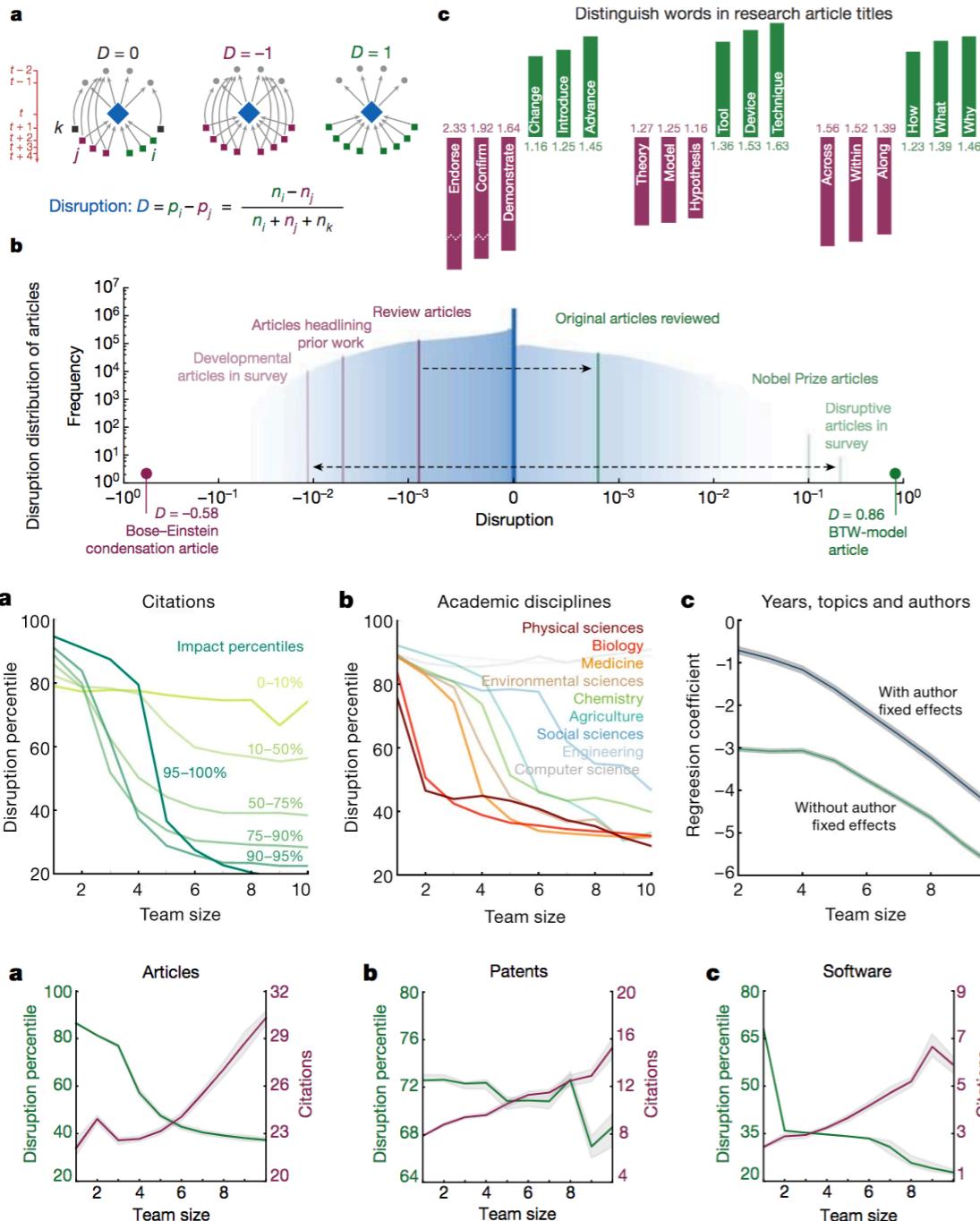
6. Relation as translation: Bordes et al. 2013

