Productivity Hurts Innovation

or Only Diamond Can Cut Diamond in Science

Lingfei Wu

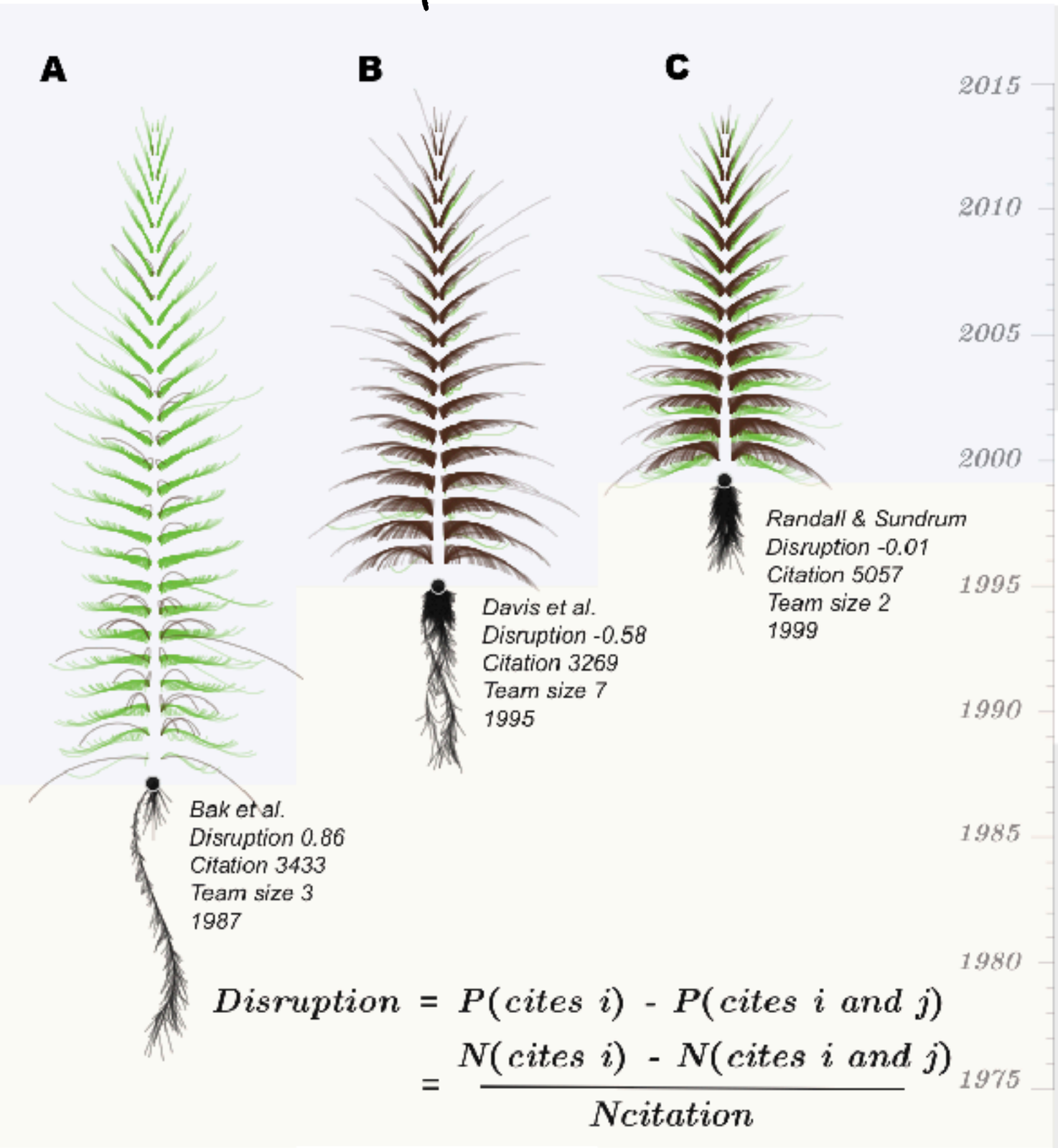
Research in Collaboration with Jie Tang, Dashun Wang, James Evans
Dept. of Sociology, U of Chicago

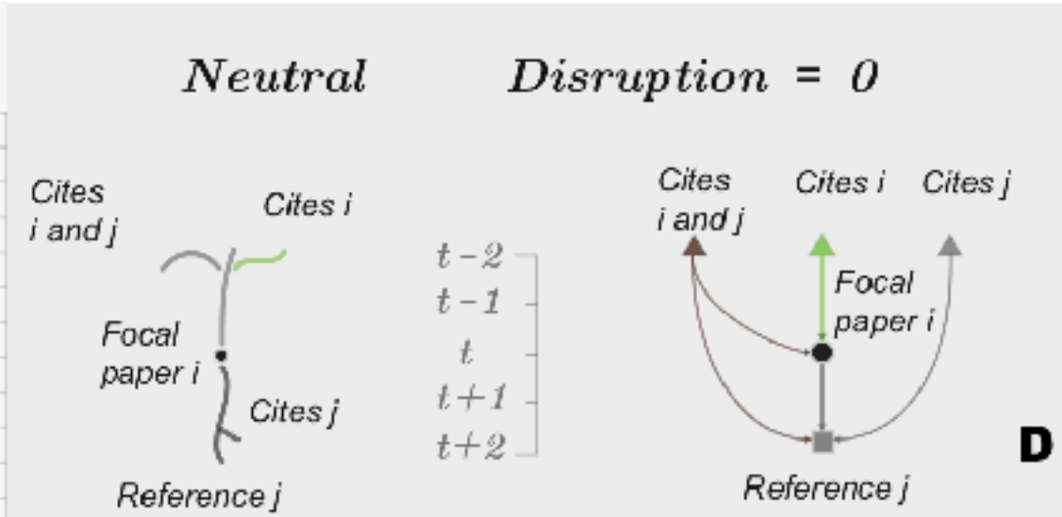
Measure Innovation

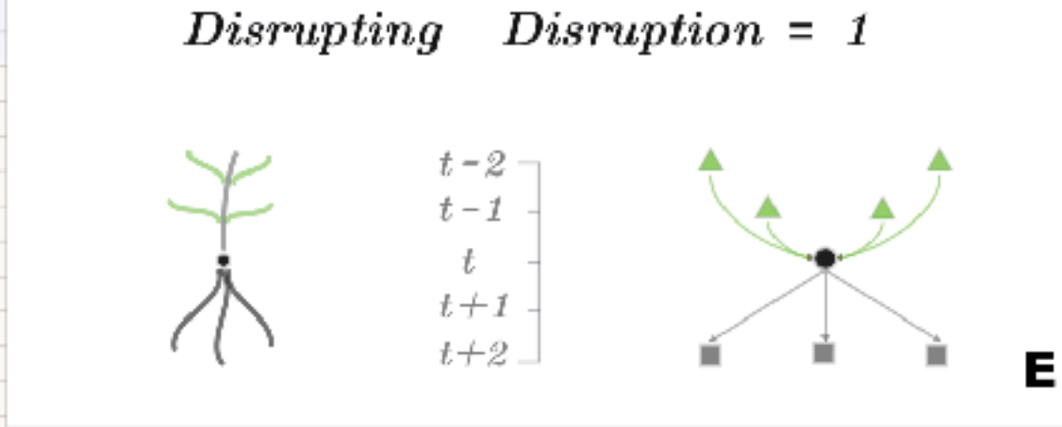
Overshadows the past and create new directions

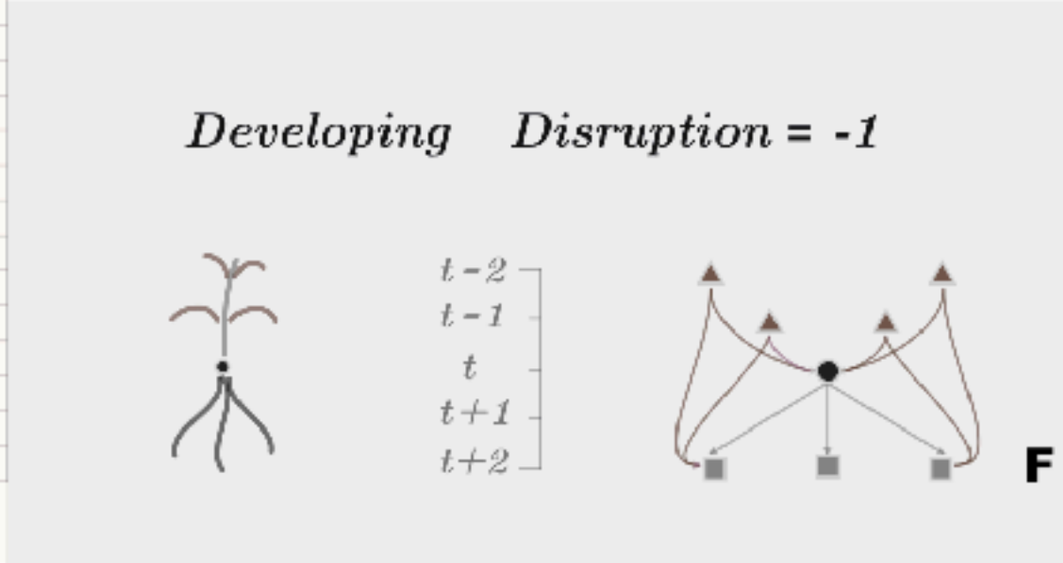
Small teams, large teams, two kinds of science

