Gendered Creative Teams Workshop
CEU Budapest, 26 May 2017

Octocat, here and elsewhere, by GitHub https://octodex.github.com

Gender Diversity in Online Software Teams

Aid or Barrier?

Bogdan Vasilescu

@b_vasilescu http://bvasiles.github.io

Carnegie Mellon University

institute for SOFTWARE RESEARCH

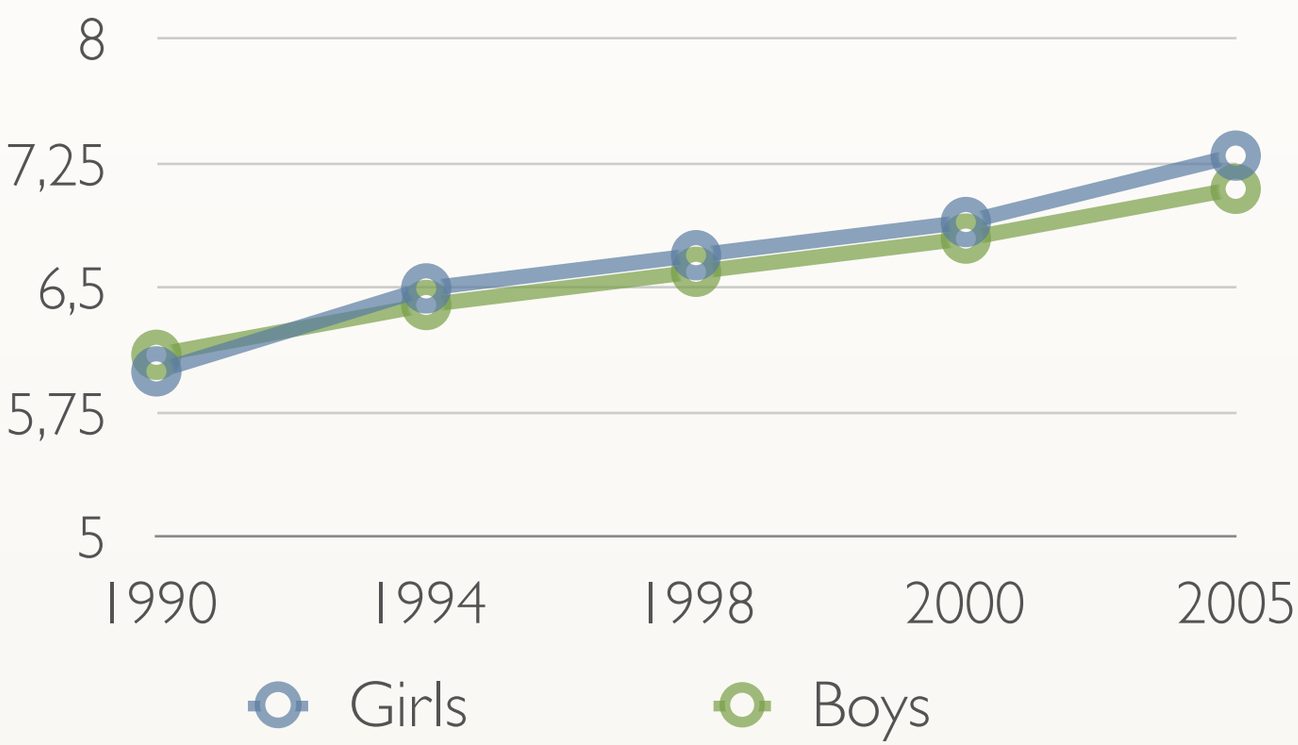
STRUDEL SOCIO-TECHNICAL RESEARCH USING DATA EXCAVATION LAB

Which is more effective?

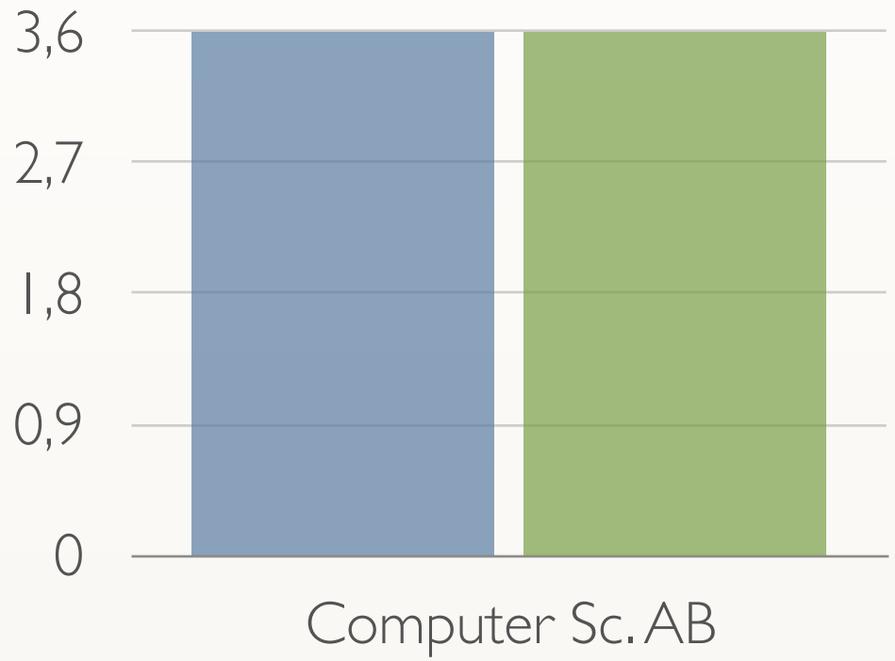
Which is more effective?

GENDER DIVERSITY IN HIGH SCHOOL

High School Credits Earned in Mathematics and Science, by Gender, 1990–2005

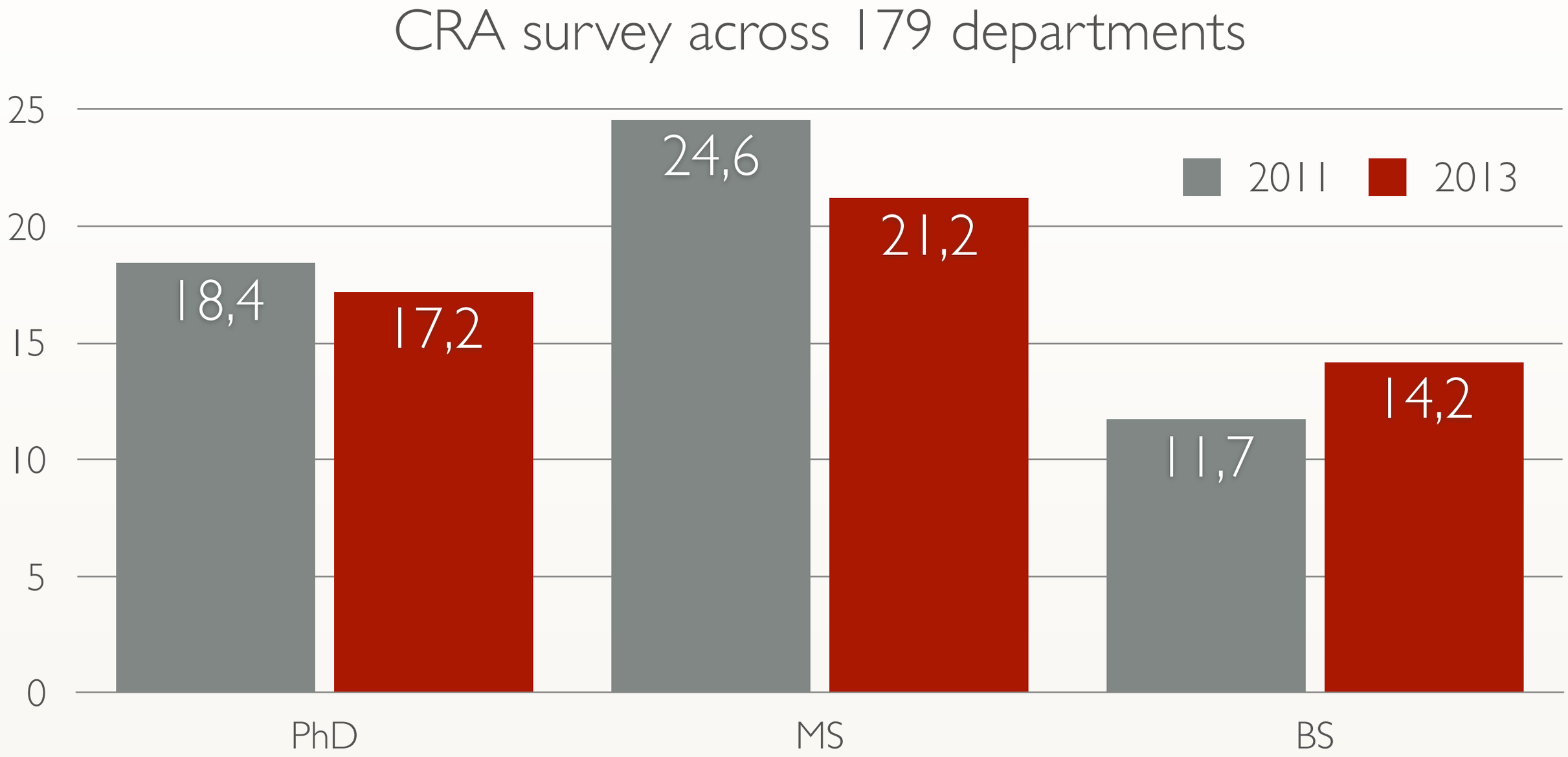


Average Scores on Advanced Placement Tests in Computer Sience 2009



No gender differences early

GENDER DIVERSITY IN HIGHER CS EDUCATION



Underrepresentation in CS

WHAT IS THE PROBLEM?

- **Stereotype** threat
- Self **confidence**
- **Bias** in classroom, advising
- Lack of women **faculty**, **mentors**, **role models**
- …

GENDER DIVERSITY IN TECH COMPANIES

Company	Male	Female
Twitter	90%	10%
Yahoo	85%	15%
Facebook	85%	15%
LinkedIn	83%	17%
Microsoft	83%	17%
Google	82%	18%
Apple	80%	20%

Underrepresentation in tech companies

GENDER DIVERSITY IN OPEN SOURCE SOFTWARE

Company	Male	Female
Twitter	90%	10%
Yahoo	85%	15%
Facebook	85%	15%
LinkedIn	83%	17%
Microsoft	83%	17%
Google	82%	18%
Apple	80%	20%

10.9%

Even worse in OSS!

FLOSS 2013: A survey dataset about free software contributors: challenges for curating, sharing, and combining G Robles, L Arjona-Reina, B Vasilescu, A Serebrenik, JM Gonzalez-Barahona. *MSR 2014*

GENDER DIVERSITY IN OPEN SOURCE SOFTWARE

The “hacker” culture is **male-dominated** and **unfriendly** to women.

[Turkle, S. The Second Self: Computers and the Human Spirit. MIT Press, 2005]

Reports of active **discrimination** and **sexism** towards women.