Time: Tuesday 12:10 - 2:50 pm, EST

Atypicality of knowledge

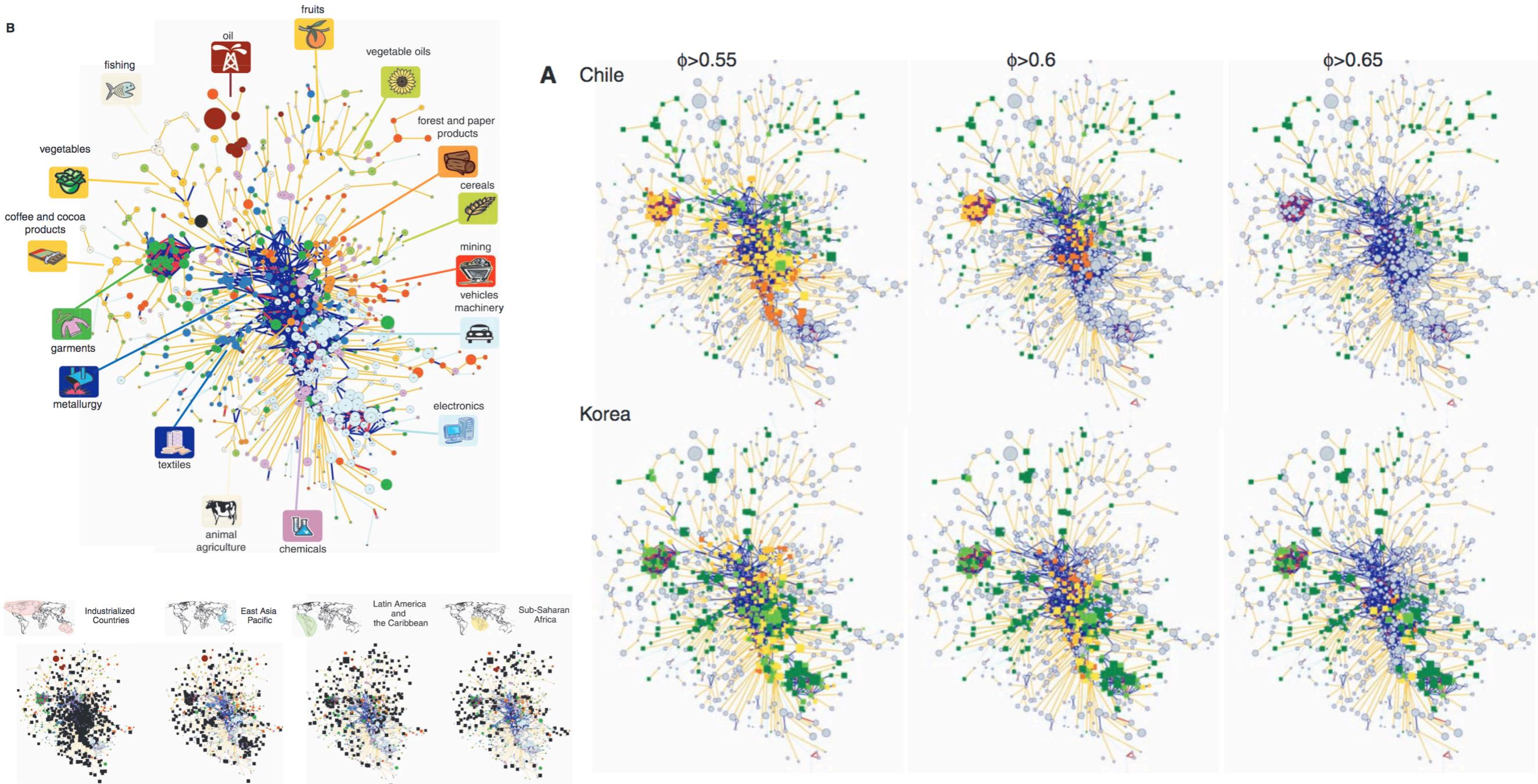


Disruption of ideas



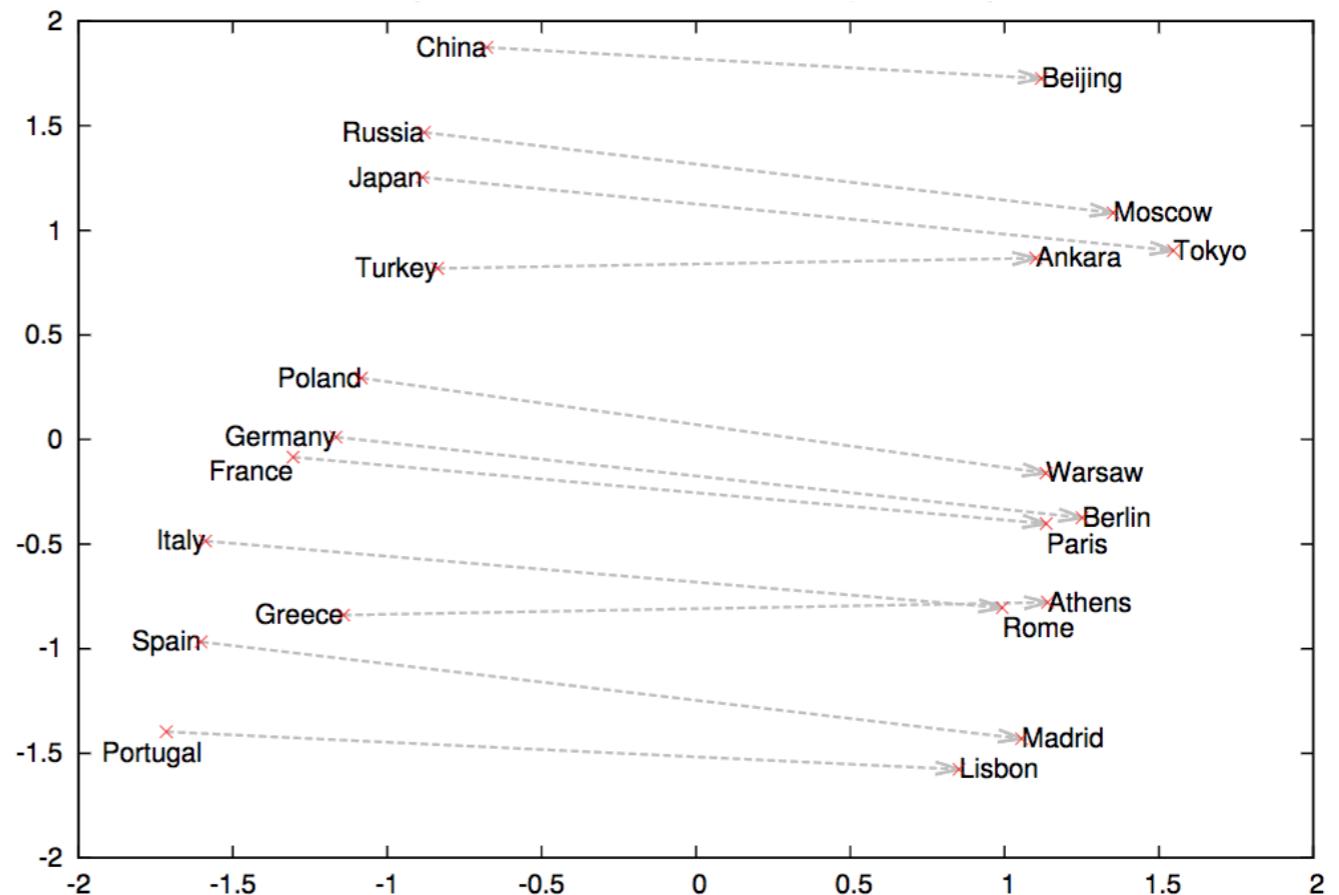
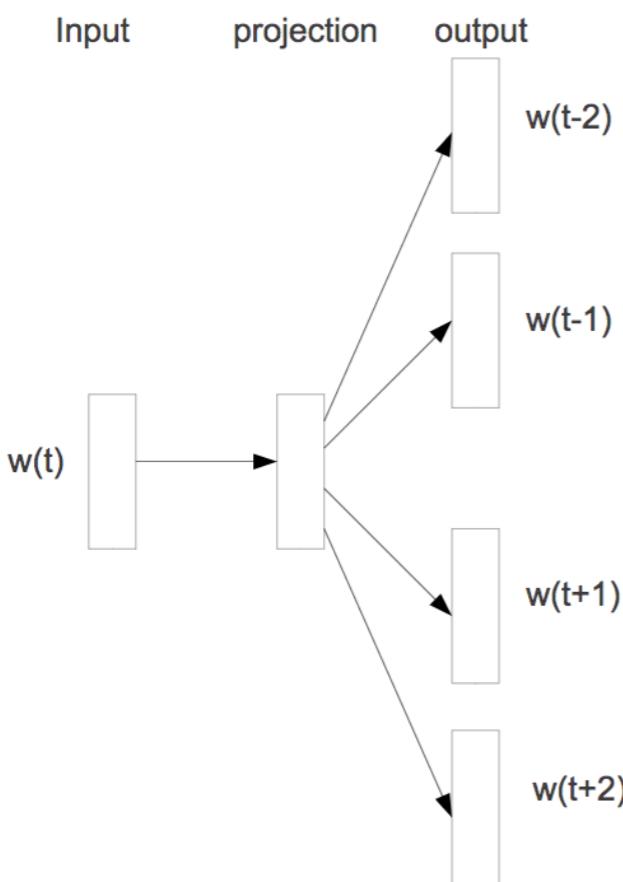
Wu, L., Wang, D., & Evans, J. A. (2019). Large teams develop and small teams disrupt science and technology. *Nature*, 566(7744), 378-382.

Localization in production



Hidalgo, C. A., Klinger, B., Barabási, A. L., & Hausmann, R. (2007). The product space conditions the development of nations. *Science*, 317(5837), 482-487.