Funk & Owen-Smith, 2016

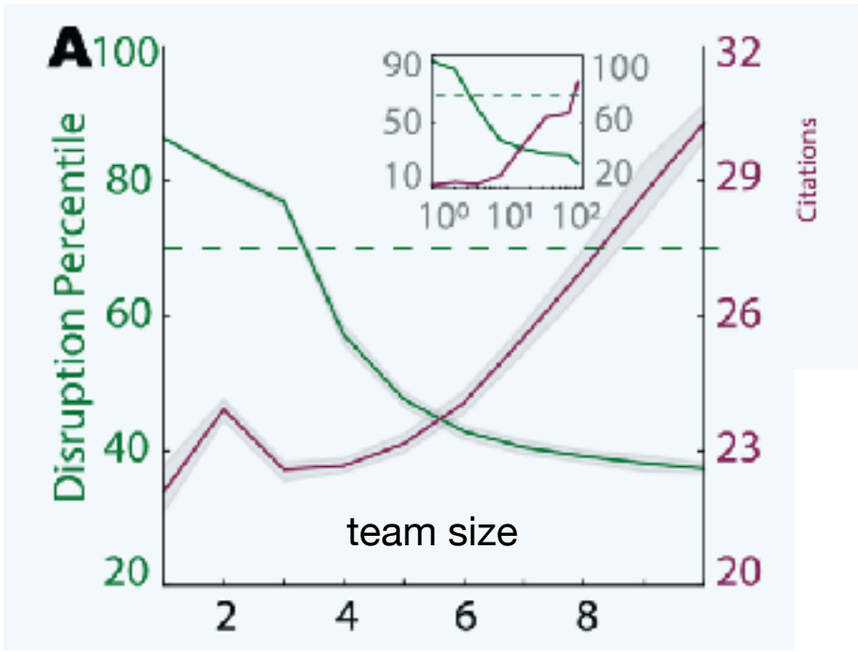








Small teams, large teams, two kinds of science



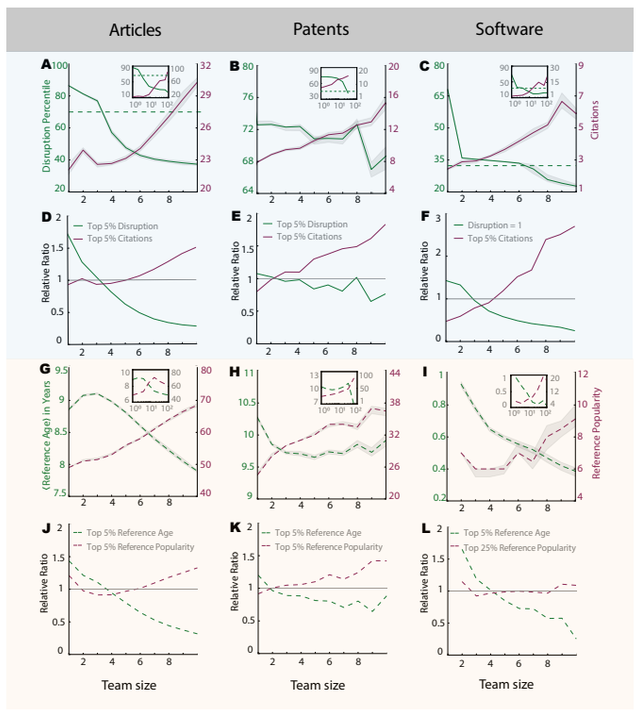
44 million articles

100 years

5 million patents

40 years

16 million software *3*



Wu, L., Wang, D., & Evans, J. A. (2017). Large Teams Have Developed Science and Technology; Small Teams Have Disrupted It. *arXiv preprint arXiv:1709.02445*.

Team roles: brain innovate, muscle produce

Team clock: innovation takes time

Team age: young innovators

Team connection: innovation by disconnection

Team roles: brain innovate, muscle produce

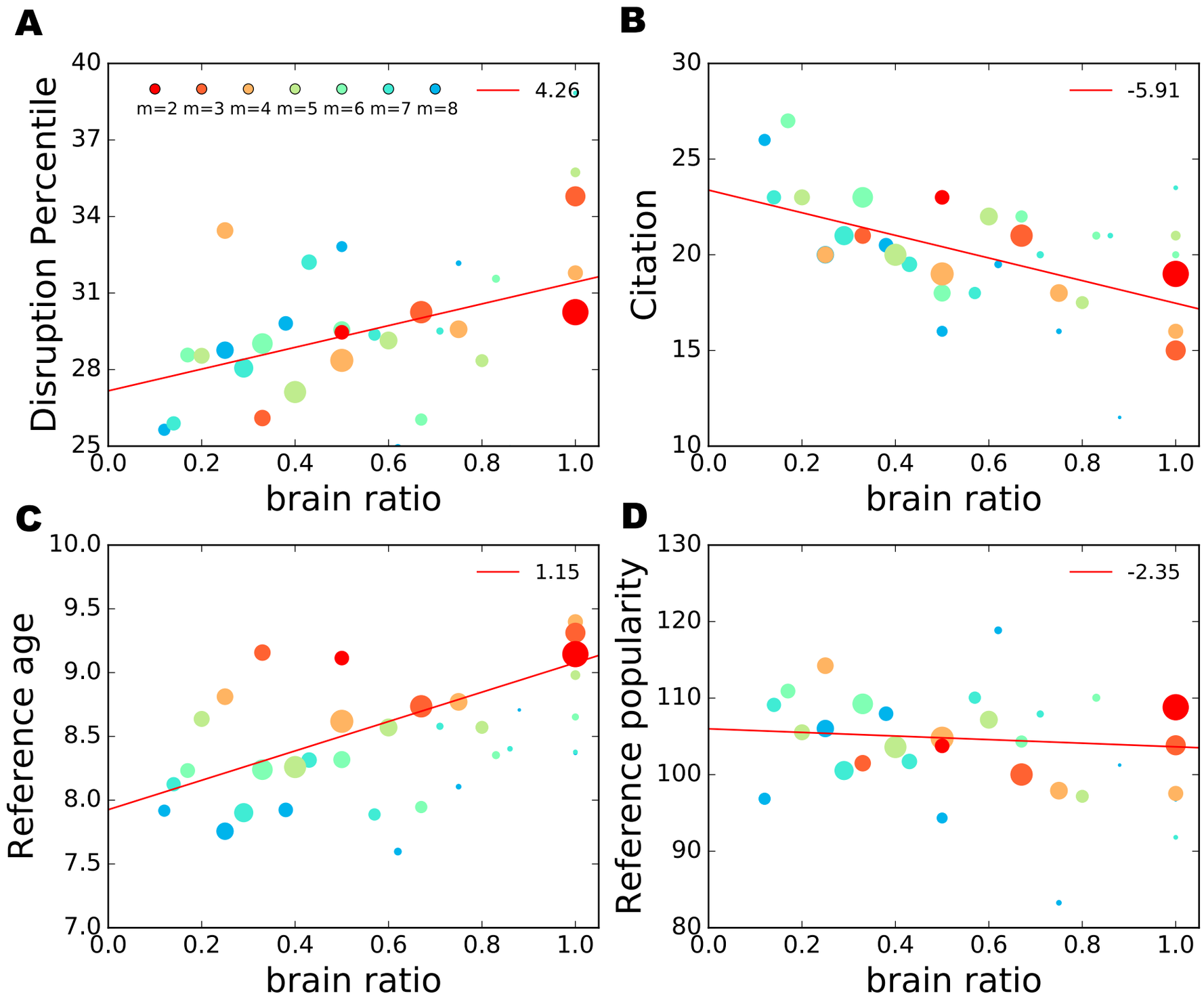
Identify "brains" and "muscles" (ground-truth)

PNAS paper	Contribution text	Summary
2010		
History of biological metal utilization inferred through phylogenomic analysis of protein structures Christopher L. Dupont, Andrew Butcher, Ruben E. Valas, Philip E. Bourne and Gustavo Caetano-Anollés	C.L.D., P.E.B., and G.C.-A. designed research; C.L.D., R.E.V., and G.C.-A. performed research; A.B. contributed new reagents/analytic tools; C.L.D., R.E.V., P.E.B., and G.C.-A. analyzed data; and C.L.D., P.E.B., and G.C.-A. wrote the paper.	*team size = 5* *N brain = 3* *N muscle = 2* *Brain ratio = 0.6*
2006		
Genome sequence of SynechococcusCC9311: Insights into adaptation to a coastal environment Brian Palenik, Qinghu Ren, Chris L. Dupont, Garry S. Myers, John F. Heidelberg, Jonathan H. Badger, Ramana Madupu, William C. Nelson, Lauren M. Brinkac, Robert J. Dodson, A. Scott Durkin, Sean C. Daugherty, Stephen A. Sullivan, Hoda Khouri, Yasmin Mohamoud, Rebecca Halpin and Ian T. Paulsen	B.P. and I.T.P. designed research; R.M., W.C.N., L.M.B., R.J.D., A.S.D., S.C.D., S.A.S., H.K., Y.M., and R.H. performed research; B.P., Q.R., C.L.D., G.S.M., J.F.H., J.H.B., and I.T.P. analyzed data; and B.P. and I.T.P. wrote the paper.	*team size = 17* *N brain = 2* *N muscle = 15* *Brain ratio = 0.1*

16,897 PNAS papers (2005 - 2014)