[Nafus, D. ‘Patches don’t have gender’: What is not open in open source software. New Media & Society 14, 4 (2012), 669–683]

THE EVOLUTION OF THE "SOCIAL PROGRAMMER"

github SOCIAL CODING

ashley williams
ashleygwilliams

npm, inc
ridgewood, queens, NYC
http://ashleygwilliams.github.io/
Joined on Oct 31, 2011

776 Followers **38** Starred **15** Following

Organizations

Contributions | Repositories | Public activity

Follow

Popular repositories

- **breakfast-repo** — a collection of videos, recordings, and podcast… — 208 ★
- **x86-kernel** — a simple x86 kernel, extended with Rust — 48 ★
- **ashleygwilliams.github.io** — hi, i'm ashley. nice to meet you. — 37 ★
- **jsconf-2015-deck** — deck for jsconf2015 talk, "if you wish to learn e… — 32 ★
- **ratpack** — sinatra boilerplate using activerecord, sqlite, a… — 32 ★

Repositories contributed to

- npm/**docs** — The place where all the npm docs live. — 44 ★
- mozilla/**publish.webmaker.org** — The teach.org publishing service for goggles a… — 2 ★
- npm/**marky-markdown** — npm's markdown parser — 104 ★
- artisan-tattoo/**assistant-frontend** — ember client for assistant-API — 5 ★
- npm/**npm-camp** — a community conference for all things npm — 1 ★

Public contributions

Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan
M W F

Summary of pull requests, issues opened, and commits. Learn how we count contributions. Less More

Contributions in the last year	Longest streak	Current streak
1,886 total	37 days	7 days
Jan 24, 2015 – Jan 24, 2016	October 7 – November 12	January 18 – January 24

https://github.com/ashleygwilliams

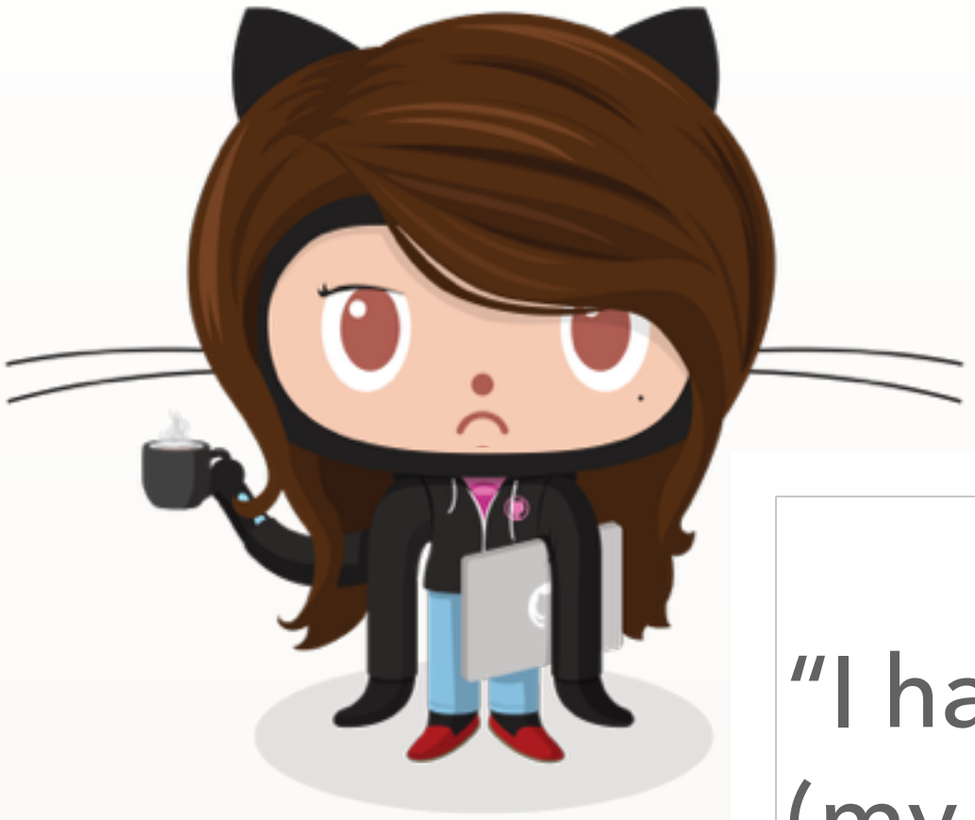
- Programming in a socially networked world: the evolution of the social programmer
  C Treude, F Figueira Filho, B Cleary, MA Storey. *FutureCSD-CSCW 2012*
- Social coding in GitHub: transparency and collaboration in an open software repository
  L Dabbish, C Stuart, J Tsay, J Herbsleb. *CSCW 2012*
- Social networking meets software development: Perspectives from GitHub, MSDN, Stack Exchange, and TopCoder
  A Begel, J Bosch, MA Storey. IEEE Software 2013

GENDER DIVERSITY IN SOCIAL CODING ENVIRONMENTS

- Google Diversity (2015) www.google.com/diversity/index.html#chart
- Inside Microsoft (2015) https://goo.gl/nT4YiI

- Exploring the data on gender and GitHub repo ownership
  Alyssa Frazee. http://alyssafrazee.com/gender-and-github-code.html
- Stack Overflow 2015 Developer Survey (26,086 people from 157 countries)
  http://stackoverflow.com/research/developer-survey-2015#profile-gender

SOME ANECDOTAL EVIDENCE OF DISCRIMINATION



"I have used a fake GitHub handle (my normal GitHub handle is my first name, which is a distinctly female name) so that people would assume I was male"

- Perceptions of Diversity on GitHub: A User Survey. Vasilescu, B., Filkov, V., and Serebrenik, A. International Workshop on Cooperative and Human Aspects of Software Engineering, CHASE, IEEE (2015), 50–56.

SOME ANECDOTAL EVIDENCE OF DISCRIMINATION

Does diversity add any value in GitHub teams?

"I ha
(my
first name, which is a distinctly female name) so that people would assume I was male"

- Perceptions of Diversity on GitHub: A User Survey. Vasilescu, B., Filkov, V., and Serebrenik, A. International Workshop on Cooperative and Human Aspects of Software Engineering, CHASE, IEEE (2015), 50–56.

DIVERSITY IS RECOGNIZED AS VALUABLE

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"Driver of internal innovation and business growth" [Forbes]

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Companies with diverse executive boards have higher earnings and returns on equity [McKinsey]

DIVERSITY IS RECOGNIZED AS VALUABLE

"Driver of internal innovation and business growth" [Forbes]

Companies with diverse executive boards have higher earnings and returns on equity [McKinsey]

BENEFITS:

- access to different networks
- broader views
- creativity
- adaptability
- problem solving

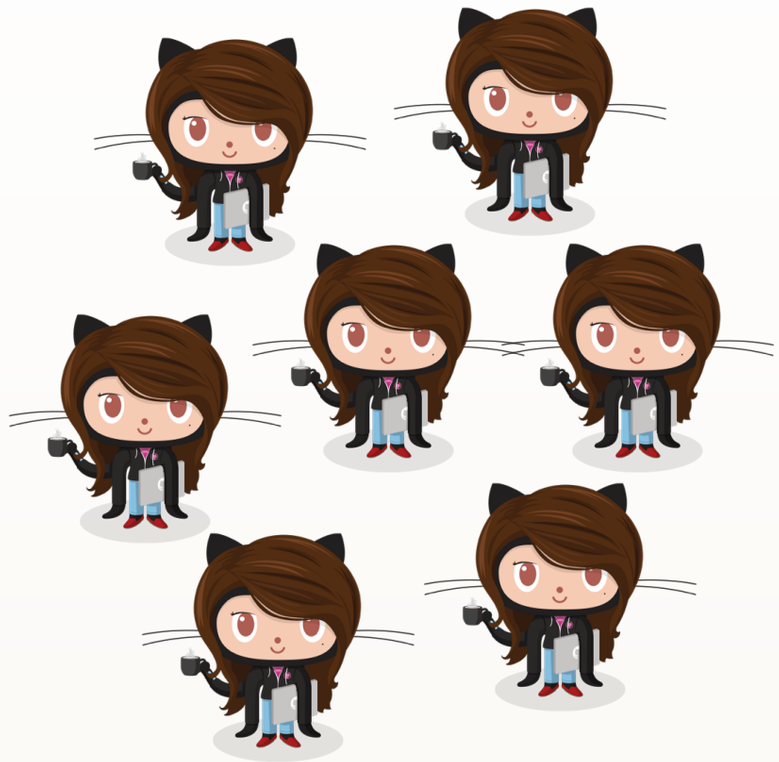
…

→ INFORMATION PROCESSING THEORY

- Salancik, G. R., and Pfeffer, J. A social information processing approach to job attitudes and task design. Admin. Sci. Quart. 23, 2 (1978), 224–253

DIVERSITY IN SOFTWARE TEAMS?

vs.



HIGHER RISK OF:

- communication breakdown
- conflict
- confusion
- stress
- discrimination

...

DIVERSITY IN SOFTWARE TEAMS?

vs.

HIGHER RISK OF:

- communication breakdown
- conflict
- confusion
- stress
- discrimination

…

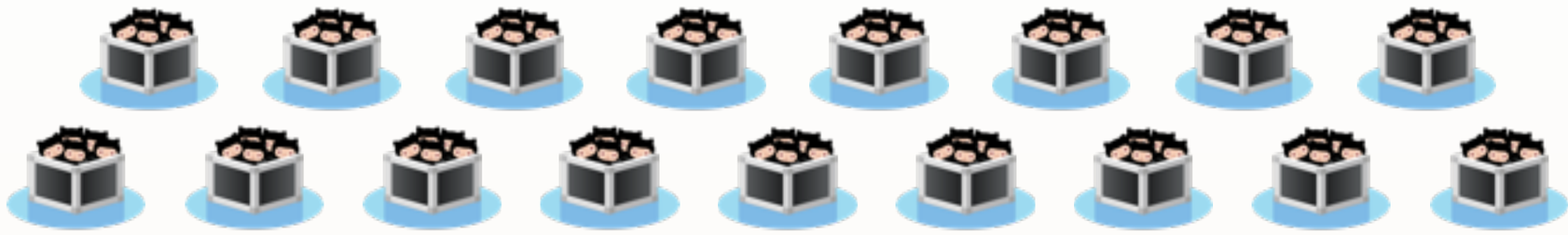
→ SIMILARITY ATTRACTION THEORY

→ SOCIAL IDENTITY, SOCIAL CATEGORIZATION THEORY

- Byrne, D. E. The attraction paradigm. Personality and psychopathology. Academic Press, 1971
- Tajfel, H. Social psychology of intergroup relations. Annu. Rev. Psychol. 33, 1 (1982), 1–39

NATURAL EXPERIMENT

1. Mine data from many **collaborative projects**



- **Gender and tenure diversity in GitHub teams**. Vasilescu, B., Posnett, D., Ray, B., Brand, M.G.J. van den, Serebrenik, A., Devanbu, P., and Filkov, V. CHI Conference on Human Factors in Computing Systems, CHI, ACM (2015), 3789–3798.