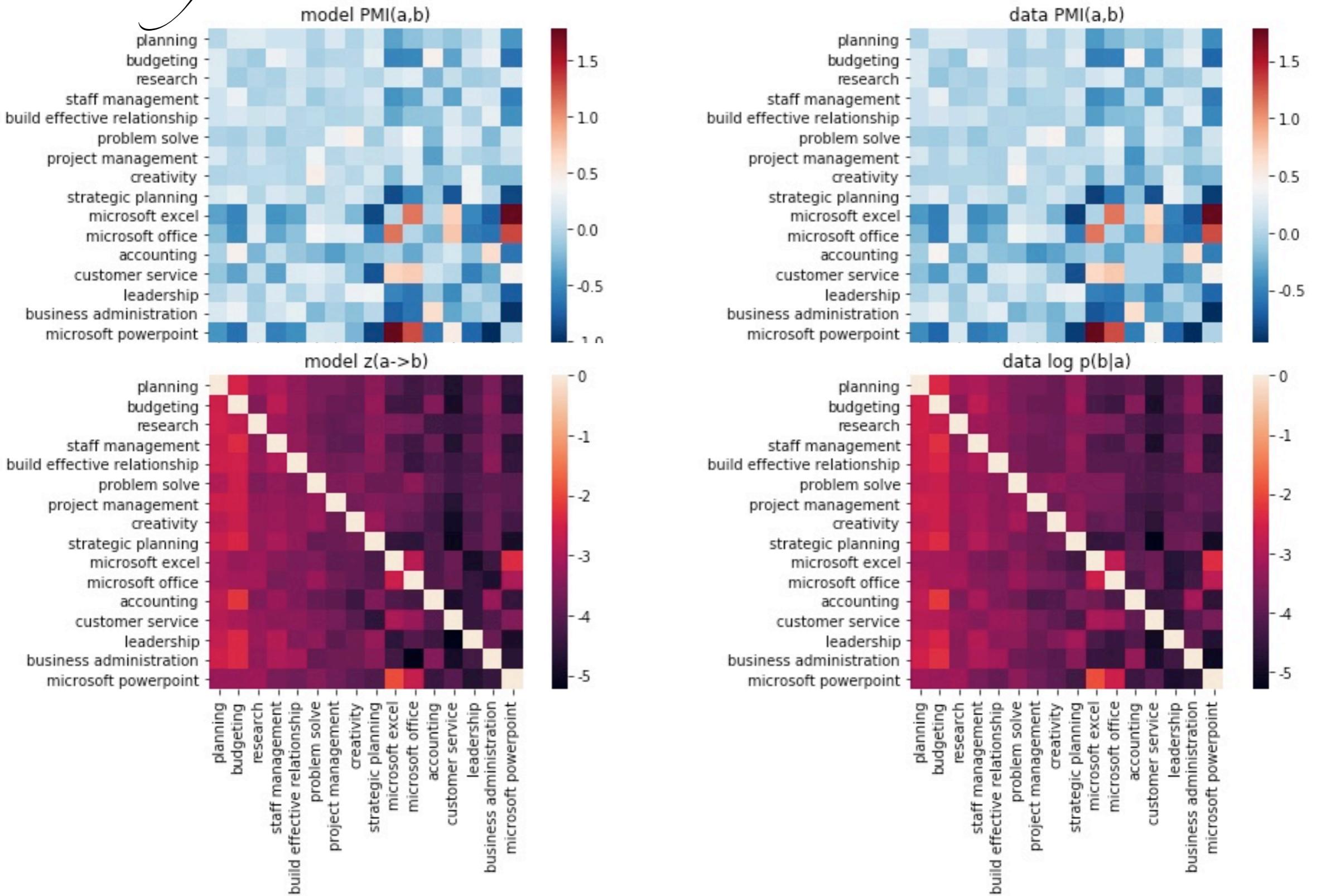
Compositionality of meanings



Czech + currency	Vietnam + capital	German + airlines	Russian + river	French + actress
koruna	Hanoi	airline Lufthansa	Moscow	Juliette Binoche
Check crown	Ho Chi Minh City	carrier Lufthansa	Volga River	Vanessa Paradis
Polish zolty	Viet Nam	flag carrier Lufthansa	upriver	Charlotte Gainsbourg
CTK	Vietnamese	Lufthansa	Russia	Cecile De

Mikolov, T., Sutskever, I., Chen, K., Corrado, G. S., & Dean, J. (2013). Distributed representations of words and phrases and their compositionality. In *Advances in neural information processing systems* (pp. 3111-3119).

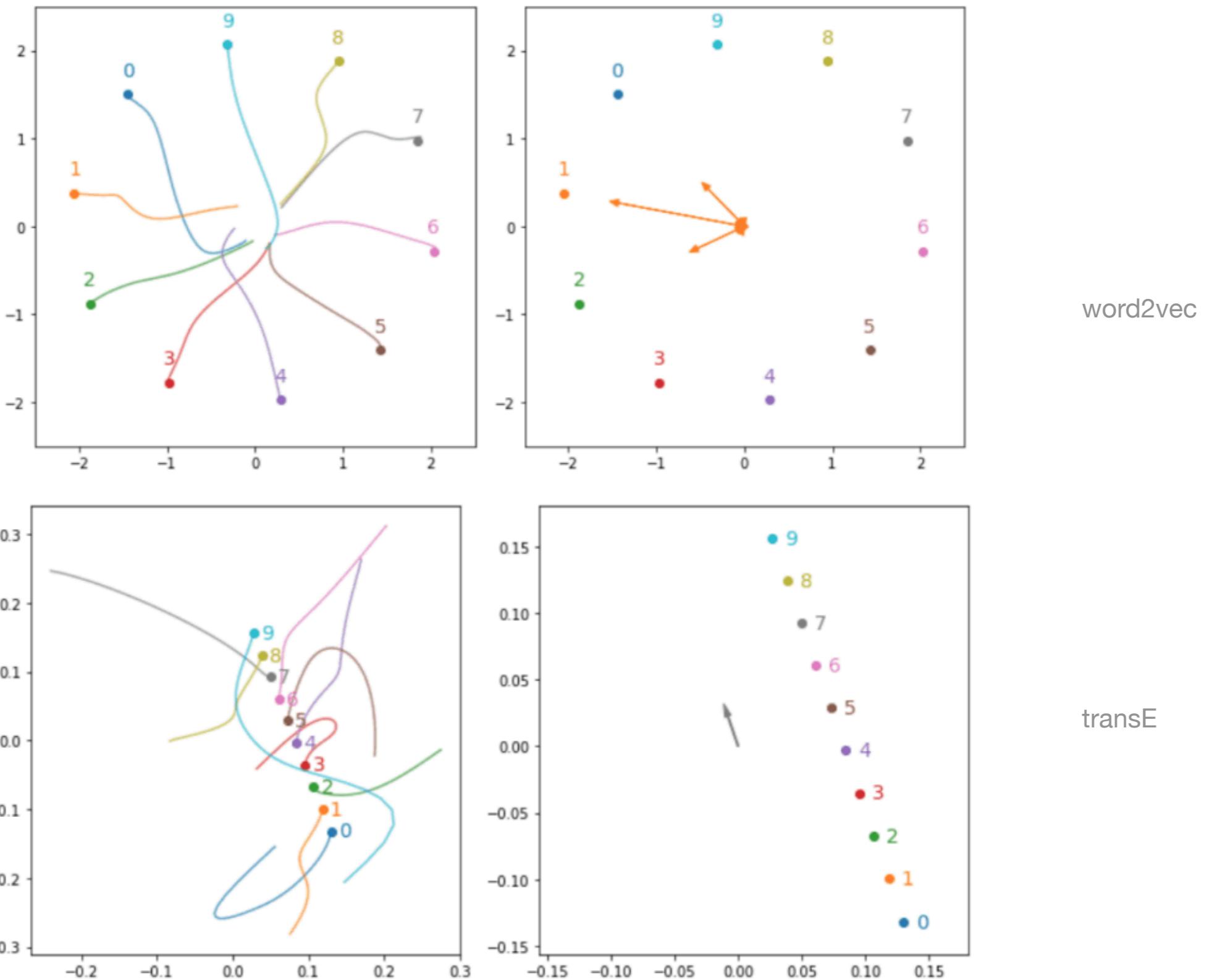
Factorization of connections



Levy, O., & Goldberg, Y. (2014). Neural word embedding as implicit matrix factorization. In Advances in neural information processing systems (pp. 2177-2185).

Figure created by Yiling & Lingfei Wu (2020)