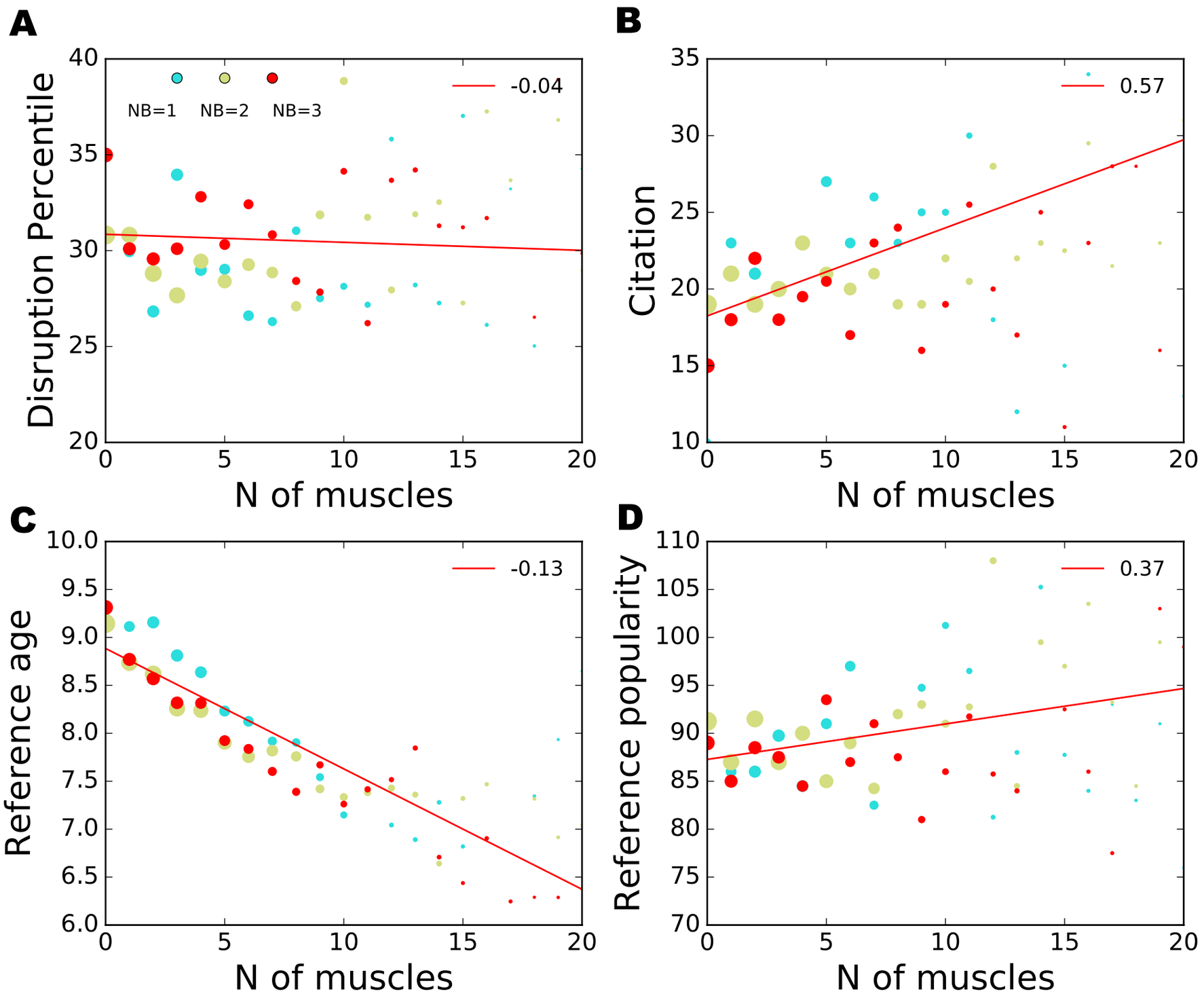
More brains (PNAS):

Draw upon older, smaller ideas -> more disruptive and less impactful



Additional increase of muscles (PNAS)

Chase newer, more popular ideas -> less disruptive and more impactful



Identify "brains" and "muscles" (estimation)

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History of biological metal utilization inferred through phylogenomic analysis of protein structures Christopher L. Dupont, Andrew Butcher, Ruben E. Valas, Philip E. Bourne and Gustavo Caetano-Anollés 5 12 30	C.L.D., P.E.B., and G.C.-A. designed research; C.L.D., R.E.V., and G.C.-A. performed research; A.B. contributed new reagents/analytic tools; C.L.D., R.E.V., P.E.B., and G.C.-A. analyzed data; and C.L.D., P.E.B., and G.C.-A. wrote the paper.	*team size = 5* *N brain = 3* *N muscle = 2* *Brain ratio = 0.6*
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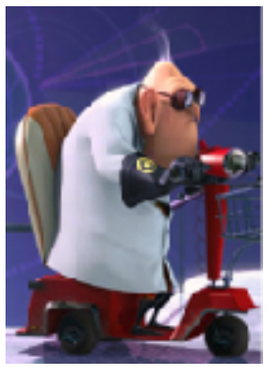
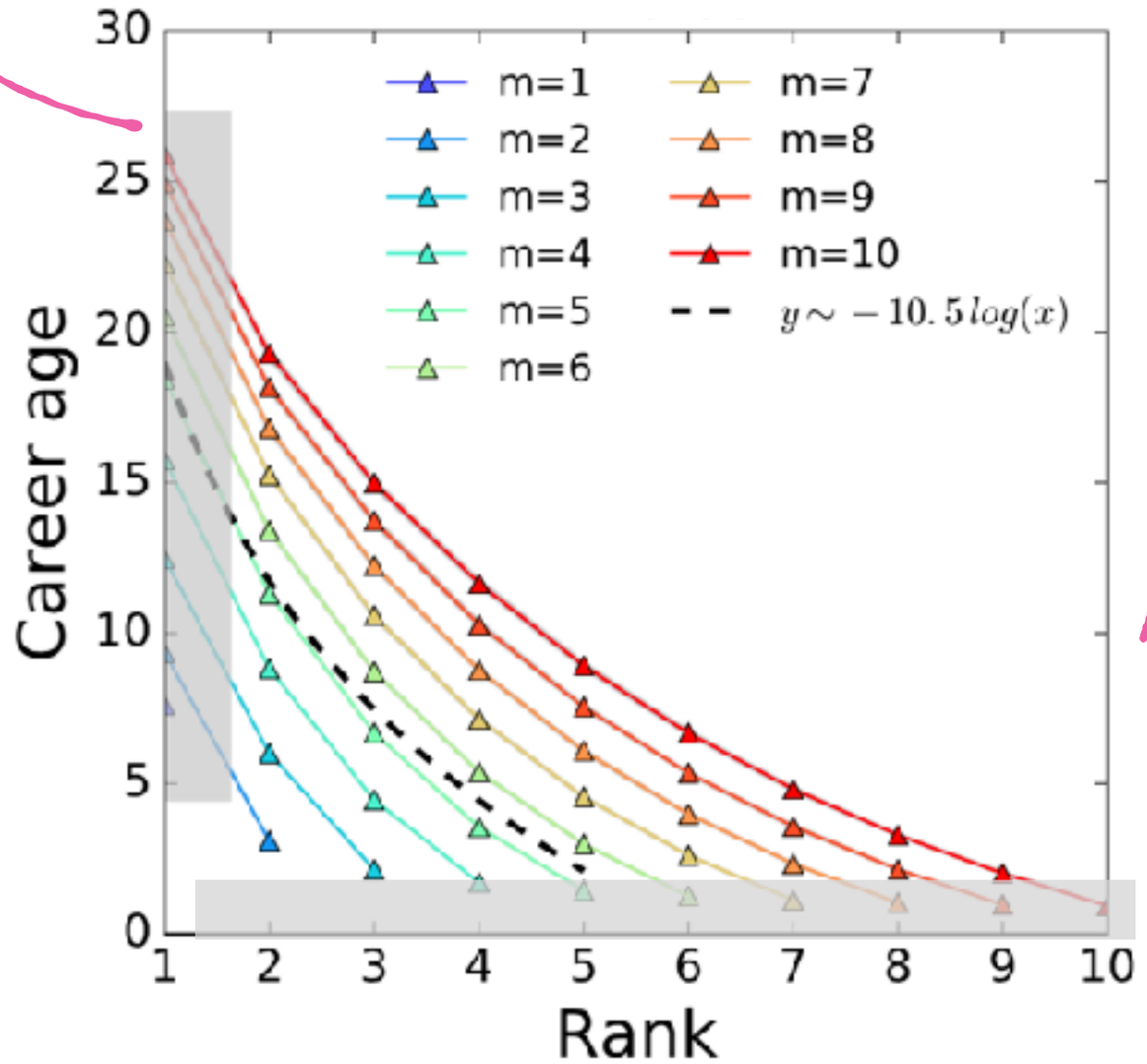
Identify "brains" and "muscles" (estimation)