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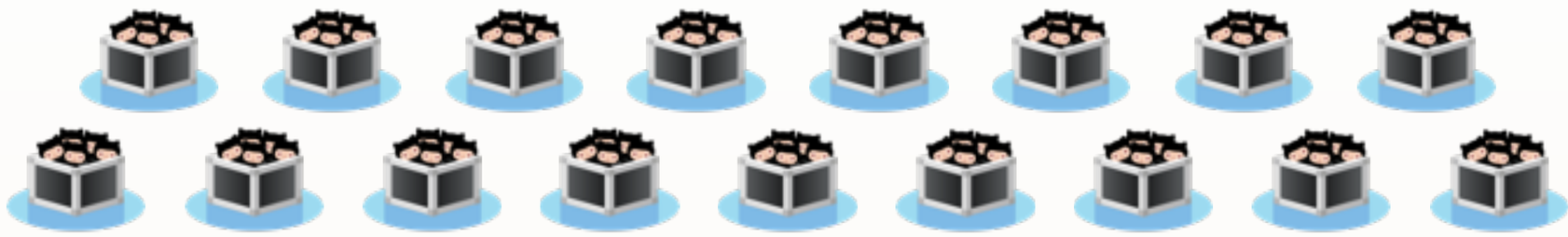

2. Compare **outputs produced per unit time**
in more/less diverse teams

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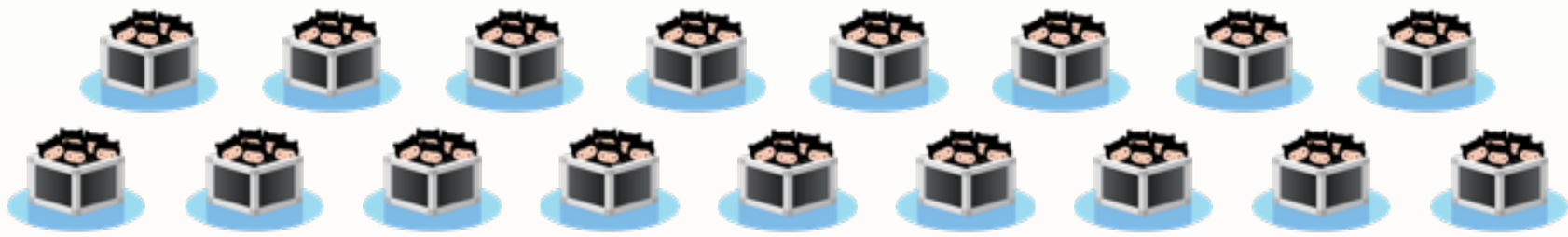

2. Compare **outputs produced per unit time**
in more/less diverse teams

Gender diversity
= mix women/men

Simplifying assumption: gender is binary

Tenure diversity
= mix junior/senior

GitHub coding experience

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OPPORTUNITIES AND CHALLENGES

World's largest open source community

Trace data available @ghtorrent [Gousios et al]

OPPORTUNITIES AND CHALLENGES

Theoretical

Technical

OSS as meritocracy; contribution quality as main driver of impression formation
[Dabbish et al, Marlow et al]

OPPORTUNITIES AND CHALLENGES

Theoretical

Technical

Demographics are less salient in OSS [Riordan & Shore]

OPPORTUNITIES AND CHALLENGES

Theoretical

Technical

Anyone can contribute to any repository.
Who's on a team?

OPPORTUNITIES AND CHALLENGES

Theoretical

Technical

Gender is not explicitly recorded

OPPORTUNITIES AND CHALLENGES

Theoretical

Technical

People contribute
under multiple aliases

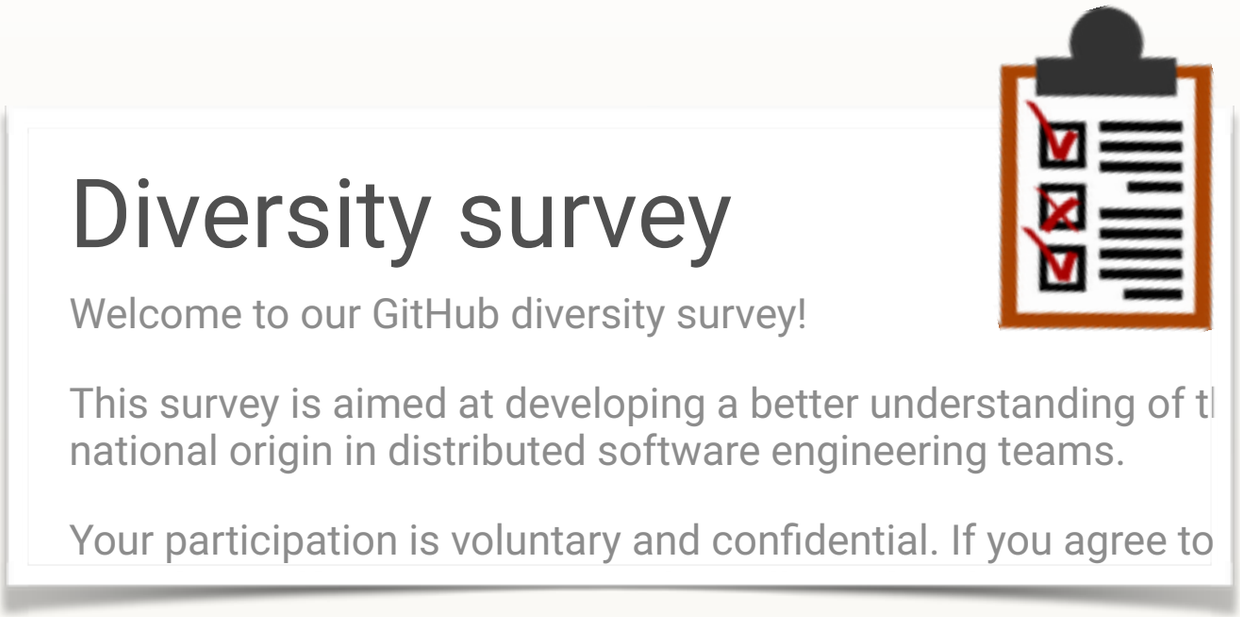
OPPORTUNITIES AND CHALLENGES

Theoretical

Technical

How to analyze such large-scale longitudinal trace data?

APPROACH: MIXED METHODS



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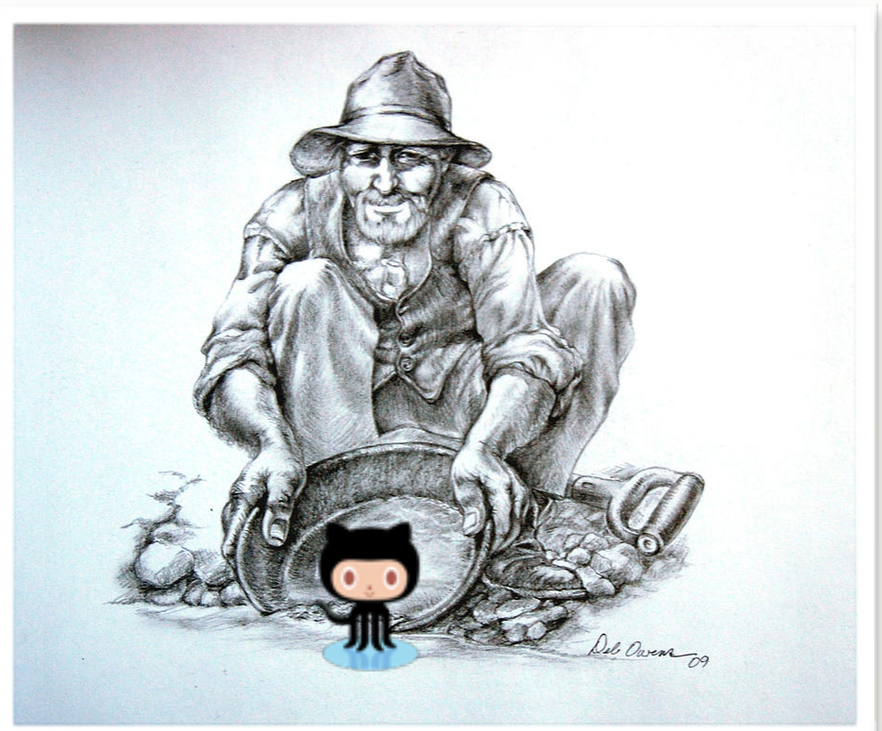

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SURVEY: QUESTIONS

What do people perceive constitutes a team?

Do people recognize differences among others on their team?
Which differences are more prominent?

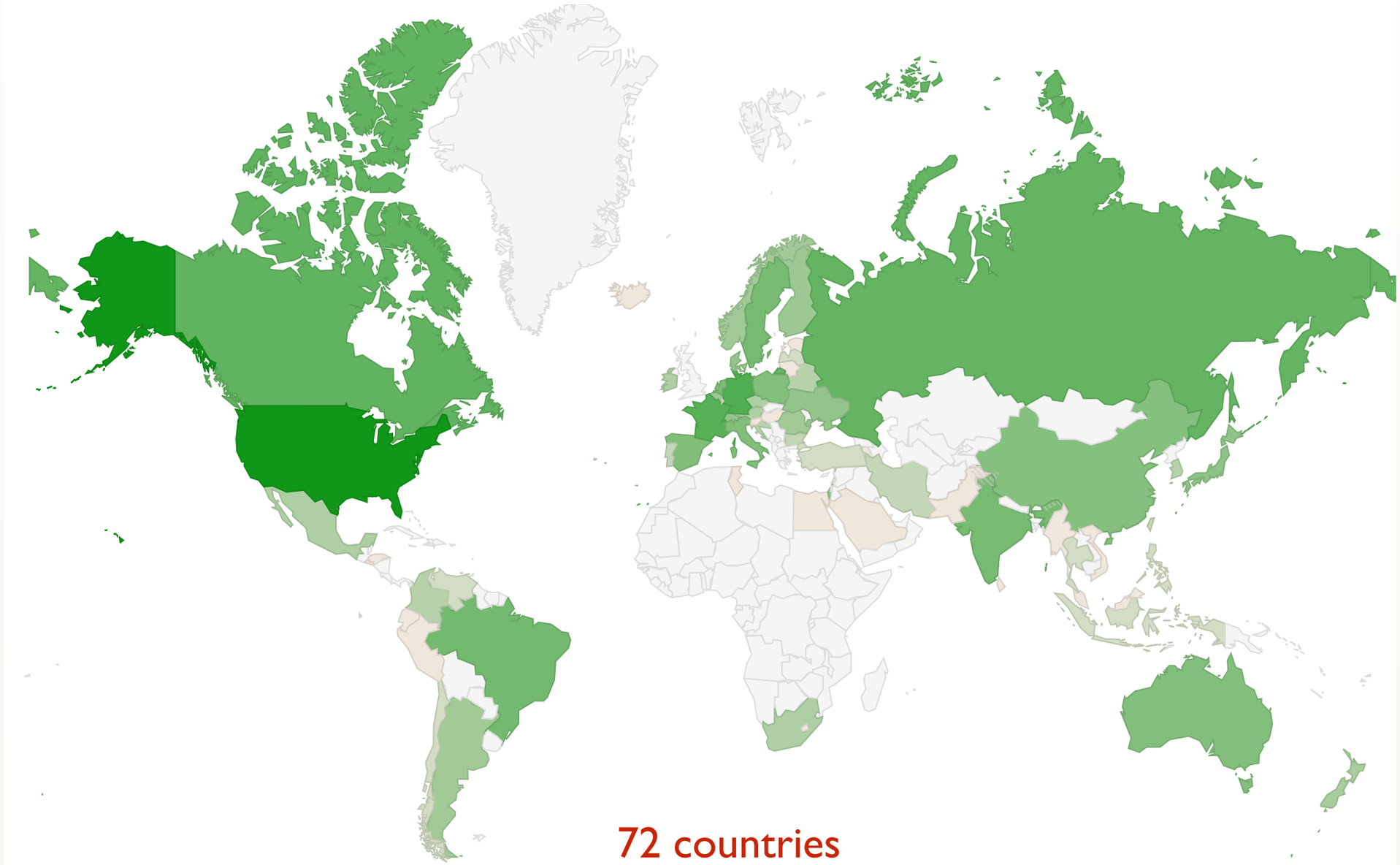
How is diversity perceived to influence collaboration?

- Perceptions of Diversity on GitHub: A User Survey. Vasilescu, B., Filkov, V., and Serebrenik, A. International Workshop on Cooperative and Human Aspects of Software Engineering, CHASE, IEEE (2015), 50–56.