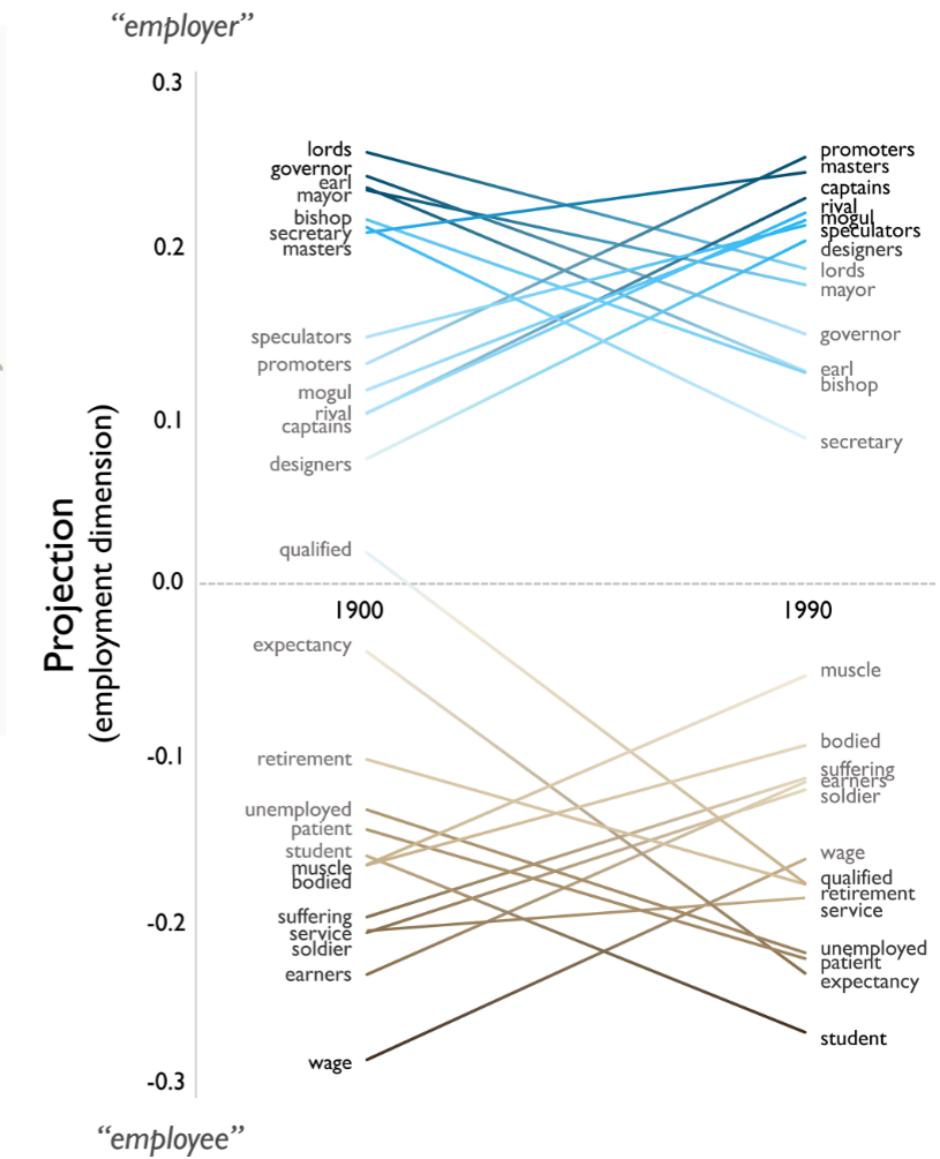
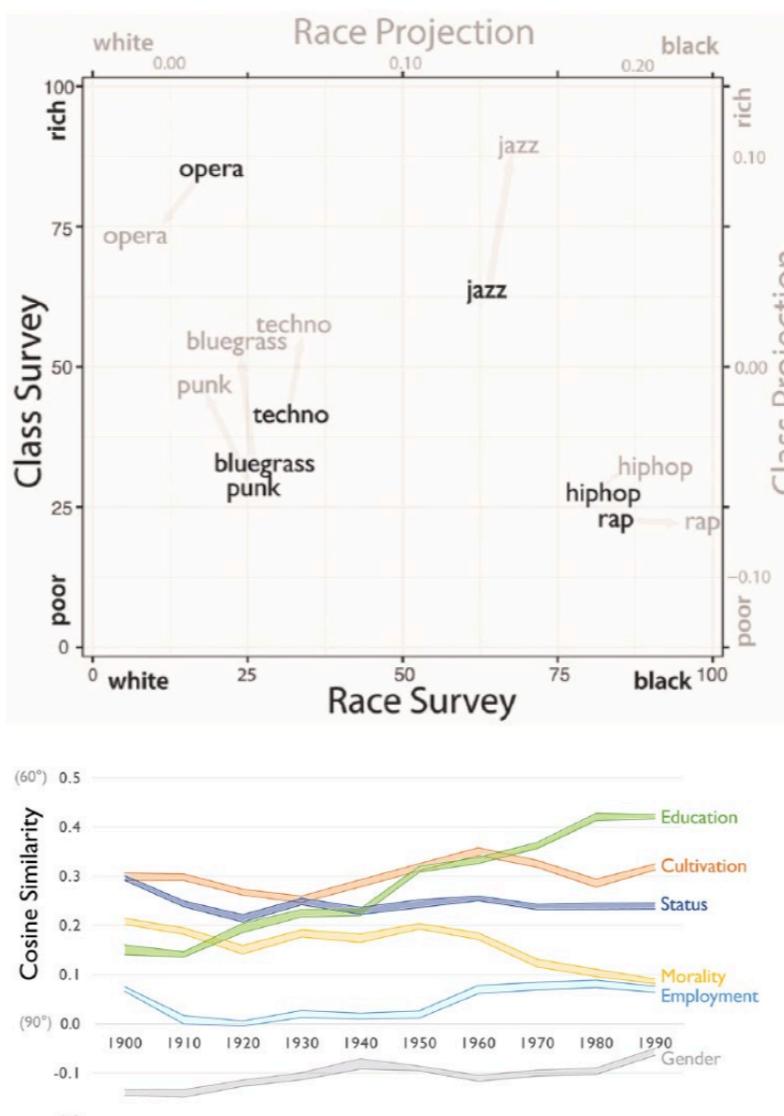
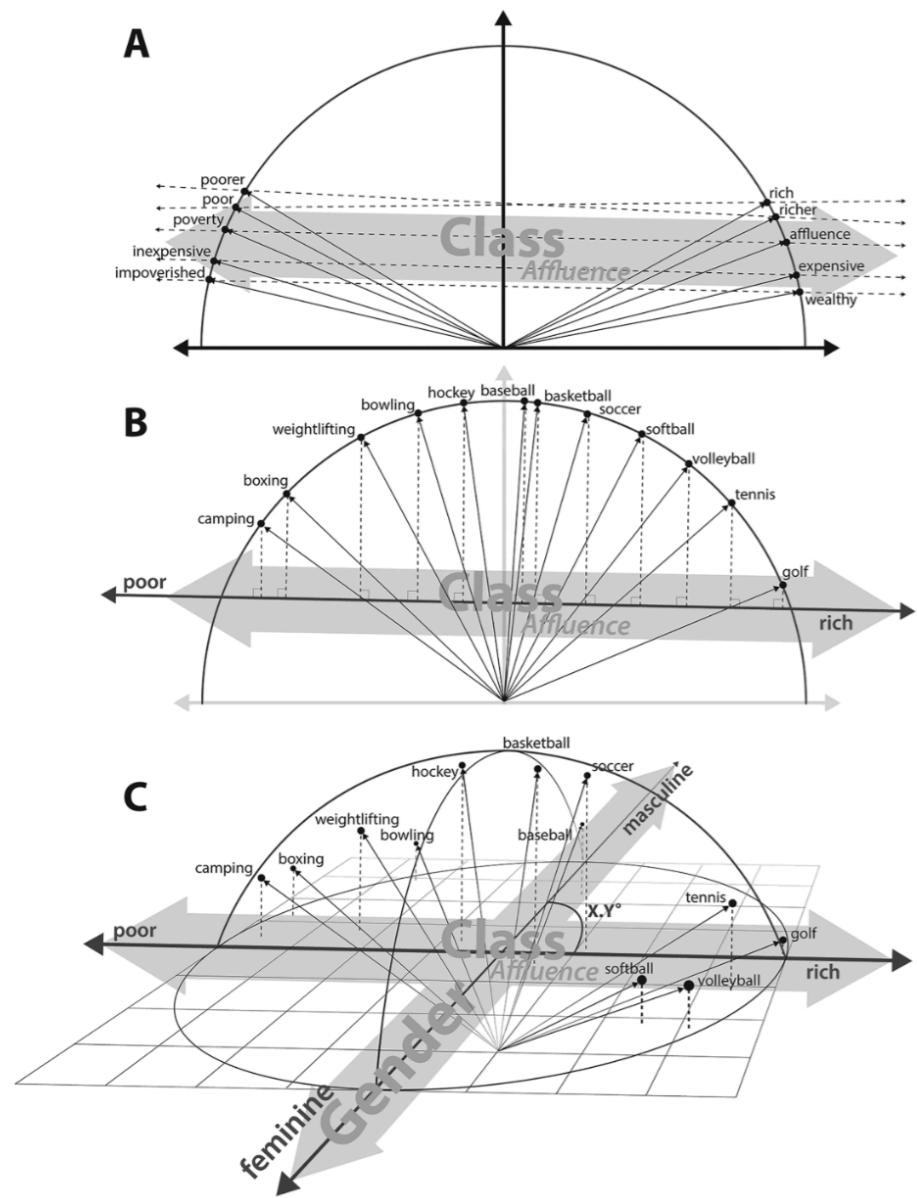
Relation as translation



Bordes, A., Usunier, N., Garcia-Duran, A., Weston, J., & Yakhnenko, O. (2013). Translating embeddings for modeling multi-relational data. In Advances in neural information processing systems (pp. 2787-2795).