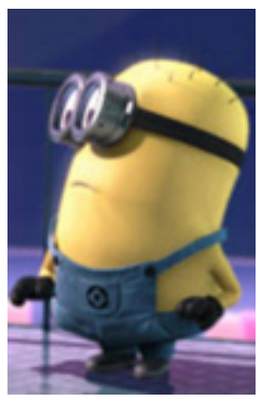
Brain



Career age composition of WOS papers



Muscle



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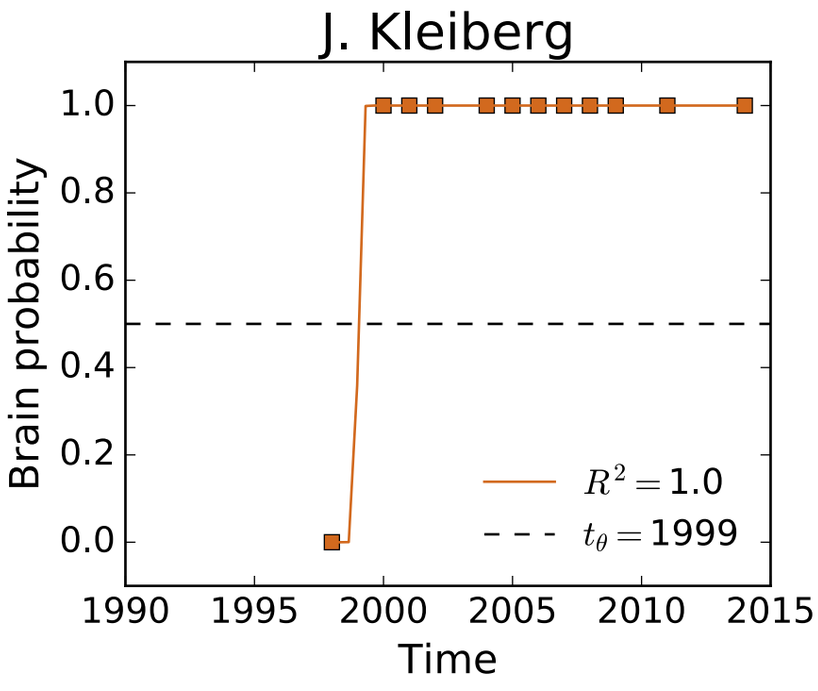
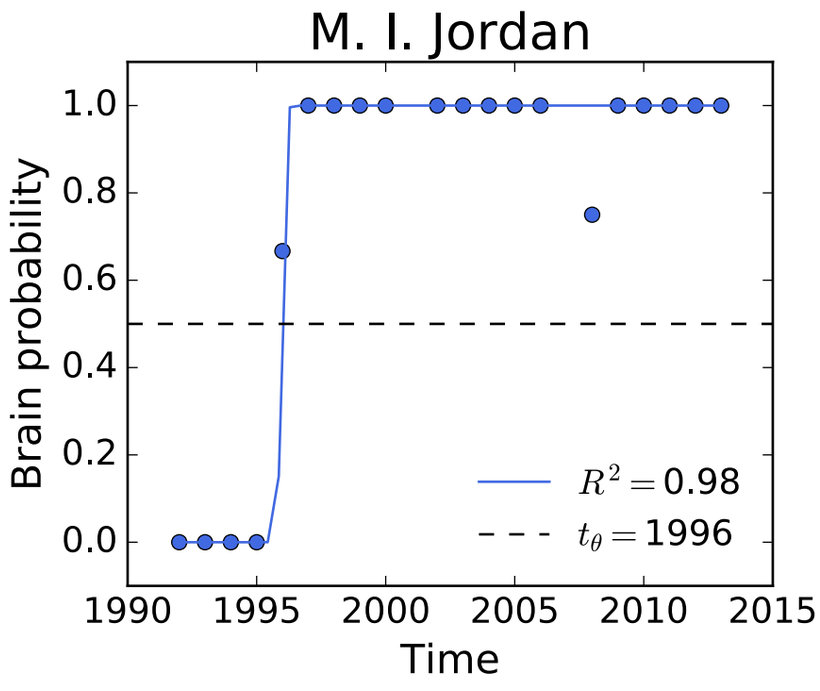
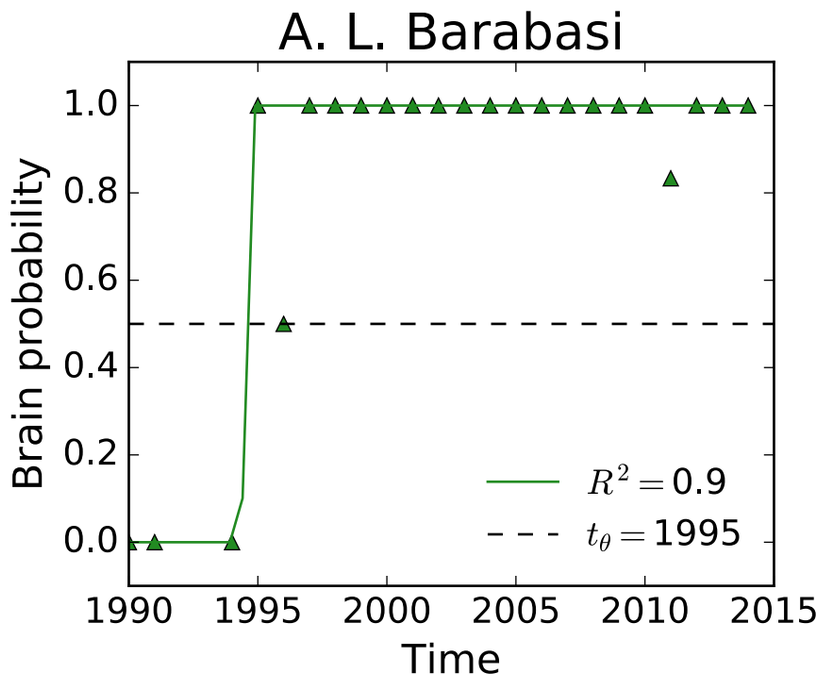
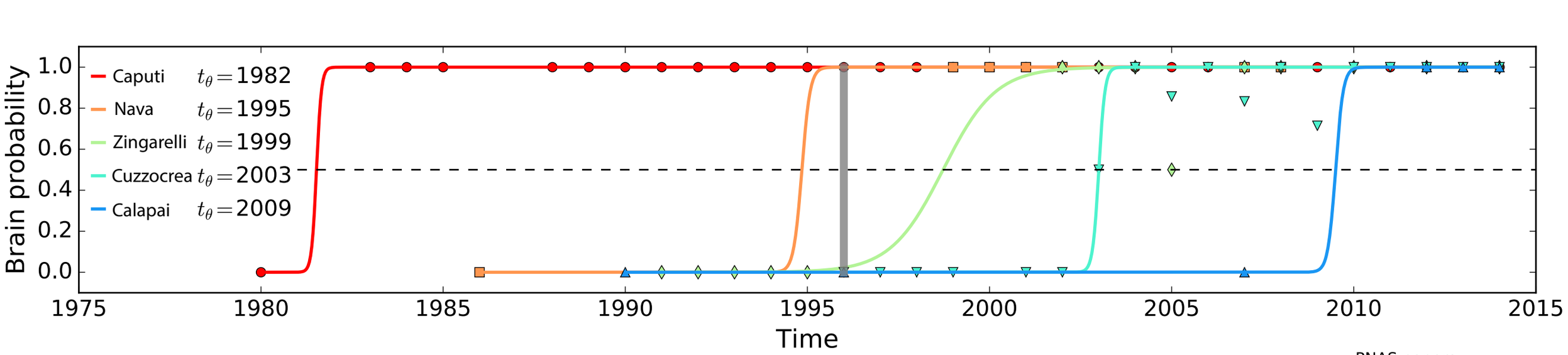
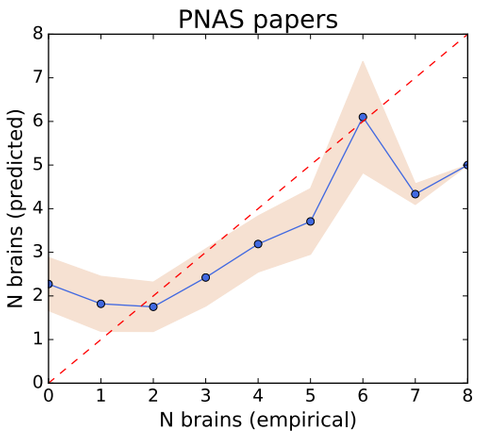








Cuzzocrea, S., Zingarelli, B., Calapai, G., Nava, F., & Caputi, A. P. (1996). Zymosan-activated plasma induces paw oedema by nitric oxide and prostaglandin production. Life Sciences, 60(3), 215-220.