SURVEY: GEOGRAPHY (1)

F 24%
M 75%

4,500 invitations, 816 responses

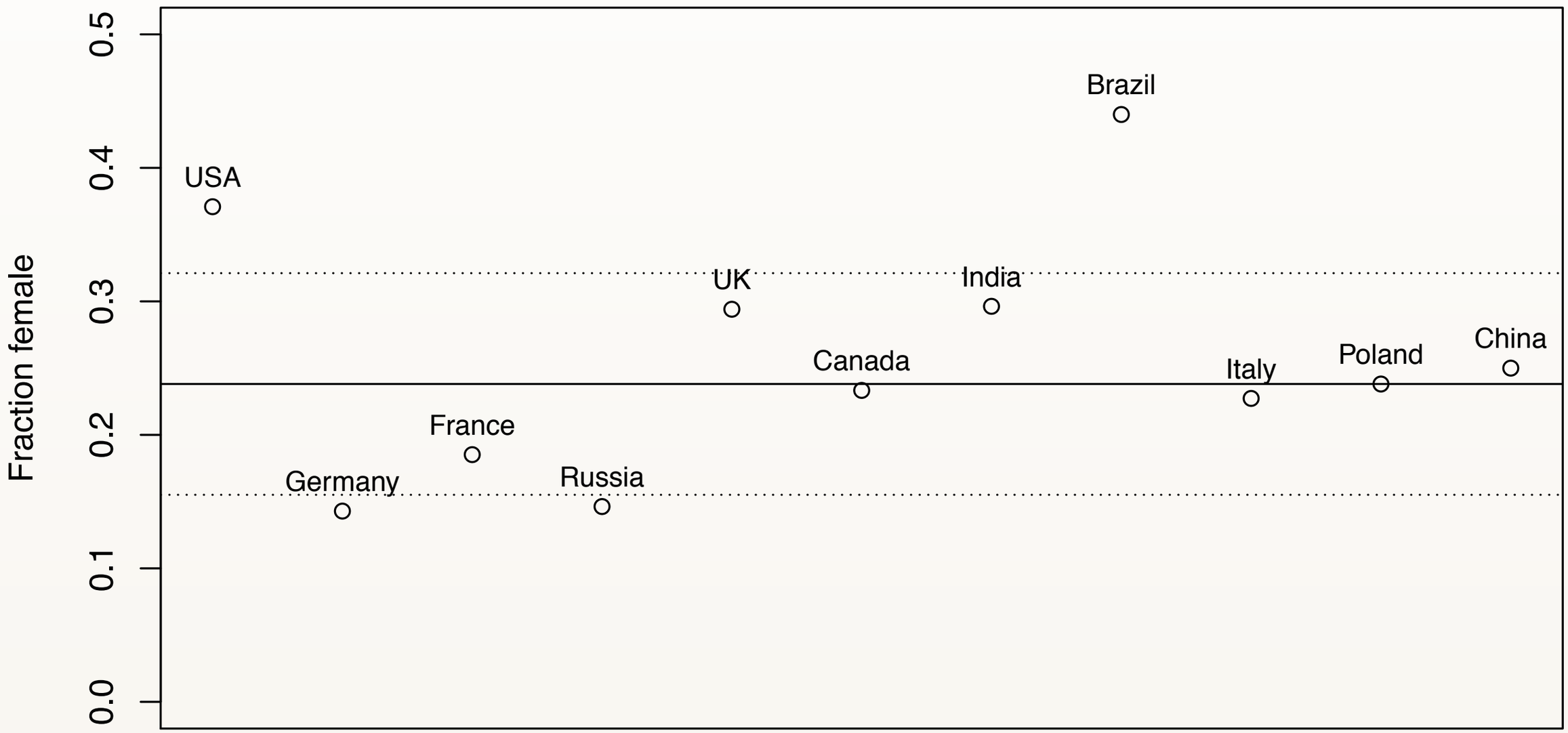


72 countries

SURVEY: GEOGRAPHY (2)

4,500 invitations, 816 responses

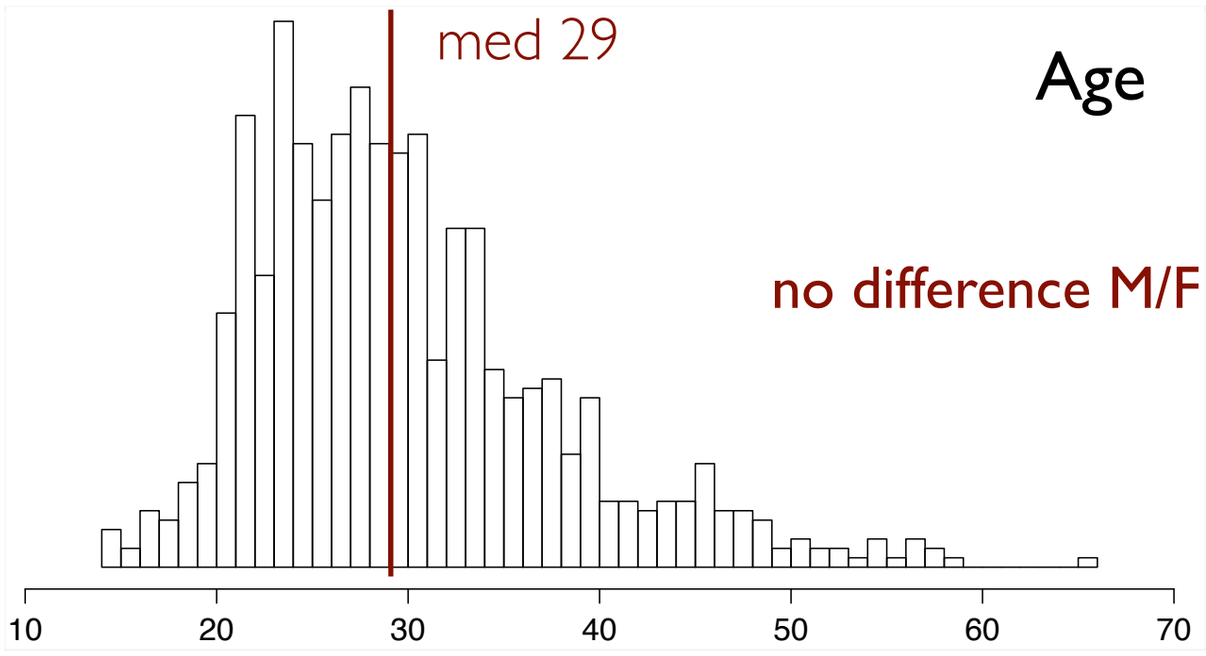
F 24%
M 75%



SURVEY: AGE & EXPERIENCE

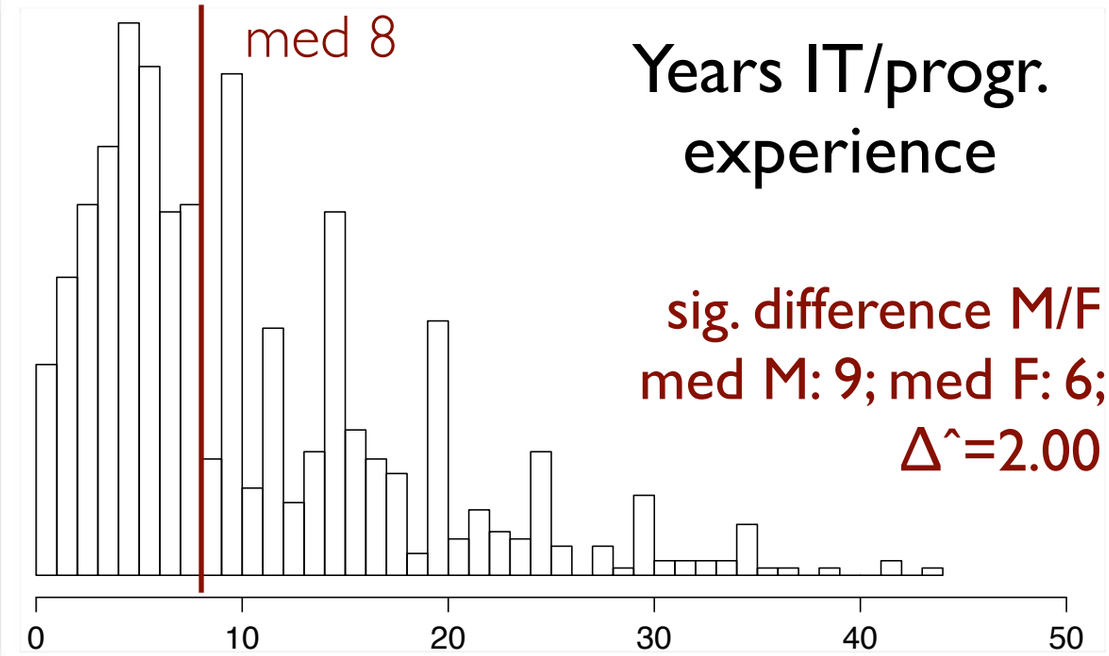
4,500 invitations, 816 responses

F 24%
M 75%



Age

no difference M/F



Years IT/progr. experience

sig. difference M/F
med M: 9; med F: 6;
$\Delta\hat{}$=2.00

SURVEY: OCCUPATIONS

4,500 invitations, 816 responses

F 24%
M 75%

Occupation	%
Web developer	59.70
Manager / Team leader	21.50
Student	20.64
Desktop software developer	21.25
Mobile application developer	19.16
IT staff / System administrator	15.48
Academic	13.51
Other	13.14
Database administrator	9.95
Embedded application developer	9.46
I don’t work in tech	2.58

SURVEY: OCCUPATIONS + MEN

F 24%
M 75%

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SURVEY: TEAM COMPOSITION

Whom do you consider part of your team?

- The repository owner and others who can push directly
- People who contribute code frequently
- People who work on my particular feature/ branch

less inclusive

more inclusive

- Everyone who does something in this repository

SURVEY: TEAM COMPOSITION

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less inclusive

more inclusive

#1 (72%)

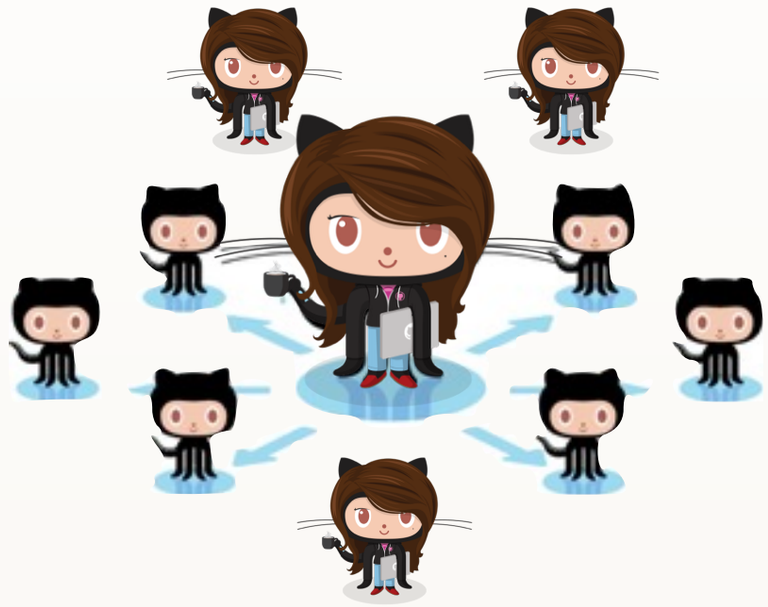
- Everyone who does something in this repository

Everyone

SURVEY: SALIENCE OF DEMOGRAPHICS

Which of the following characteristics of your team members are you aware of?