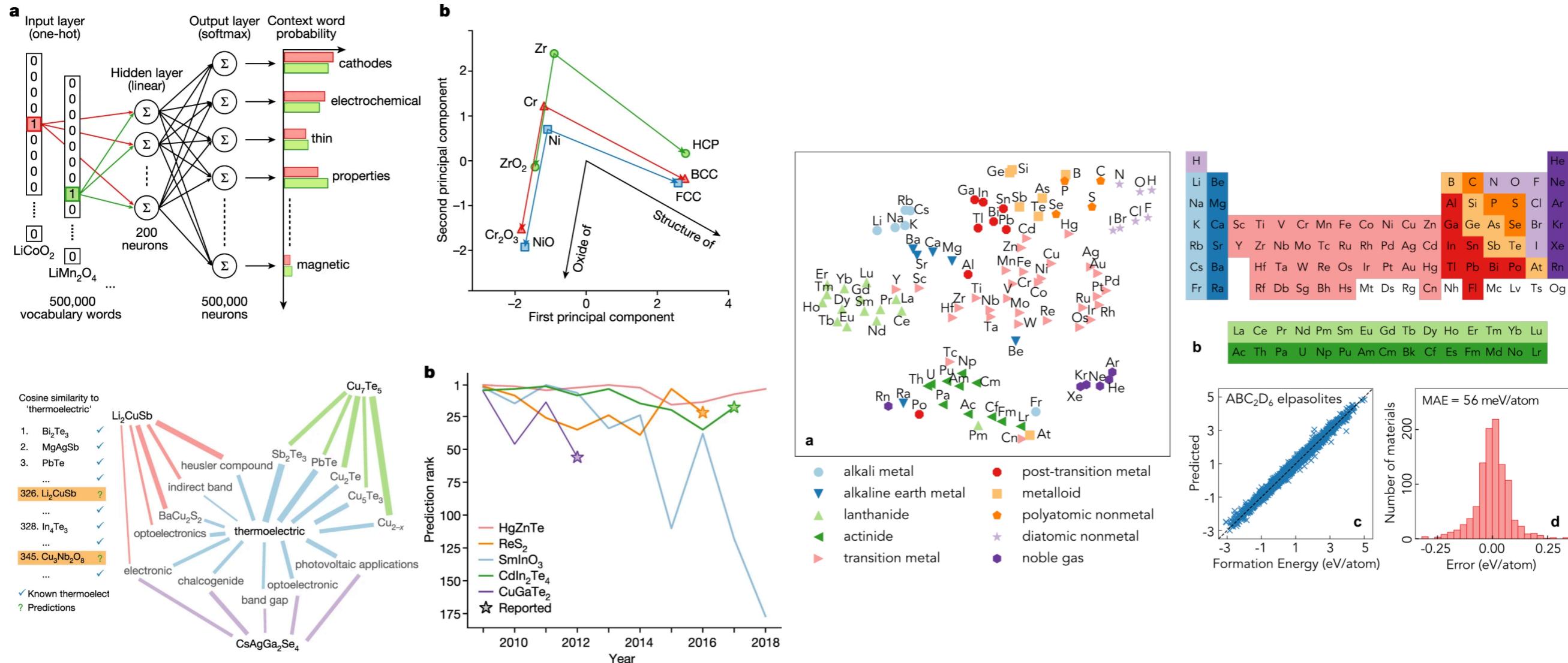
Figure created by Lingfei Wu (2019)

Geometry of culture



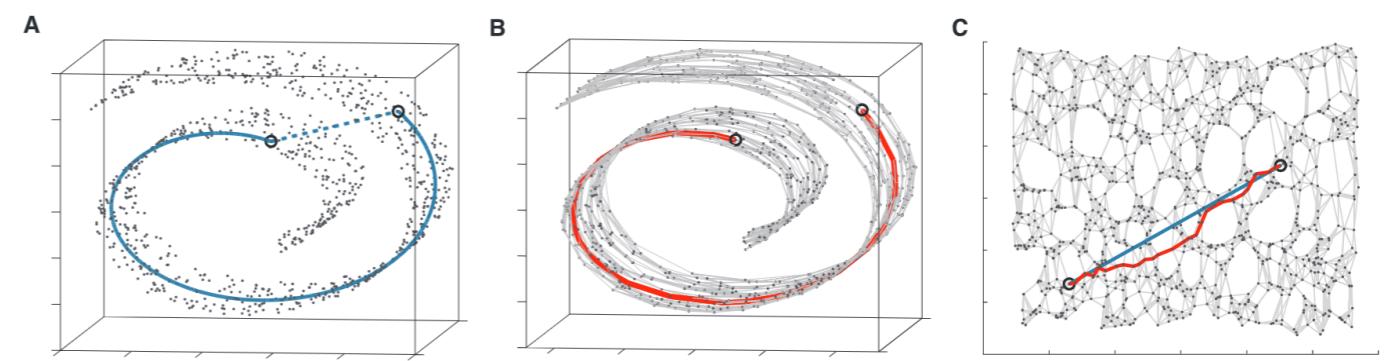
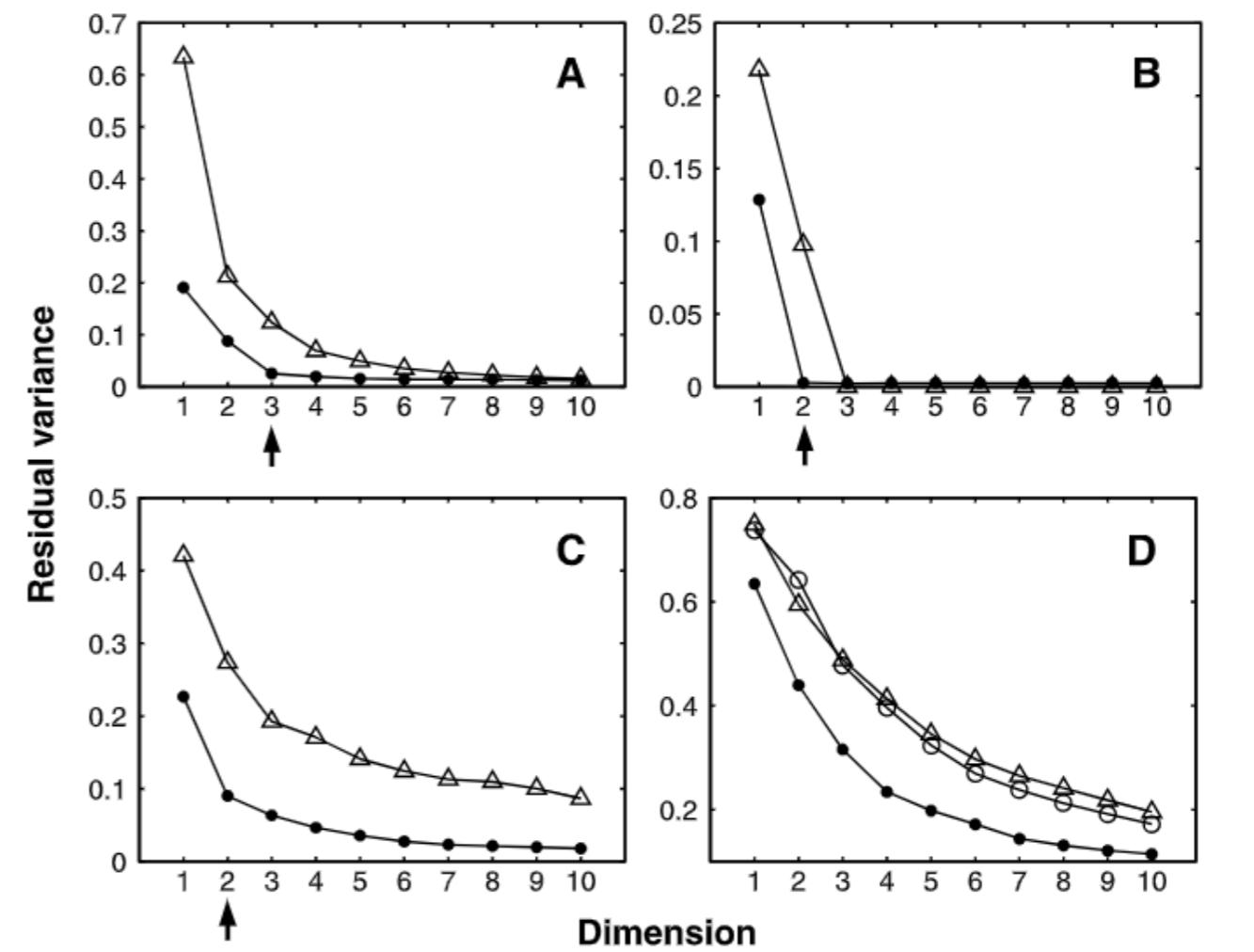
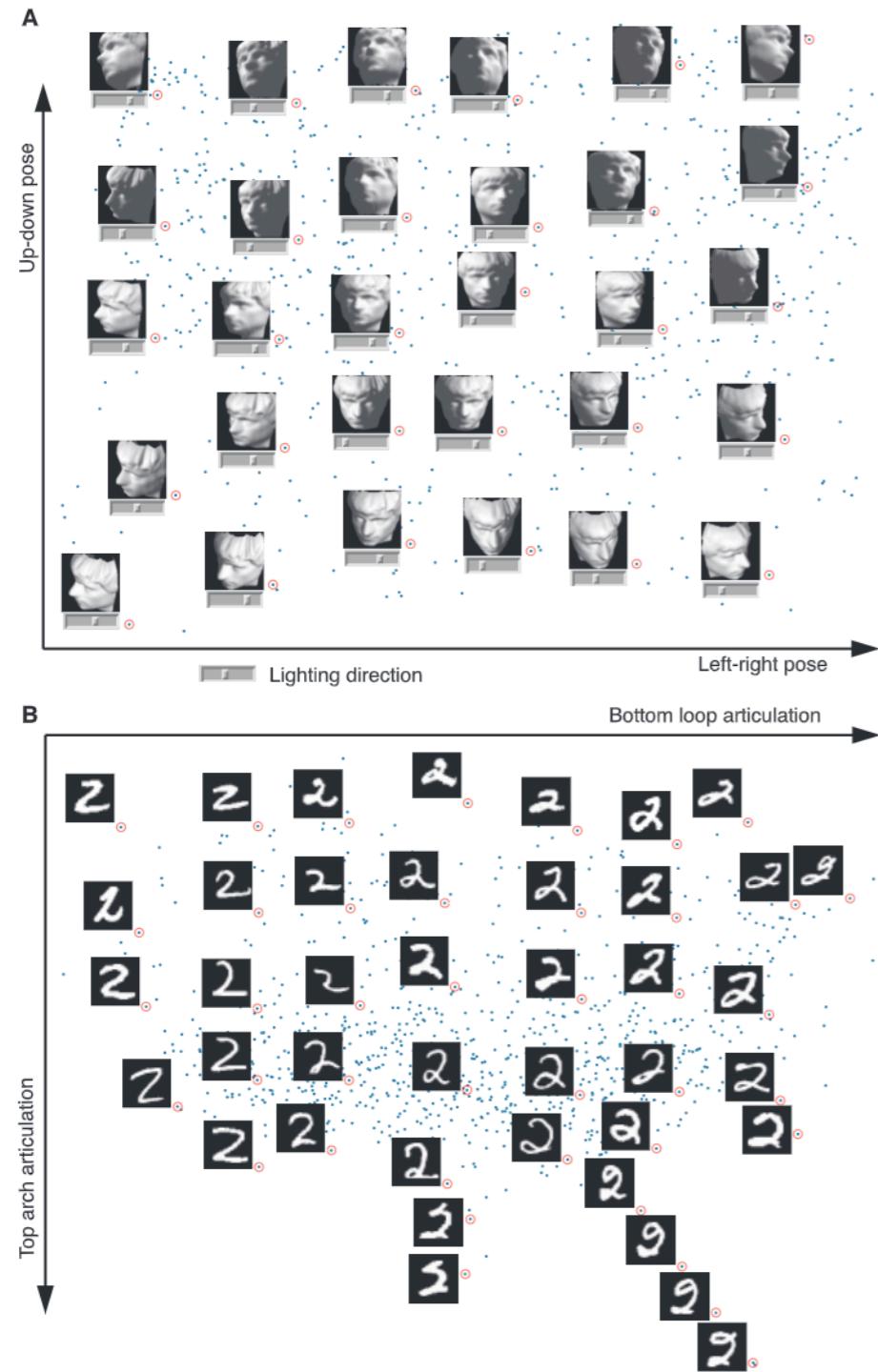
Kozlowski, A. C., Taddy, M., & Evans, J. A. (2019). The geometry of culture: Analyzing the meanings of class through word embeddings. *American Sociological Review*, 84(5), 905-949.