More brains (WOS):

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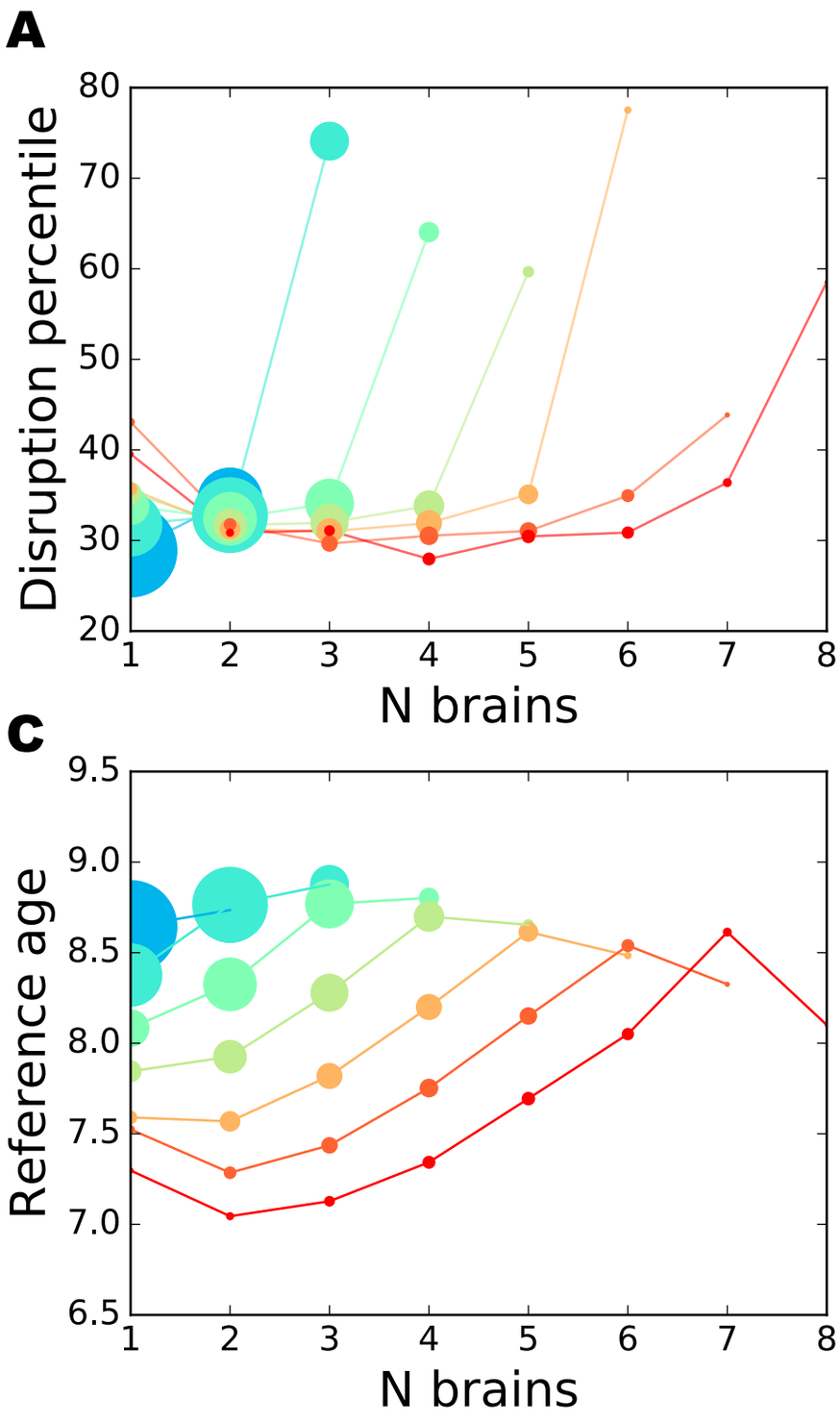
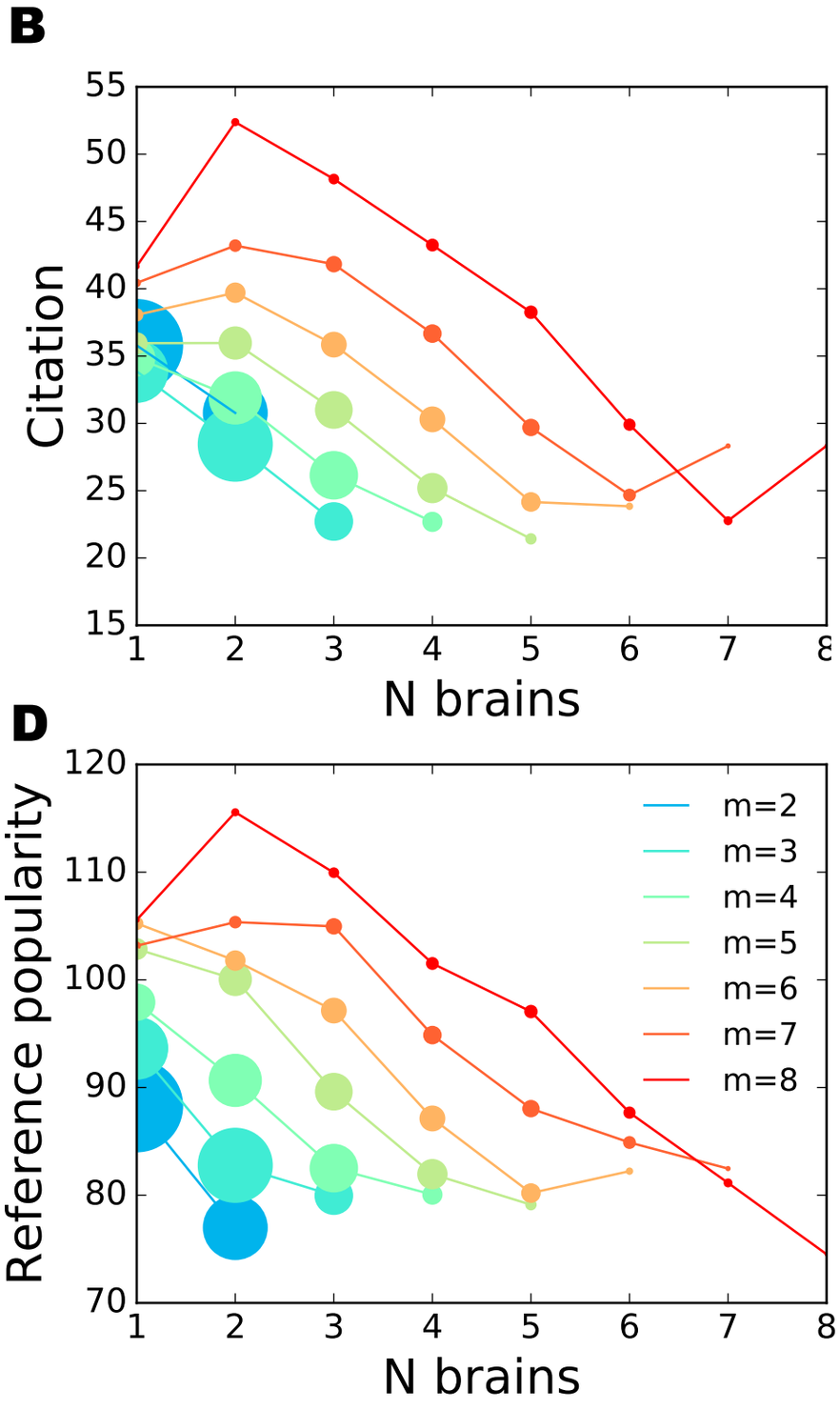
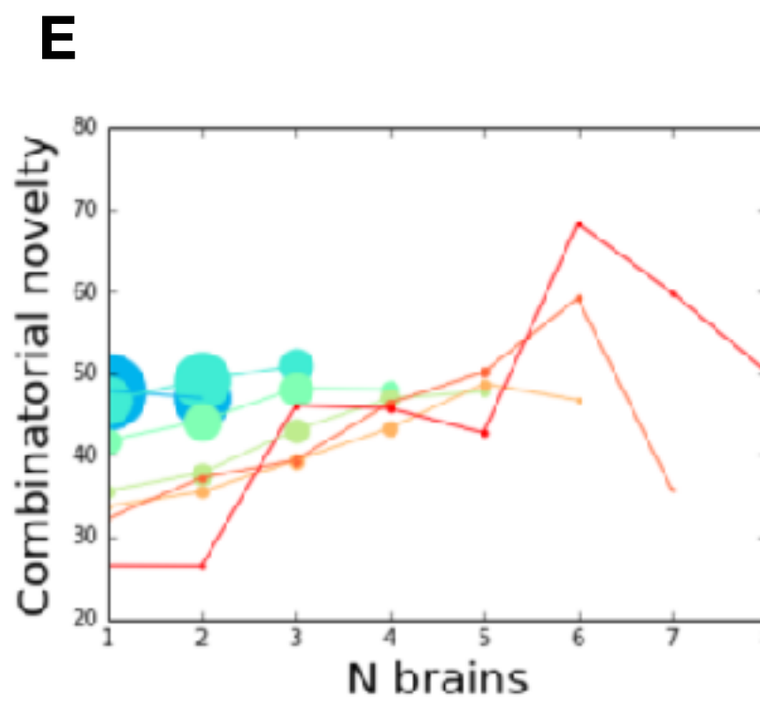






Evidence for a Collective Intelligence Factor in the Performance of Human Groups

Anita Williams Woolley,[1*] Christopher F. Chabris,[2,3] Alex Pentland,[3,4]
Nada Hashmi,[3,5] Thomas W. Malone[3,5]

Psychologists have repeatedly shown that a single statistical factor—often called "general intelligence"—emerges from the correlations among people's performance on a wide variety of cognitive tasks. But no one has systematically examined whether a similar kind of "collective intelligence" exists for groups of people. In two studies with 699 people, working in groups of two to five, we find converging evidence of a general collective intelligence factor that explains a group's performance on a wide variety of tasks. This "*c* factor" is not strongly correlated with the average or maximum individual intelligence of group members but is correlated with the average social sensitivity of group members, the equality in distribution of conversational turn-taking, and the proportion of females in the group.

*Woolley, A. W., Chabris, C. F., Pentland, A., Hashmi, N., & Malone, T. W. (**2010**).*
Evidence for a collective intelligence factor in the performance of human groups. science, 330(6004), 686-688.