… for (none other / few other / most other) team members



- Programming skills
- Social skills
- Gender
- Ethnicity
- Overall GitHub experience
- Reputation as programmer
- Country of residence
- Personality
- Age
- Educational level
- Real name
- Hobbies
- Employment
- Political views

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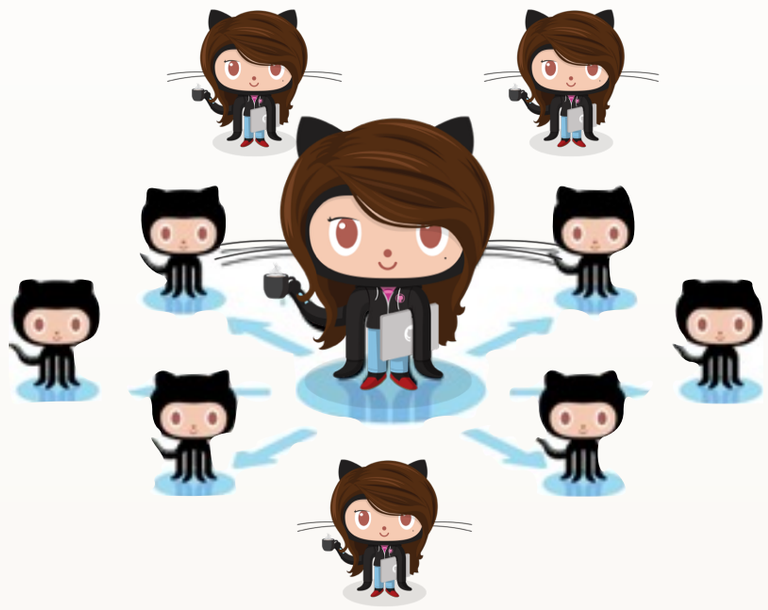

<—> Demographics not salient is OSS [Riordan & Shore]

- Programming skills 74%
- Gender 48%
- Real name 45%
- Social skills 42%
- Country of residence 40%
- Personality 39%
- Reputation as programmer 31%
- Ethnicity 30%
- Employment 30%
- GitHub experience 28%
- Educational level 26%
- Age 23%
- Hobbies 11%
- Political views 4%

Developers are aware of each other's gender

SURVEY: SALIENCE OF DEMOGRAPHICS + WOMEN

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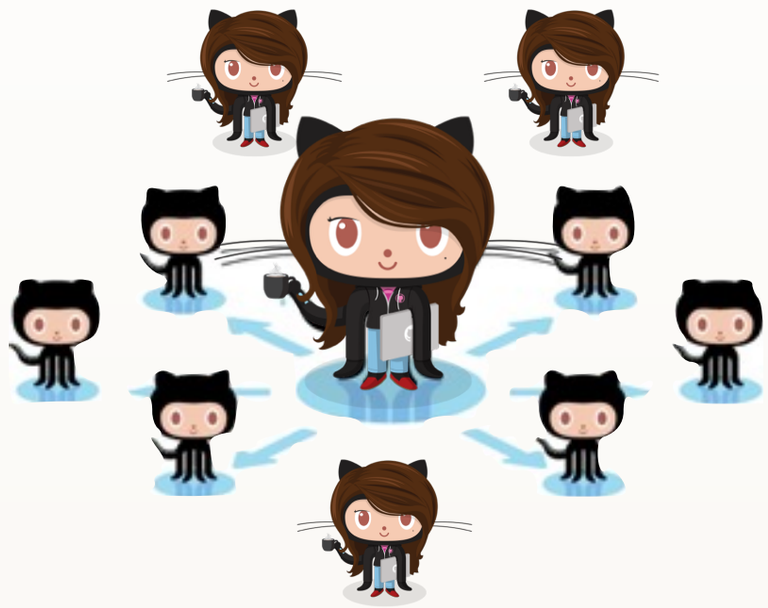

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SURVEY: VIEWS ON DIVERSITY (1)

Experiences working in a diverse team

"code sees no color or gender"

"any demographic identity is irrelevant"

"more about the contributions to the code than the 'characteristics' of the person"

Meritocracy; no effects of diversity

SURVEY: VIEWS ON DIVERSITY (2)

Experiences working in a diverse team

"diverse viewpoints often lead to **lively discussions and new ideas**"

"in general it is always **enriching** to communicate with someone different"

"diversity in the body of folks willing to interact and contribute works to **strengthen the usability** of the library"

Positive effects of diversity

SURVEY: VIEWS ON DIVERSITY (3)

Experiences working in a diverse team

Gender related

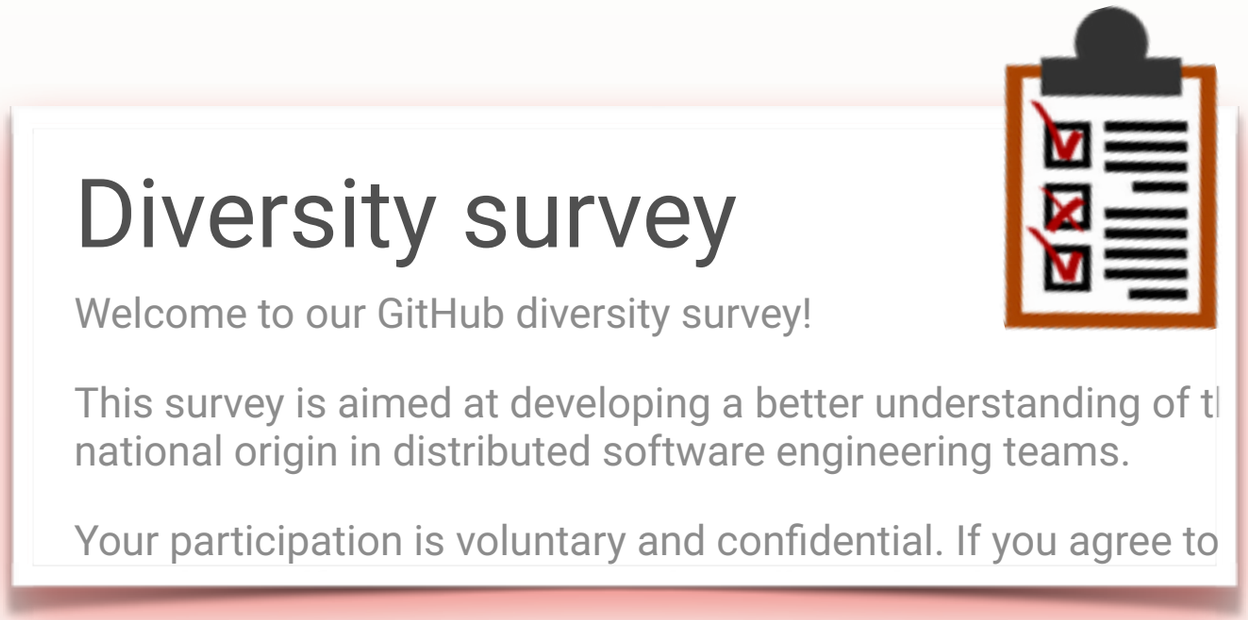
"I have used a fake GitHub handle (my normal GitHub handle is my first name, which is a distinctly female name) **so that people would assume I was male**"

"interactions are usually positive too, with occasional sexism, but **nothing more then one encounters in the rest of life**"

"… caused me to **leave a project**"

Negative effects of diversity

APPROACH: MIXED METHODS



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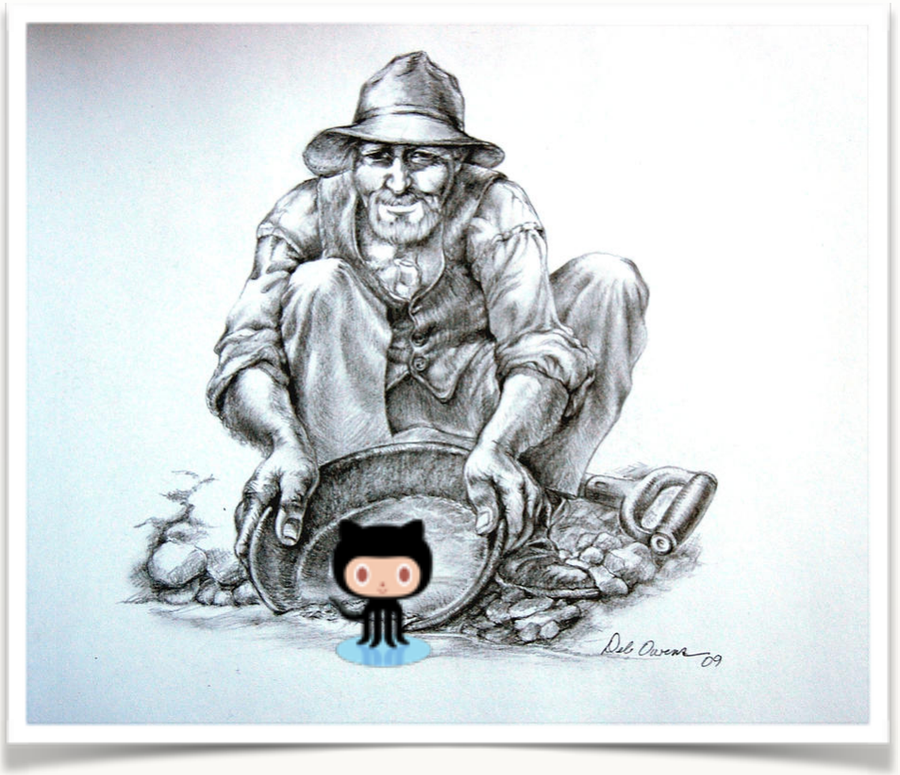
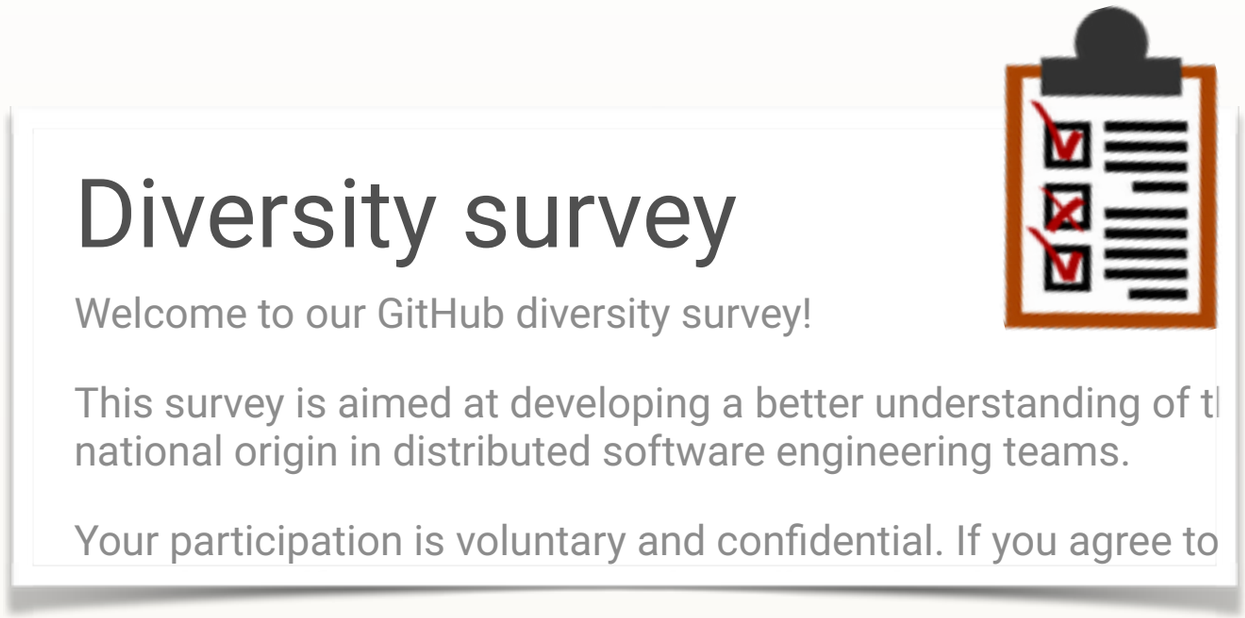