Diffusion of attention



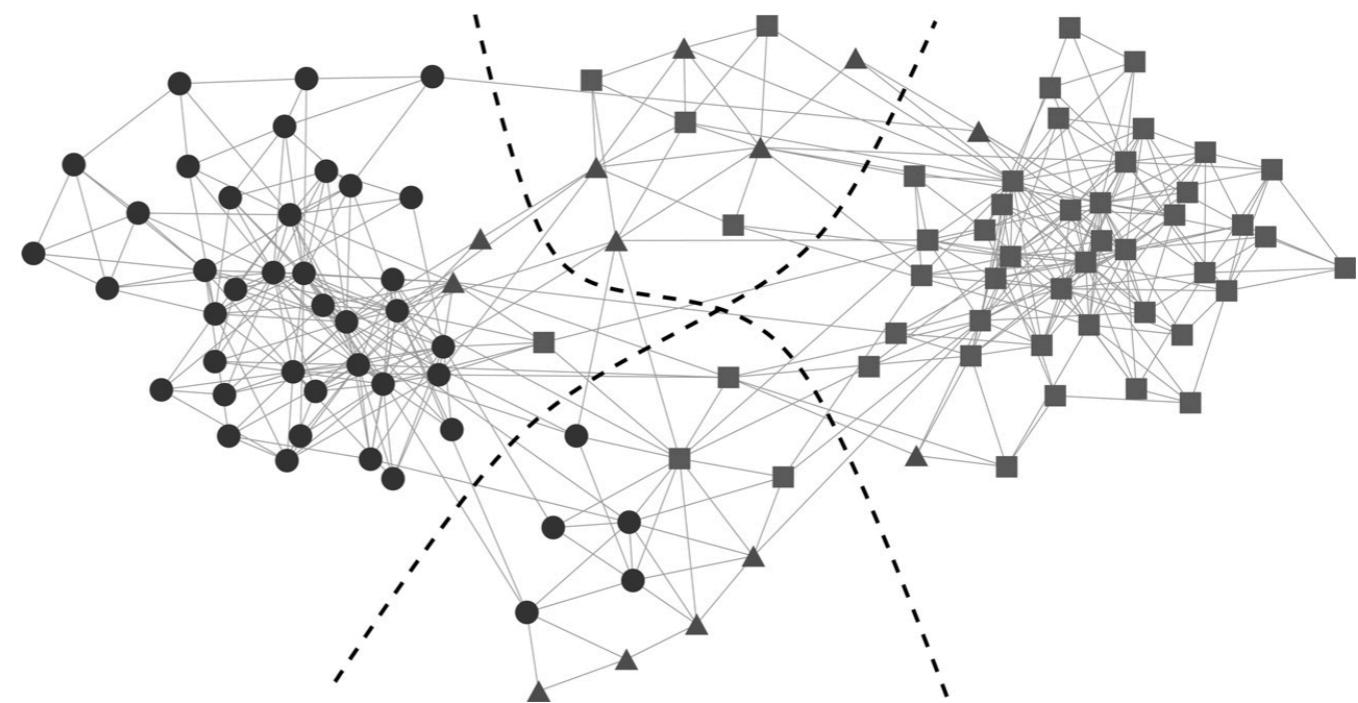
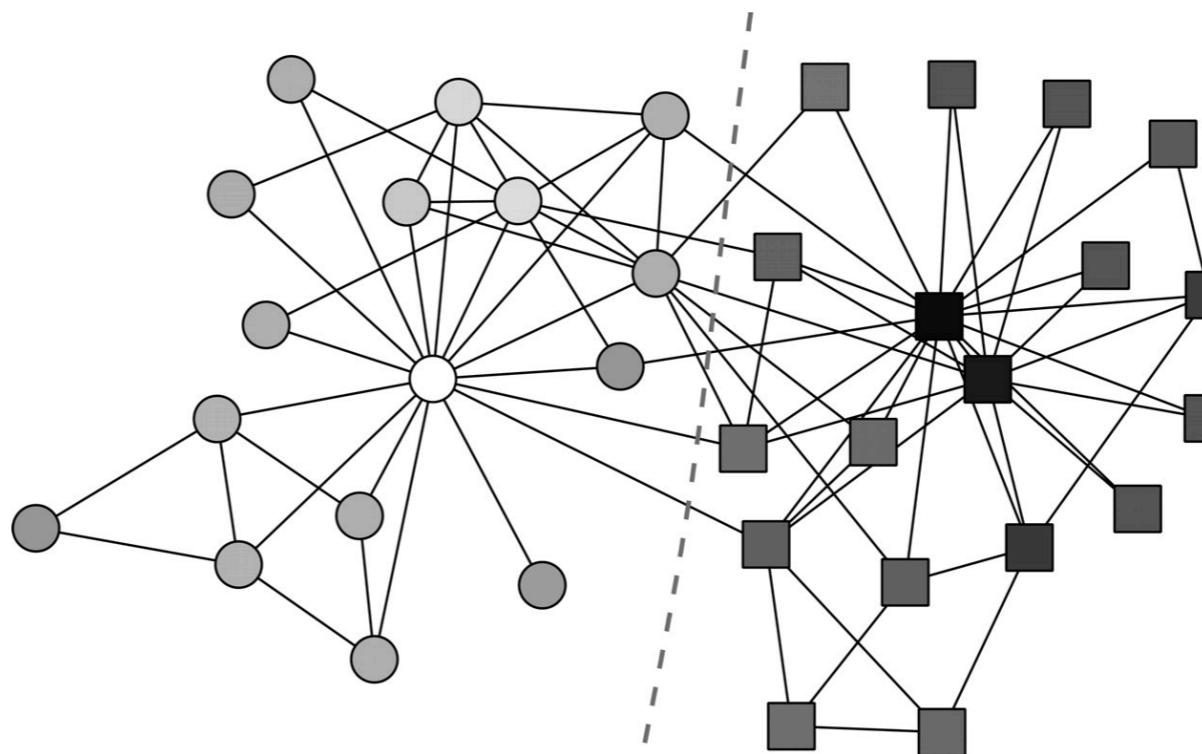
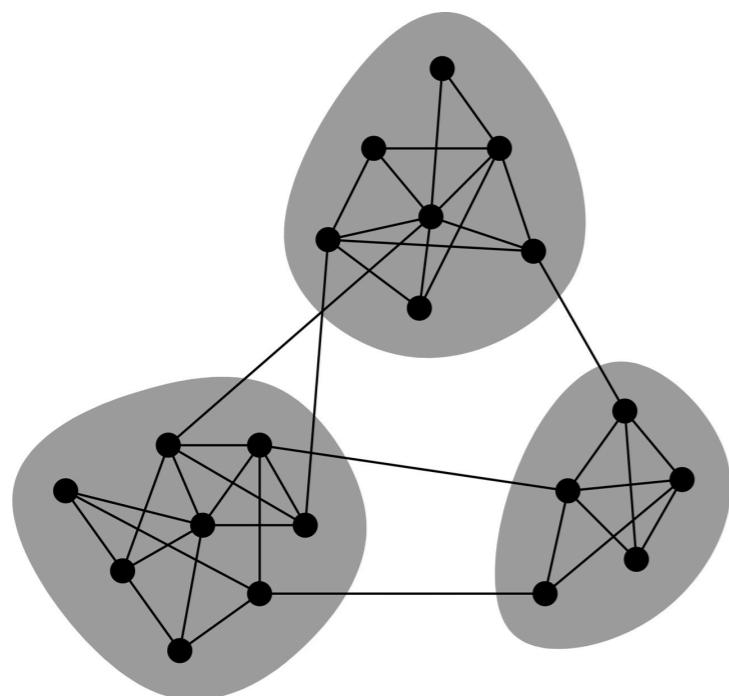
Tshitoyan, V., Dagdelen, J., Weston, L., Dunn, A., Rong, Z., Kononova, O., ... & Jain, A. (2019). Unsupervised word embeddings capture latent knowledge from materials science literature. *Nature*, 571(7763), 95-98.