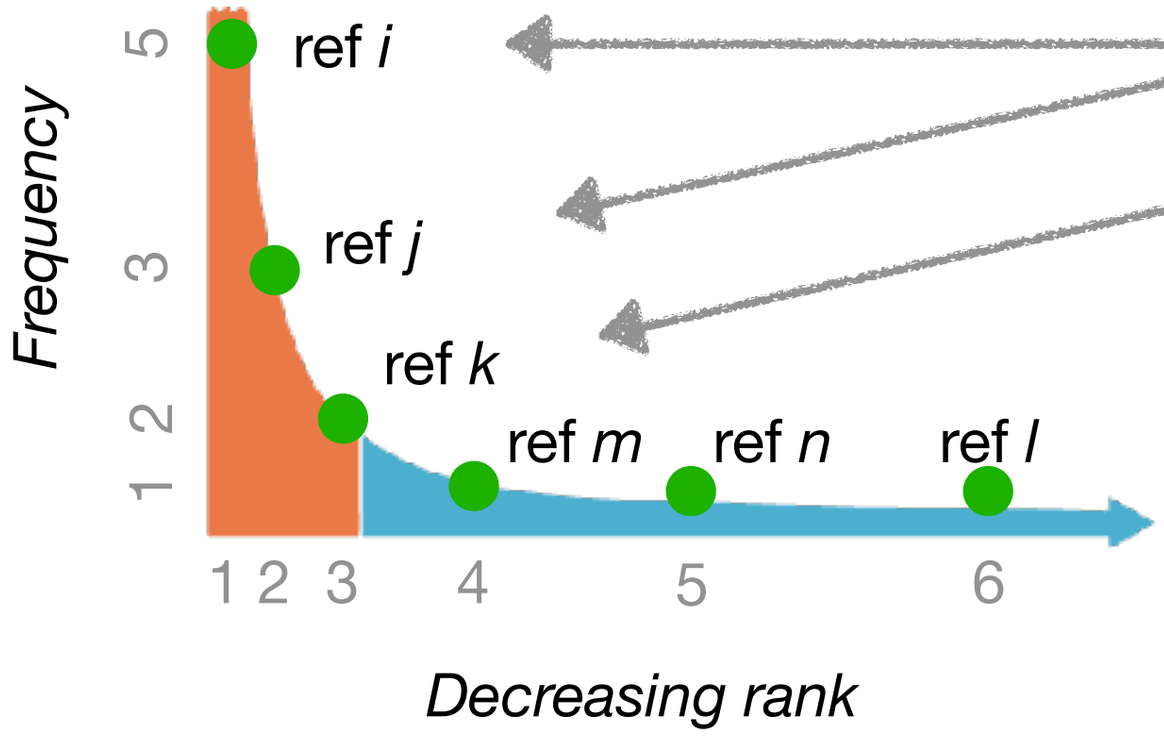
Balanced conversational turn-taking ?

Balanced conversational turn-taking in Science ?

Quantify knowledge stock exchange

Tom's knowledge stock

(all references in the whole career)



First time citing in collaboration *x*	Importance of collaboration I_x
Tom & Summer, 2009	*(5+3)/(5+3+2) = 0.8*
Tom & Rachel, 2010	*2/(5+3+2) = 0.2*

Core references: {*i, j, k*}
cited twice or more, 18%

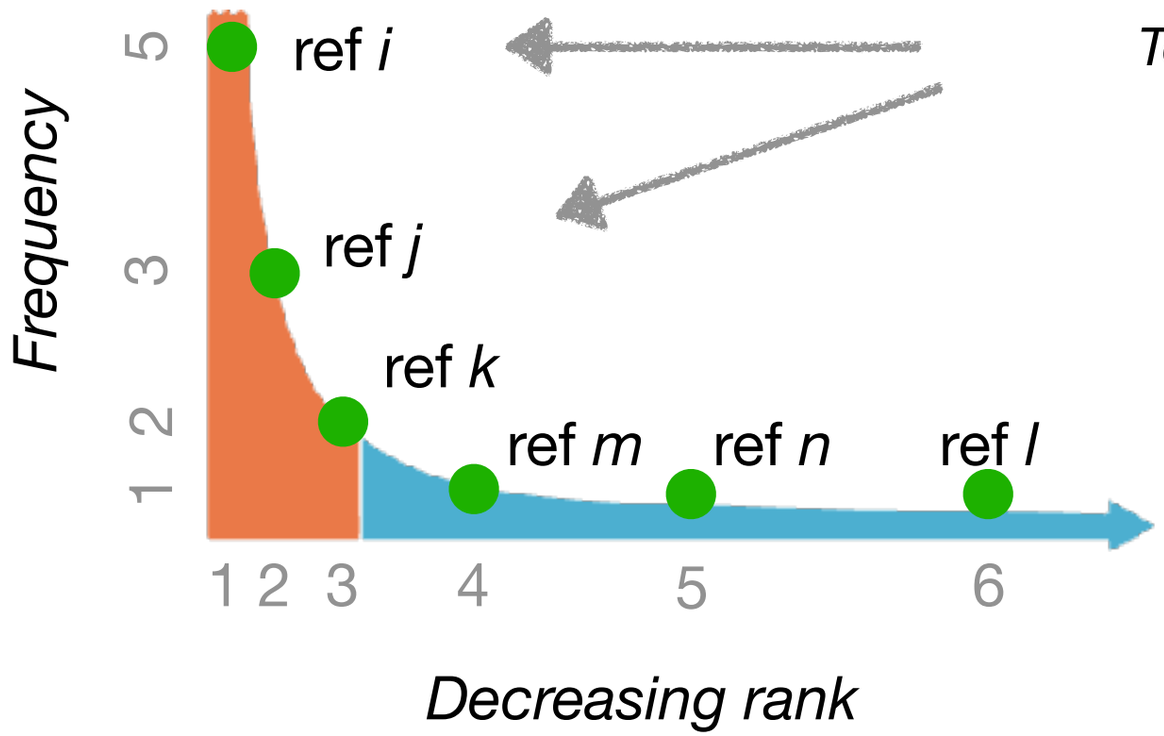
Strategic references: {*m, n, l*}
only cited once, 72%

Quantify knowledge stock exchange

Tom's knowledge stock

First time citing in collaboration *x*

Importance of collaboration I_x

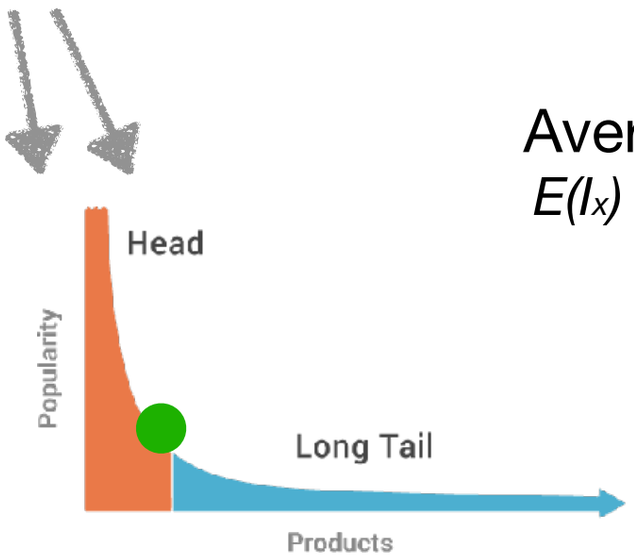


Tom & Summer, 2009

$I_{x\ Tom} = 0.8$

$I_{x\ Summer} = 0.1$

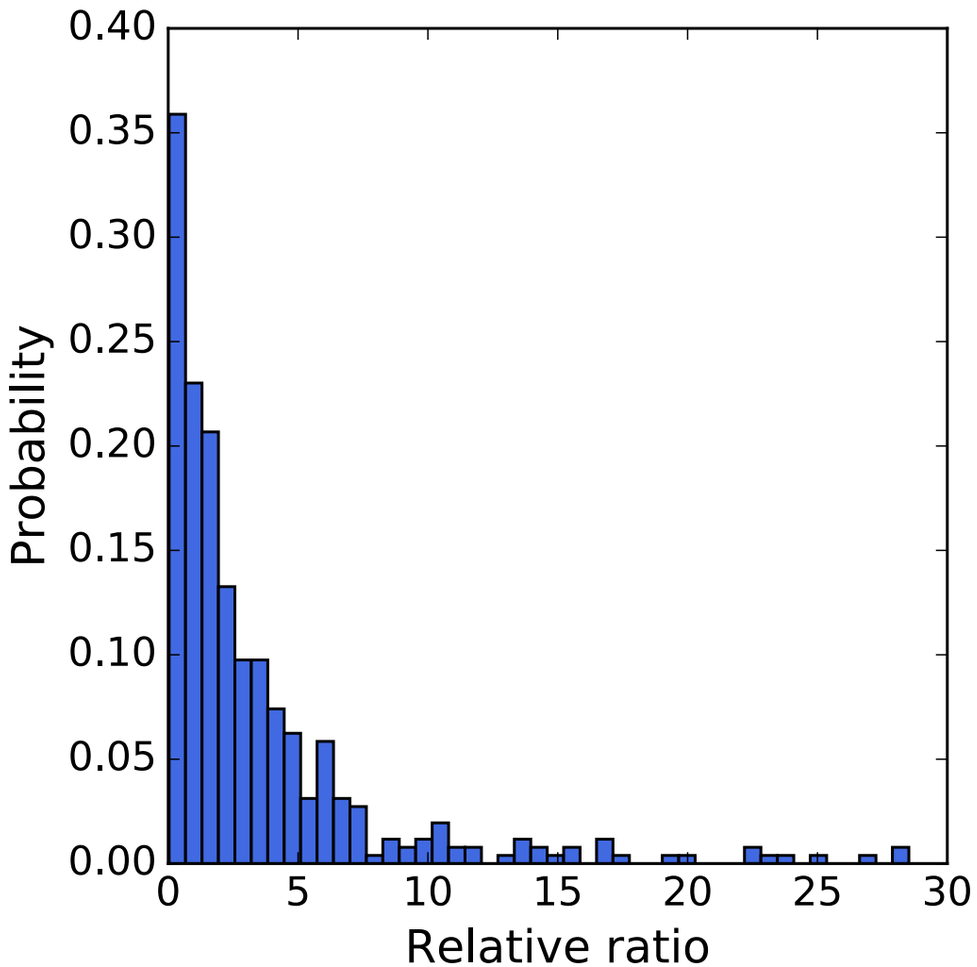
Average importance:
$E(I_x) = (0.8+0.1)/2=0.45$