The team is everyone

Gender is surprisingly salient

Positive/negative/no effects of diversity

APPROACH: MIXED METHODS



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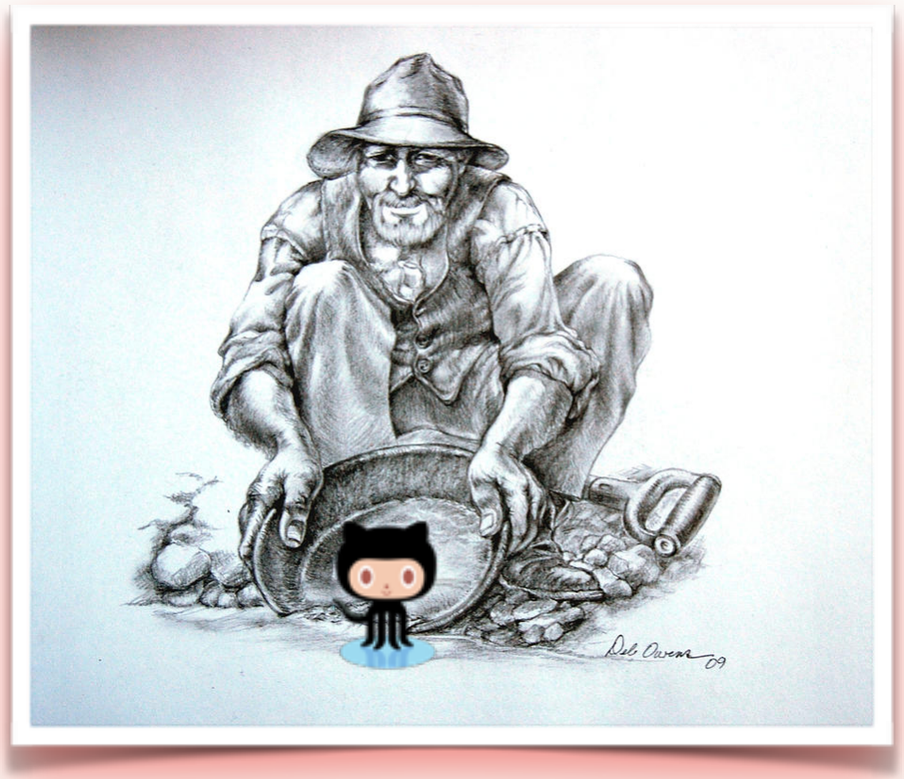


MINING GITHUB

2.6M projects

@ghtorrent Jan 2014 data dump
[Gousios et al]
http://ghtorrent.org

MINING GITHUB

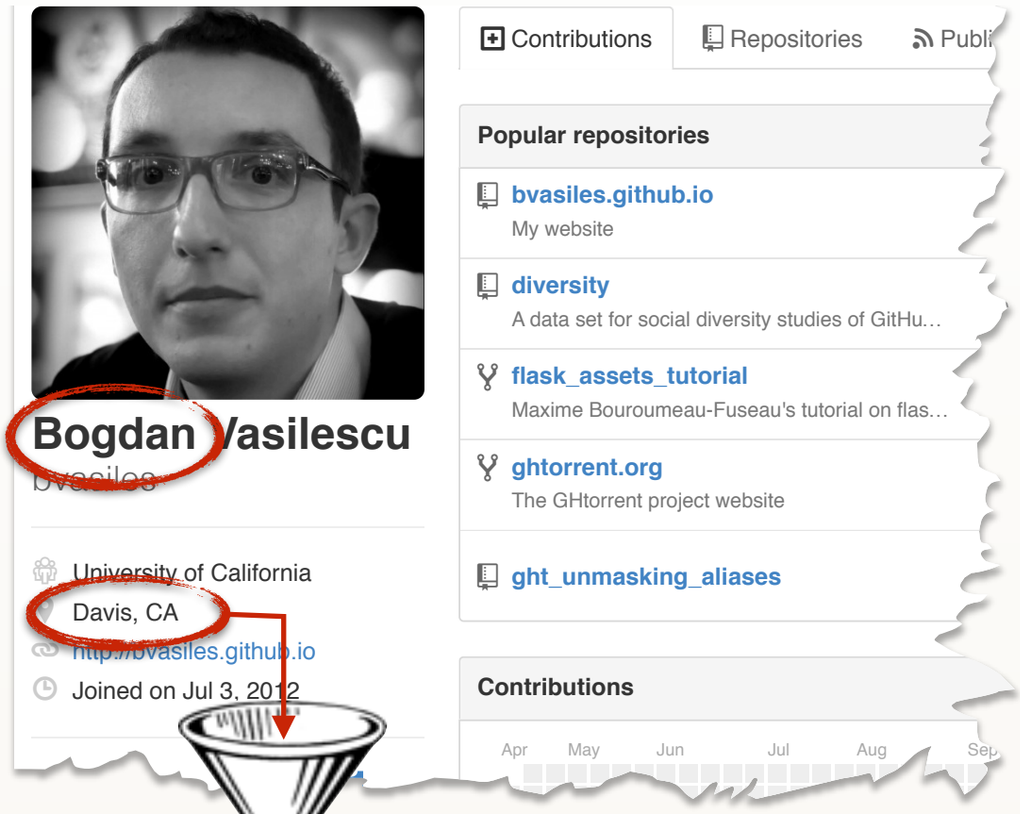
2.6M projects

Active projects:
- Jan 1, 2008 - Jan 2, 2014
- ≥100 commits
- ≥90 days
- ≥4 contributors

MINING GITHUB

2.6M projects

Infer genders
(93% precision)



Bing Maps + Heuristics

Bogdan + USA

Name frequency tables
for 30 countries

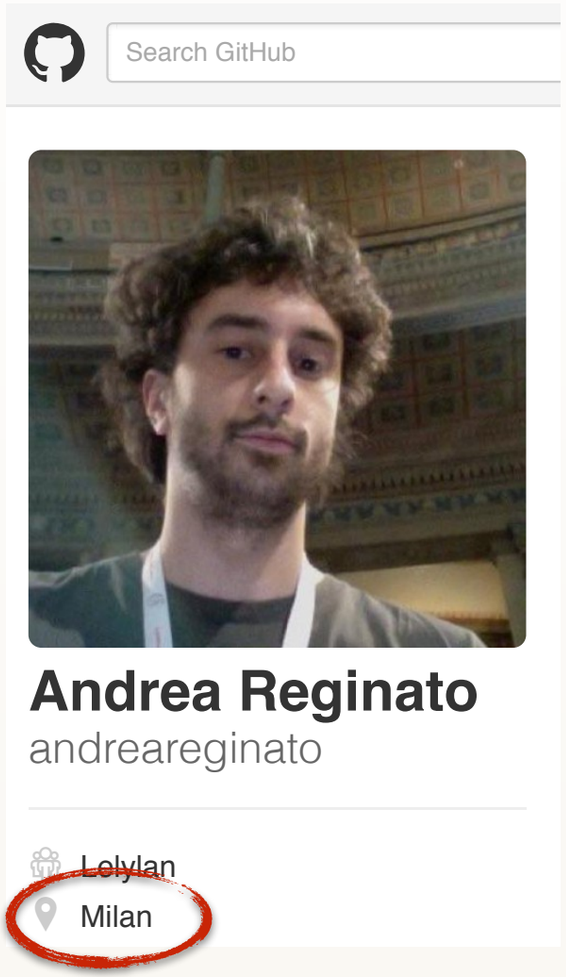
male

http://github.com/tue-mdse/genderComputer
http://github.com/tue-mdse/countryNameManager

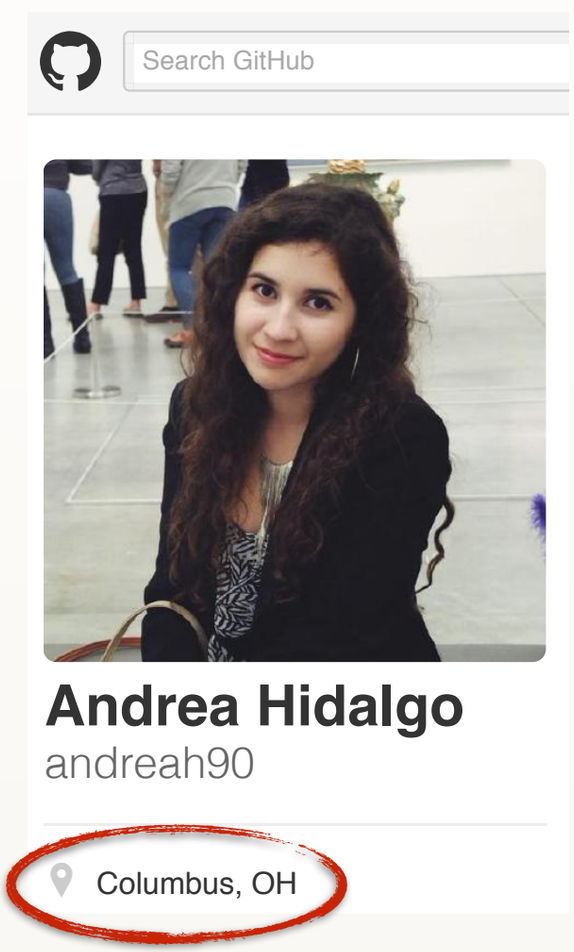
- Gender, representation and online participation: A quantitative study.
Vasilescu, B., Capiluppi, A., and Serebrenik, A. *Interacting with Computers 2014*

MINING GITHUB

2.6M projects



Italy



USA

Location matters!

MINING GITHUB

2.6M projects

Merge aliases

INTUITION:

Laurent Gautier - laurent@cbs.dtu.dk

Laurent Gautier - s010592@student.dtu.dk

Laurent - lgautier@gmail.com

- lgautier@altern.org

- Mining email social networks. Bird, C., et al. *MSR 2006*

MINING GITHUB

2.6M projects

Merge aliases

INTUITION:

- first name

Laurent Gautier - laurent@cbs.dtu.dk

Laurent Gautier - s010592@student.dtu.dk

Laurent - lgautier@gmail.com

- lgautier@altern.org

- Mining email social networks. Bird, C., et al. *MSR 2006*

MINING GITHUB

2.6M projects

Merge aliases

INTUITION:

- first name
- email prefix

Laurent Gautier - laurent@cbs.dtu.dk

Laurent Gautier - s010592@student.dtu.dk

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- lgautier@altern.org

- Mining email social networks. Bird, C., et al. *MSR 2006*

MINING GITHUB

2.6M projects

Merge aliases

INTUITION:

- first name
- email prefix
- first initial + last name

…

Laurent Gautier - laurent@cbs.dtu.dk

Laurent Gautier - s010592@student.dtu.dk

Laurent - lgautier@gmail.com

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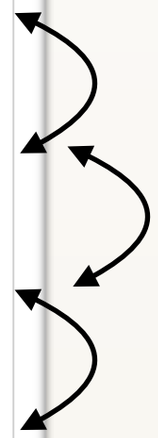

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MINING GITHUB

2.6M projects

Compute variables

Response

Productivity (#commits/quarter)

Turnover (fraction team new w.r.t. prev. quarter)

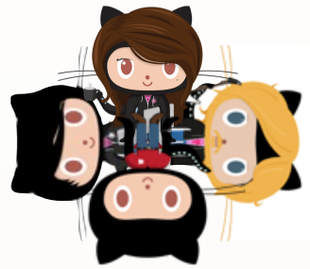
MINING GITHUB

2.6M projects

Compute variables

Response

Productivity (#commits/quarter)



Turnover (fraction team new w.r.t. prev. quarter)

Independent

Gender diversity (Blau index)

Tenure diversity (coeff. variation)