Reduction of Dimensions



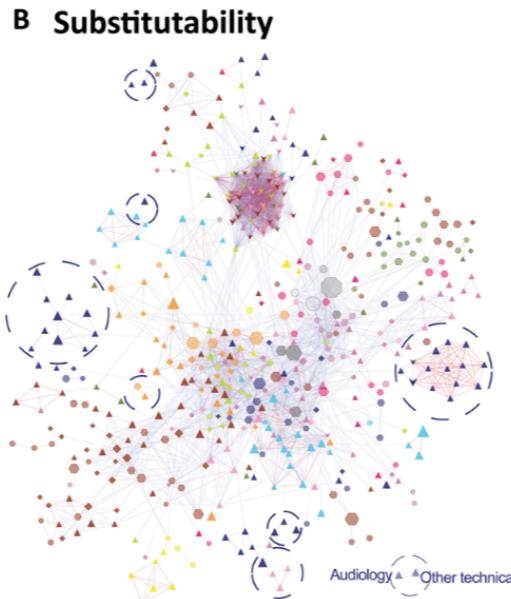
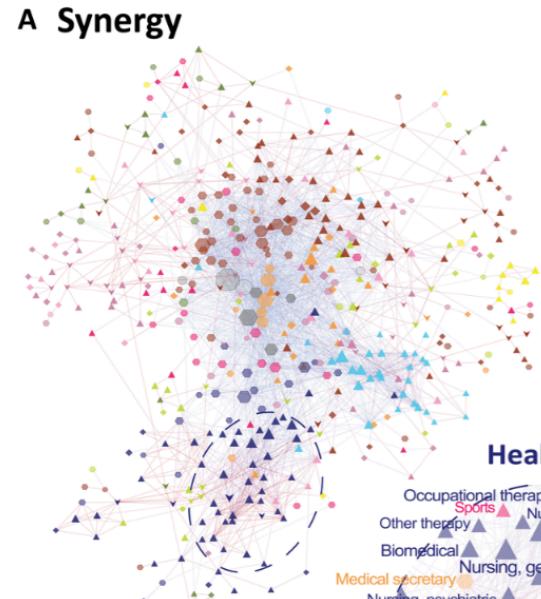
Tenenbaum, J. B., De Silva, V., & Langford, J. C. (2000). A global geometric framework for nonlinear dimensionality reduction. *science*, 290(5500), 2319-2323.

Encoding of complexity



Newman, M. E. (2006). Modularity and community structure in networks. *Proceedings of the national academy of sciences*, 103(23), 8577-8582.