Summer's knowledge stock

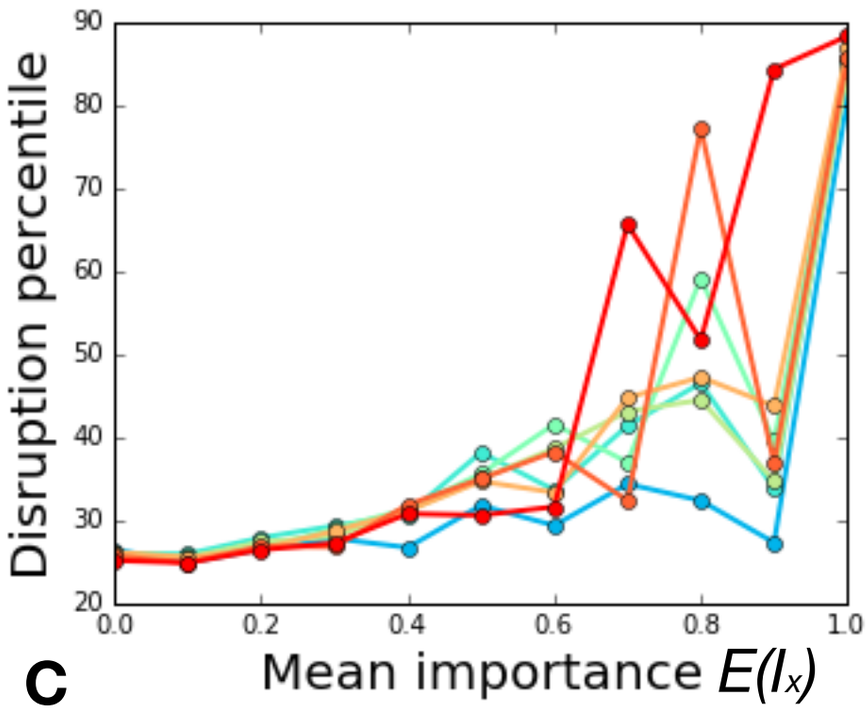
“Just because she likes the same bizzaro crap you do doesn't mean she's your soul mate.”

— Rachel Hansen in *500 Days of Summer*

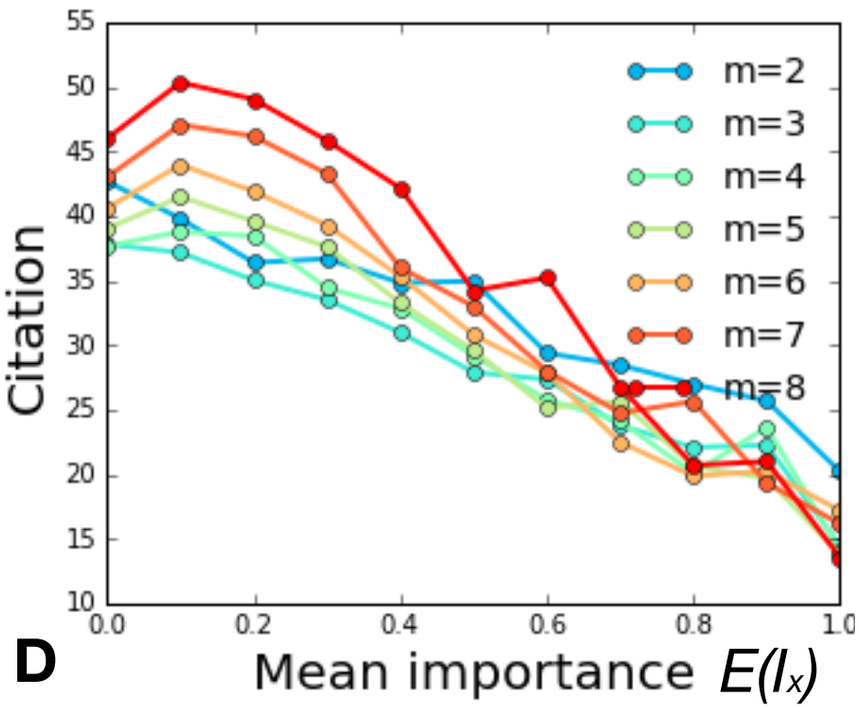


Yes. We select 405 scholars, who after becoming “brains”, involved in two different types of collaboration in the same year, with the other author either muscle (only contributed one paper ever) or brain, and calculate k. **For 70% cases k>1, 30% cases otherwise. The mean value of k is 3.8 - a brains is almost four times more likely to affect other brains’ mind in the long term than a muscle.**