- project
- overall coding

MINING GITHUB

2.6M projects

Compute variables

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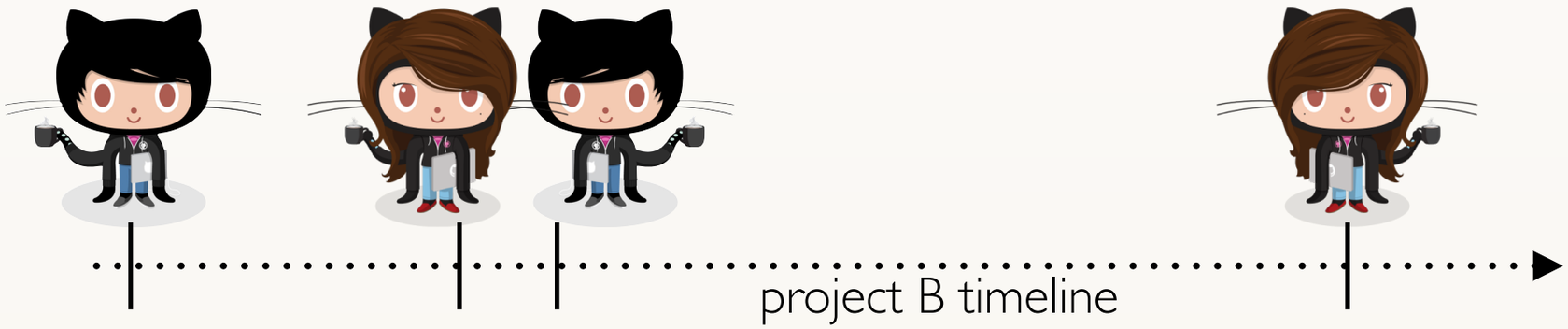
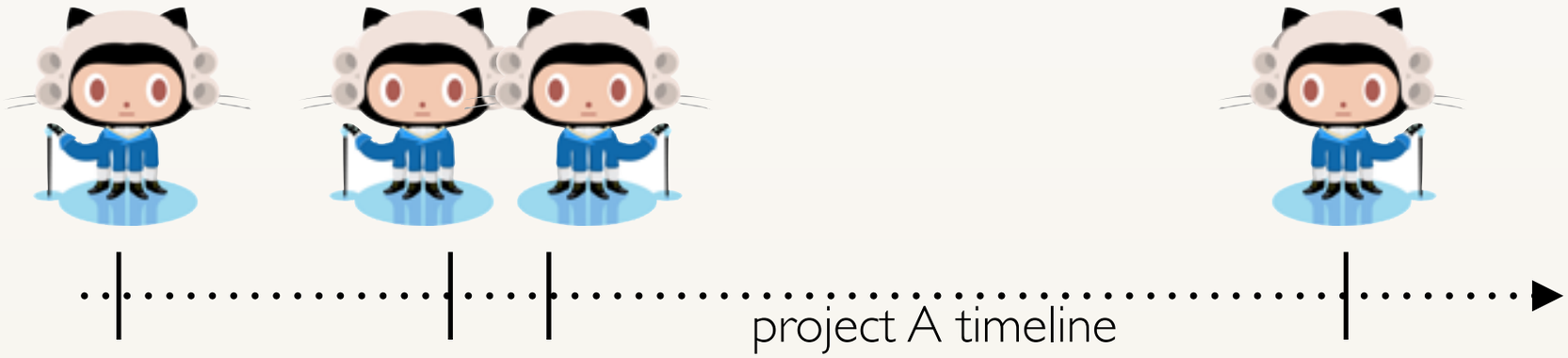




MINING GITHUB

2.6M projects

Compute variables

Response

Productivity (#commits/quarter)

Turnover (fraction team new w.r.t. prev. quarter)

Independent

Gender diversity (Blau index)

Tenure diversity (coeff. variation)

- project
- overall coding

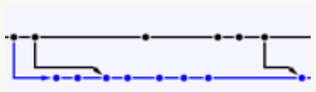
Controls

Human resources

Team size

Experience

Project size



Total commits

Evolution of GitHub & time passing

Project age

Time

Popularity / Distributed development

Comments

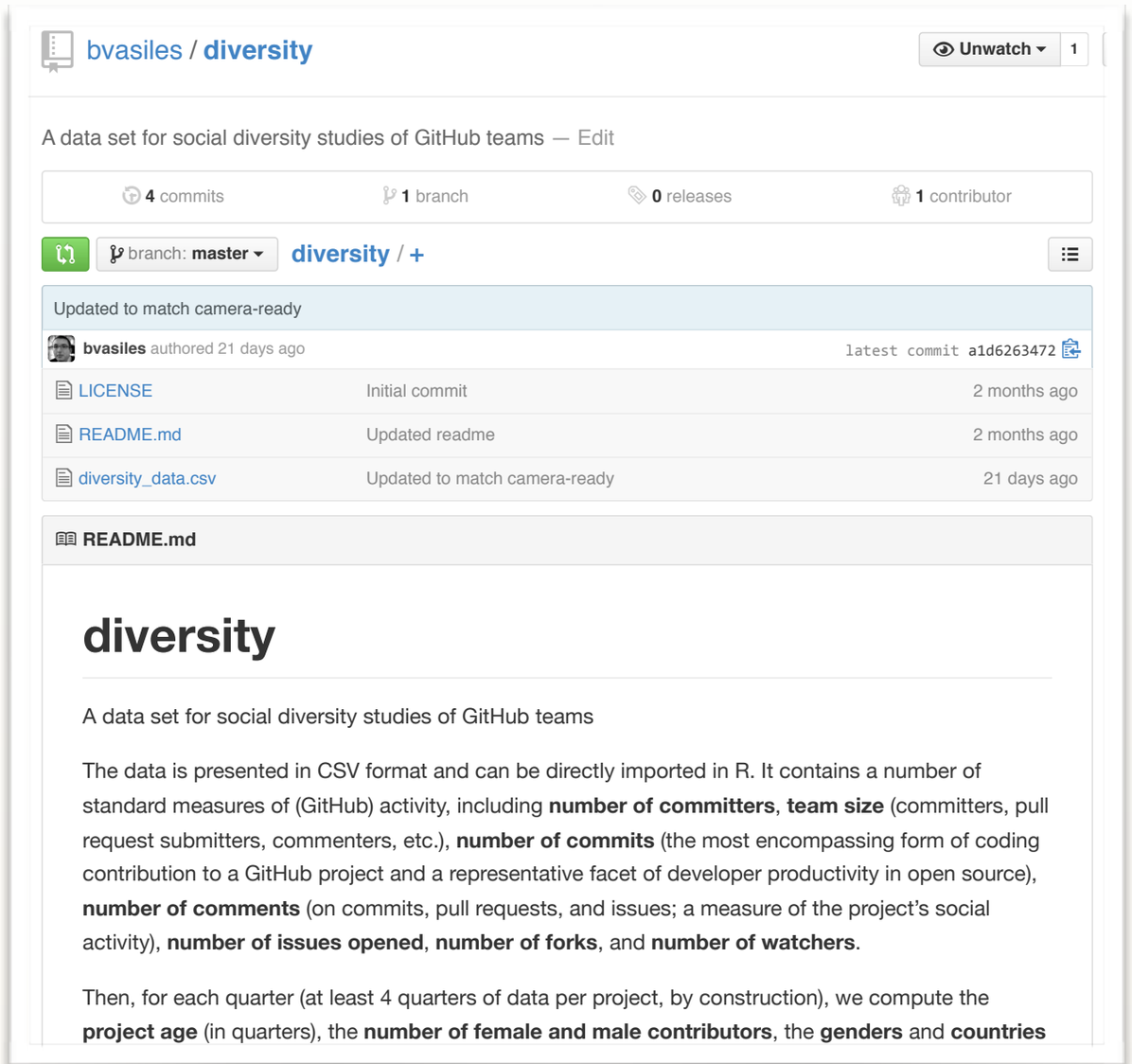
Forks

MINING GITHUB

Mining github SOCIAL CODING

2.6M projects

23K projects
(671K devs, 10.7M commits)



[Vasilescu et al, MSR'15]

- http://bvasiles.github.io/papers/msr_data15.pdf
- https://github.com/bvasiles/diversity

MULTIVARIATE REGRESSION

productivity ~ #team + #forks + … + prj_age
+ gender_diversity + tenure_diversity

MULTIVARIATE REGRESSION

productivity ~ #team + #forks + … + prj_age
+ gender_diversity + tenure_diversity

Project	Created on	Project age	Total #commits	#Forks	Time	#Commits	#Comments	Team size	Gender diversity	Commit tenure diversity	Turnover
A	2011-02-15	12	557	51	Q2	47	26	9	0.25	0.47	0.67
					Q5	19	12	10	0.00	0.93	0.75
					Q6	7	13	12	0.25	0.54	0.67
					Q7	56	53	20	0.00	0.56	0.87
					…						
B	2010-09-21	11	2075	578	Q4	71	169	83	0.03	0.66	0.87
					Q5	116	219	93	0.05	0.73	0.56
					Q6	186	367	119	0.06	0.80	0.86
					Q7	129	453	114	0.08	0.85	0.82
					…						

MULTIVARIATE REGRESSION

productivity ~ #team + #forks + … + prj_age
+ gender_diversity + tenure_diversity
+ (1 | prj_id)

Project	Created on	Project age	Total #commits	#Forks	Time	#Commits	#Comments	Team size	Gender diversity	Commit tenure diversity	Turnover
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					…						

MULTIVARIATE REGRESSION

$$\begin{aligned} \text{productivity} \sim\ & \#\text{team} + \#\text{forks} + \ldots + \text{prj_age} \\ & + \text{gender_diversity} + \text{tenure_diversity} \\ & + (1 \mid \text{prj_id}) + (1 \mid \text{qtr_id}) \end{aligned}$$

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MULTIVARIATE REGRESSION

productivity ~ #team + #forks + … + prj_age
+ gender_diversity + tenure_diversity
+ (1 + #team | prj_id) + (1 | qtr_id)

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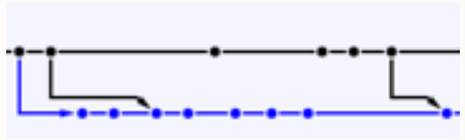
INCREASED DIVERSITY CORRELATES TO HIGHER PRODUCTIVITY

Productivity
(#commits/quarter)



positive; highly stat significant; stable across different team sizes

Gender diversity

\+

\+

\+

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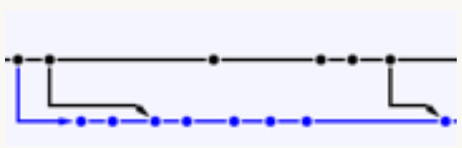
positive; highly stat significant; for mid-size & large teams

Commit tenure diversity

Team size



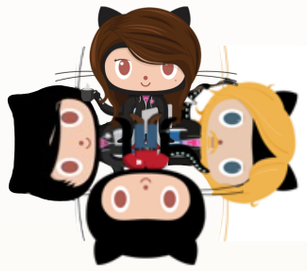
Overall project activity

Project age

But small effects!