Complementarity of labors

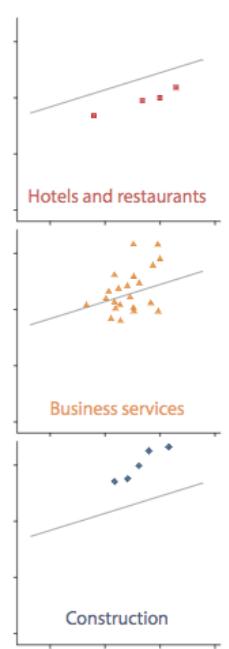
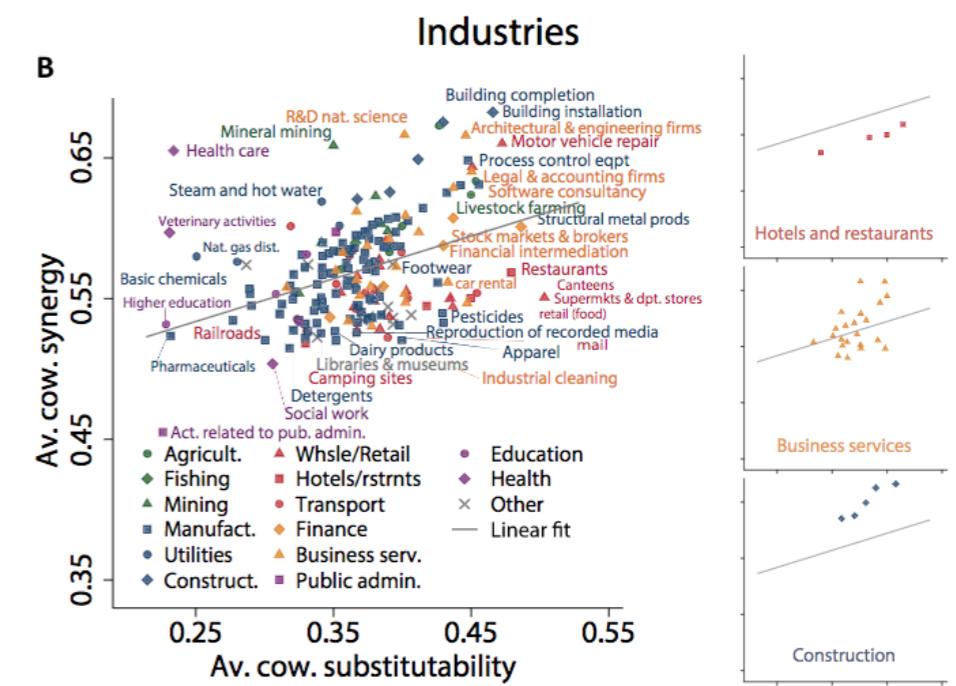
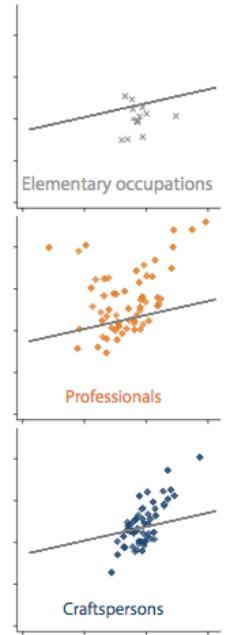
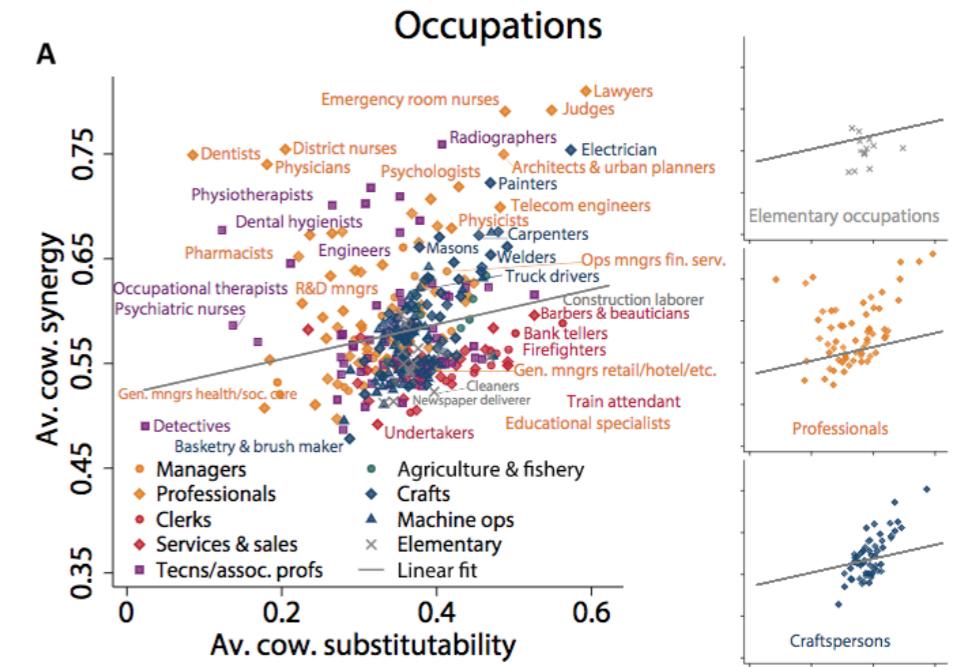
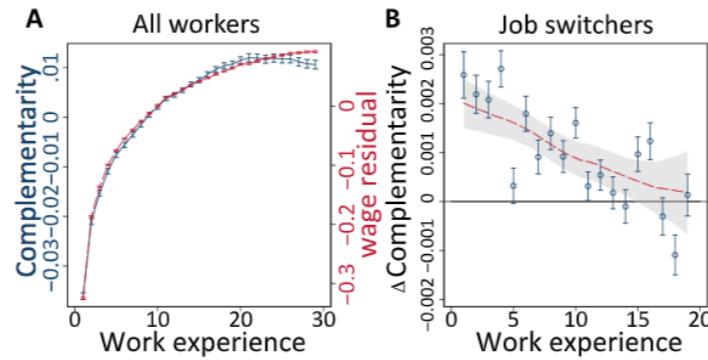
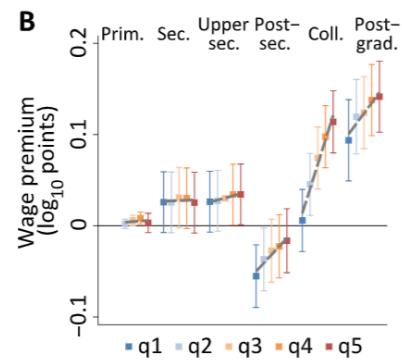
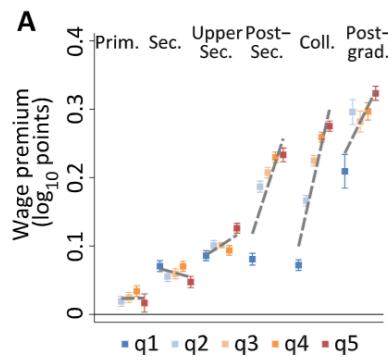


Content

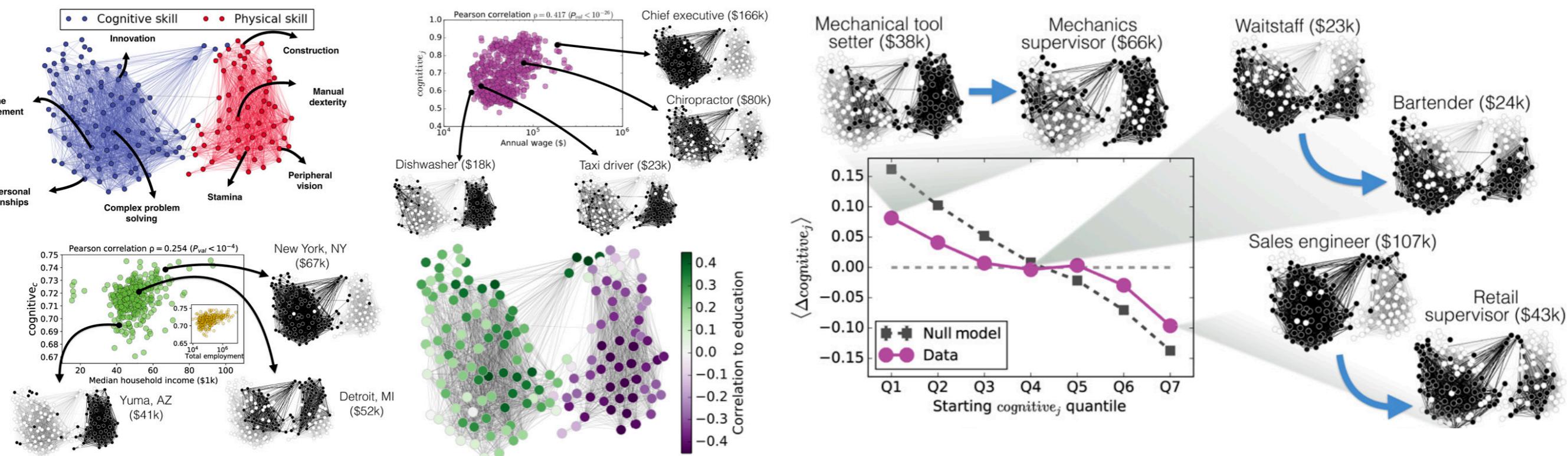
- General
- Teaching
- Humanities
- Soc. sc./journalism
- Business/law
- Natural sciences
- Engin. and manuf.
- Agric./anim. hth
- Health care
- Misc. services
- Security services

Level

- Primary
- Secondary
- Upper sec.
- Postsec.
- College
- Postgrad.



Polarization of skills



Alabdulkareem, A., Frank, M. R., Sun, L., AlShebli, B., Hidalgo, C., & Rahwan, I. (2018). Unpacking the polarization of workplace skills. *Science advances*, 4(7), eaao6030.