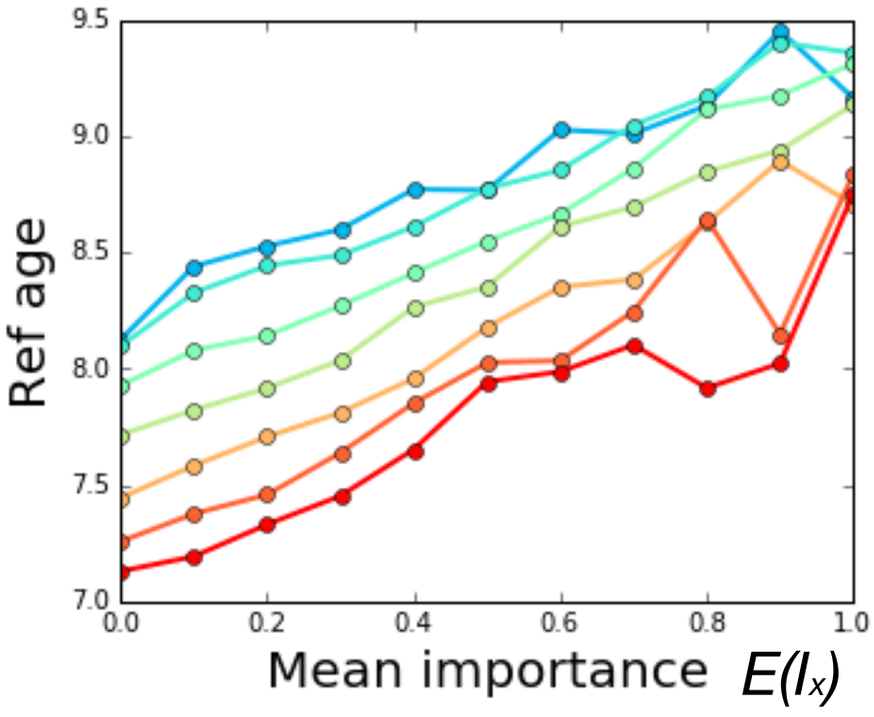
A


Disruption percentile
Mean importance $E(I_x)$

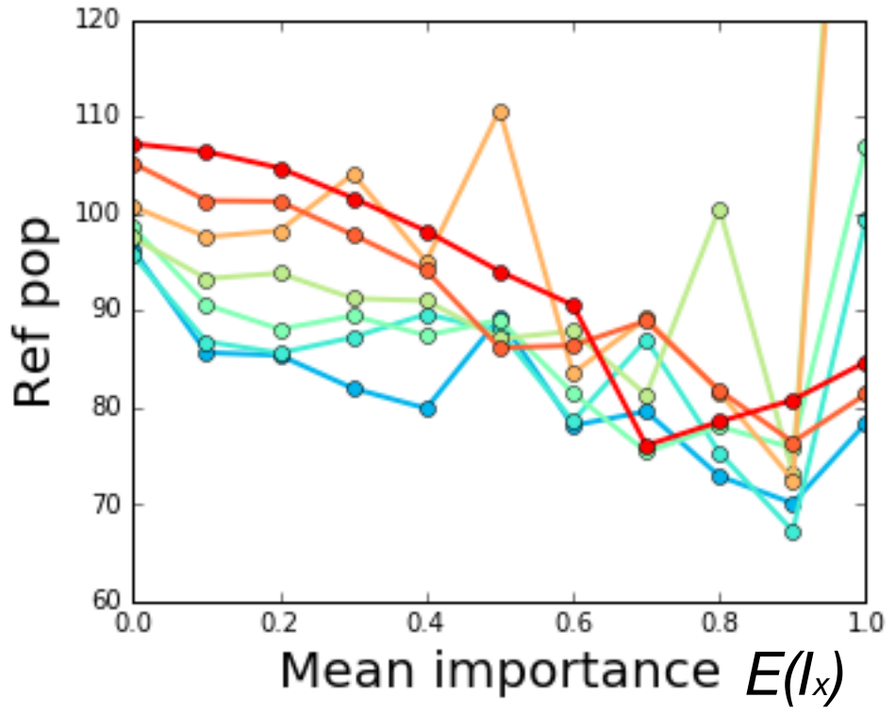
B


Citation
m=2
m=3
m=4
m=5
m=6
m=7
m=8
Mean importance $E(I_x)$

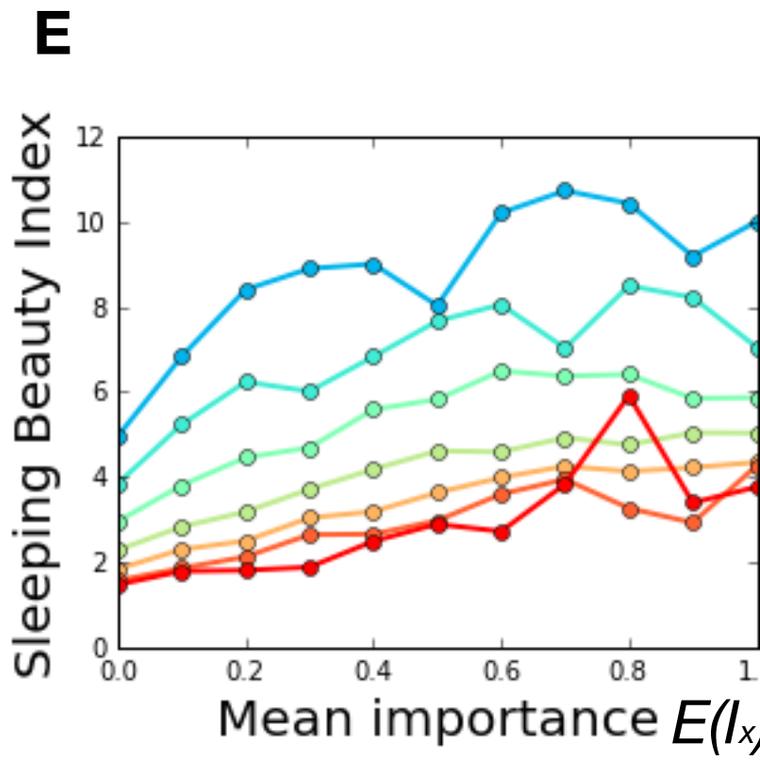
C


Ref age
Mean importance $E(I_x)$

D

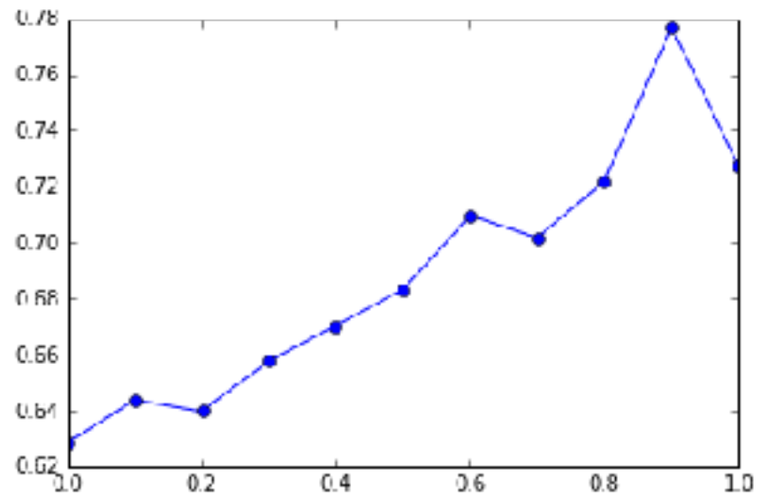

Ref pop
Mean importance $E(I_x)$

E


Sleeping Beauty Index
Mean importance $E(I_x)$

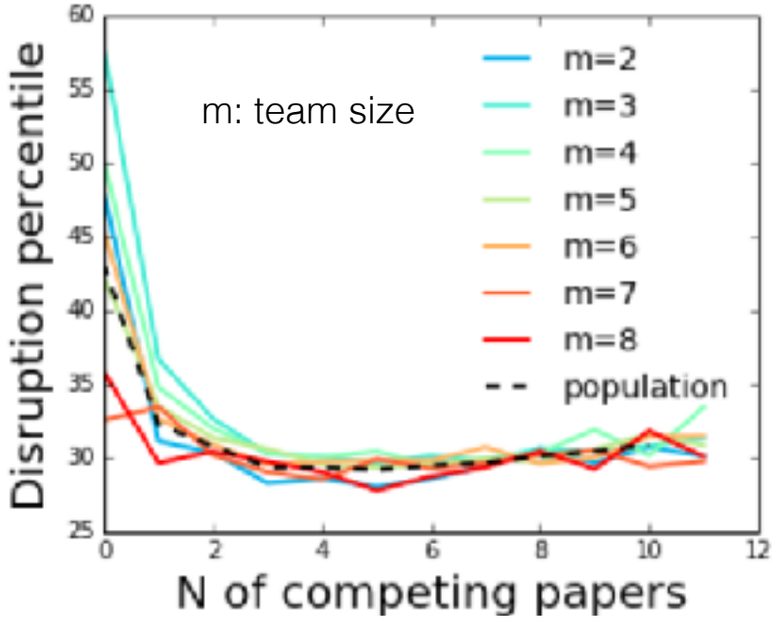
Multiple brain experience as brain

The reproduction of team structures

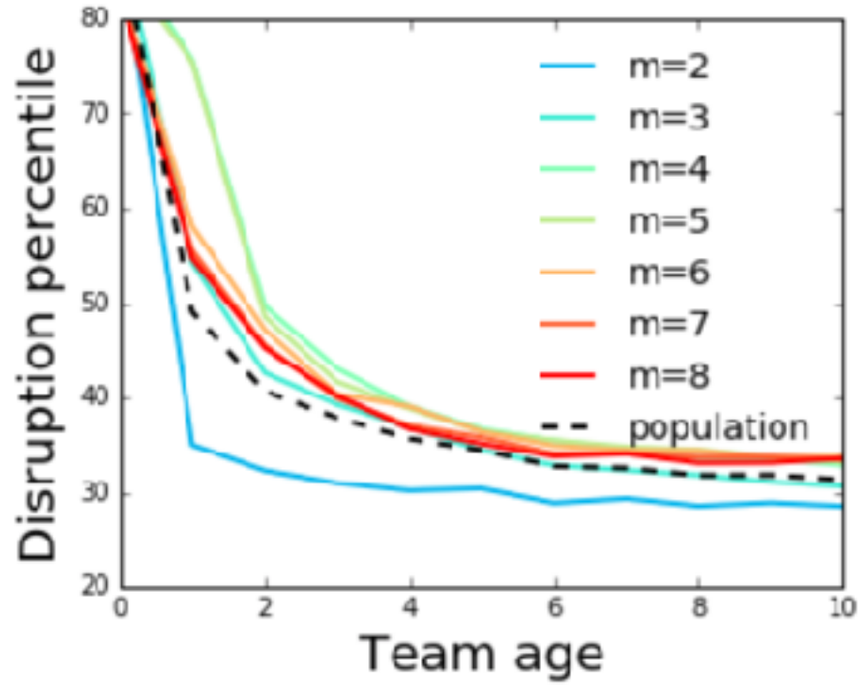


Multiple brain experience as muscle

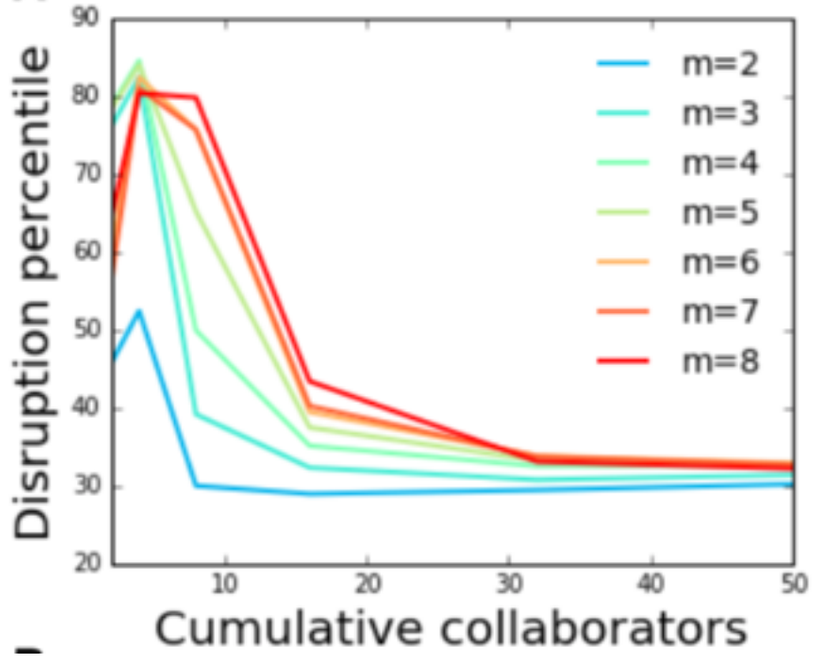
Team clock: innovation takes time



A



Team age: young innovators



Team connection: innovation by disconnection