NO EFFECT OF GENDER DIVERSITY ON TURNOVER

Turnover (fraction team new w.r.t. prev. quarter)



Gender diversity

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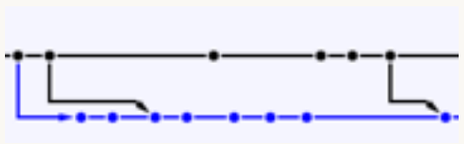
positive; highly stat significant

Commit/ project tenure diversity

Team size



Overall project activity

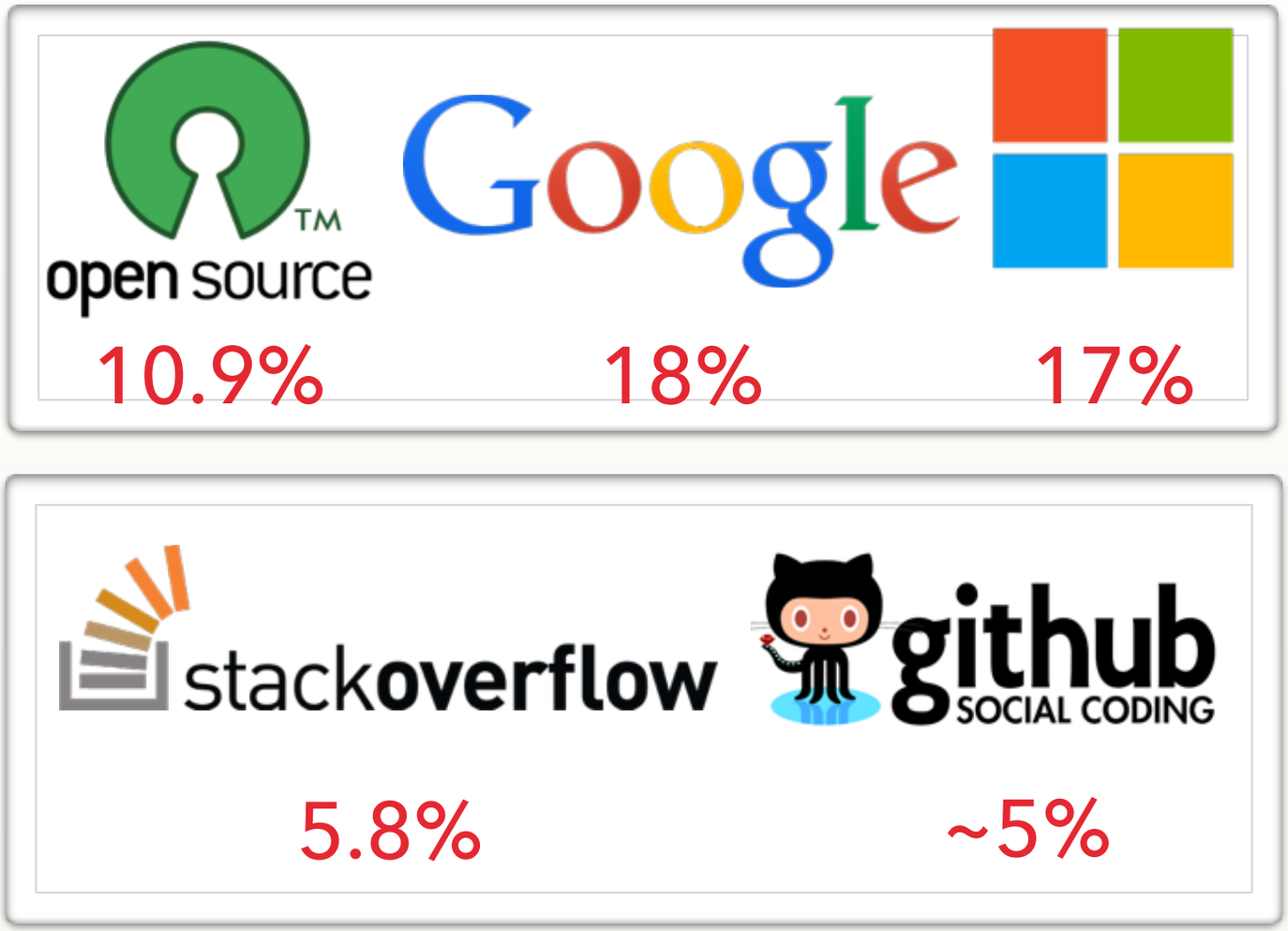
Med project tenure

But small effects!

Which is more effective?

Other confounds held fixed, **higher team diversity (gender & tenure)** is associated with **increased code production**,

HOW CAN WE IMPROVE THINGS?



HOW CAN WE IMPROVE THINGS?

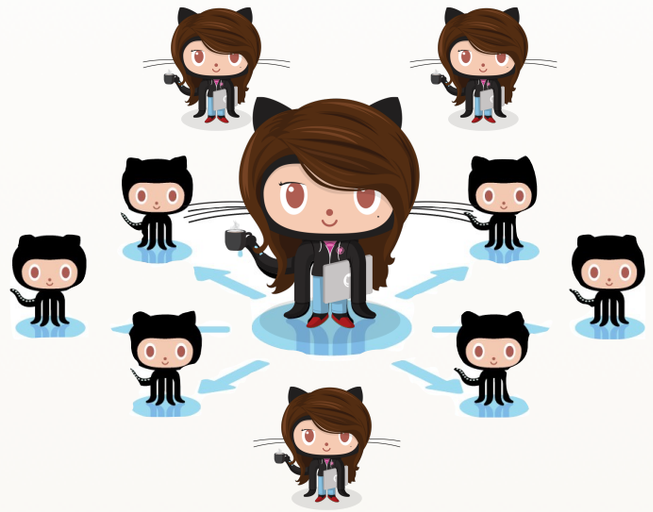
Community culture + Platform design

GENDER BIASES

SURVEY: SALIENCE OF DEMOGRAPHICS

Which of the following characteristics of your team members are you aware of?

… for (none other / few other / **most other**) team members

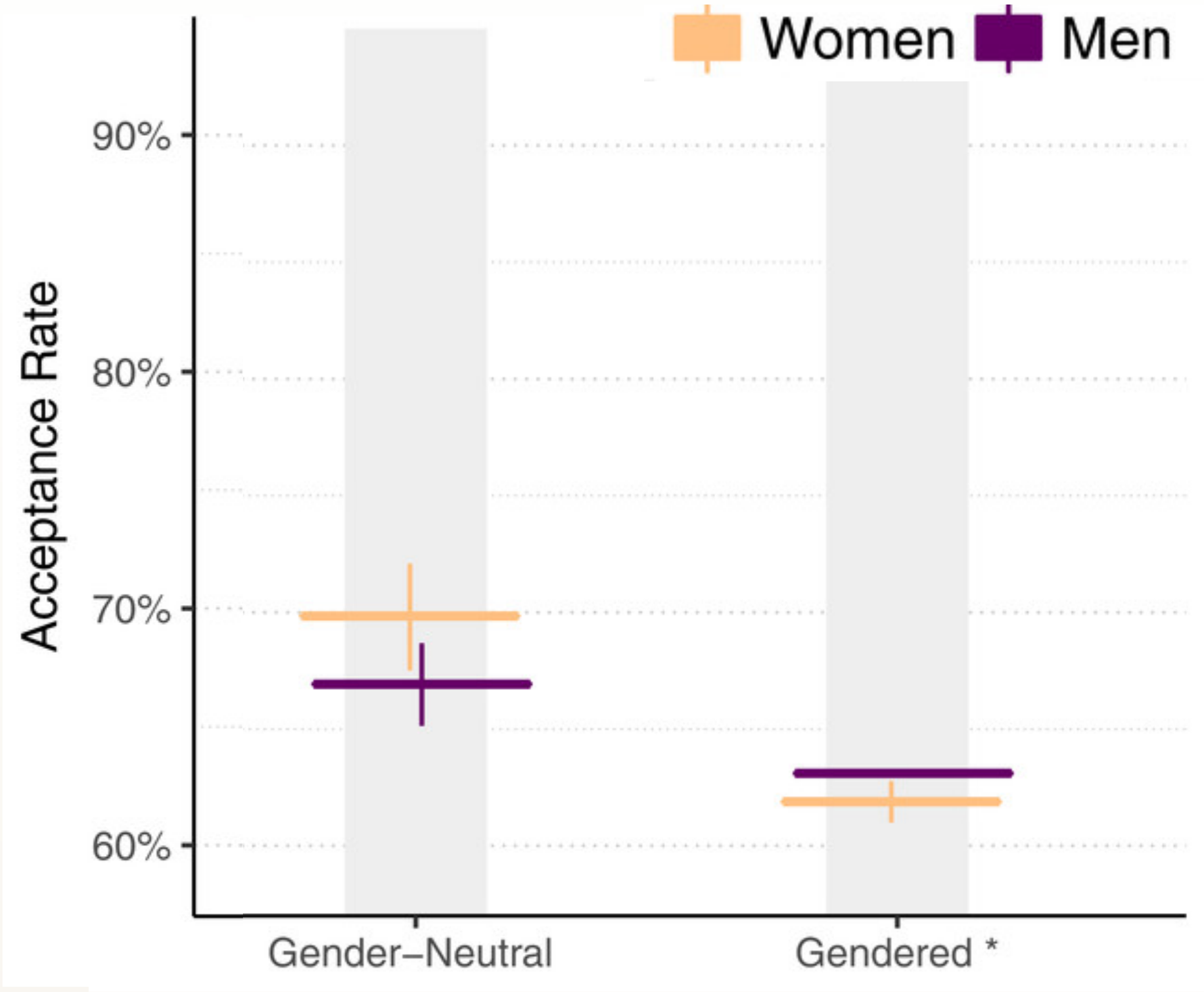


<—> Demographics not salient is OSS [Riordan & Shore]

- Programming skills 74%
- Gender 48%
- Real name 45%
- Social skills 42%
- Country of residence 40%
- Personality 39%
- Reputation as programmer 31%
- Ethnicity 30%
- Employment 30%
- GitHub experience 28%
- Educational level 26%
- Age 23%
- Hobbies 11%
- Political views 4%

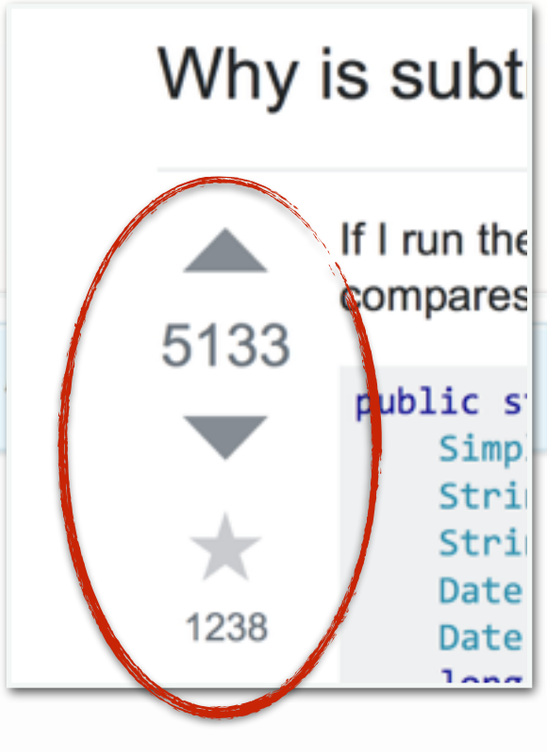
Developers are aware of each other's gender

GENDER BIASES – PULL REQUEST ACCEPTANCE



Terrell J, Kofink A, Middleton J, Rainear C, Murphy-Hill E, Parnin C, Stallings J. (2017) Gender differences and bias in open source: pull request acceptance of women versus men. *PeerJ Computer Science* 3:e111

GAMIFICATION – STACK OVERFLOW

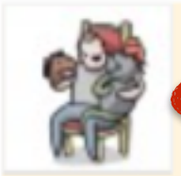


Stack Overflow

Q&A for professional and enthusiast programmers

(7,176,478 total users)

Type to find users:



Jon Skeet

554 6962 7774

member for: 8 years, 8 months

#1 all time rank

948,505 all time reputation

Darin Dimitrov

179 2694 2500

member for: 8 years, 7 months

#2 all time rank

734,602 all time reputation

BalusC

237 2698 2871

member for: 7 years, 9 months

#3 all time rank

728,504 all time reputation

GAMIFICATION – GITHUB

ashley williams
ashleygwilliams

npm, inc
ridgewood, queens, NYC
http://ashleygwilliams.github.io/
Joined on Oct 31, 2011

776 Followers **38** Starred **15** Following

Organizations

Contributions | Repositories | Public activity

Follow

Popular repositories

breakfast-repo 208 ★
a collection of videos, recordings, and podcast…

x86-kernel 48 ★
a simple x86 kernel, extended with Rust

ashleygwilliams.github.io 37 ★
hi, i'm ashley. nice to meet you.

jsconf-2015-deck 32 ★
deck for jsconf2015 talk, "if you wish to learn e…

ratpack 32 ★
sinatra boilerplate using activerecord, sqlite, a…

Repositories contributed to

npm/**docs** 44 ★
The place where all the npm docs live.

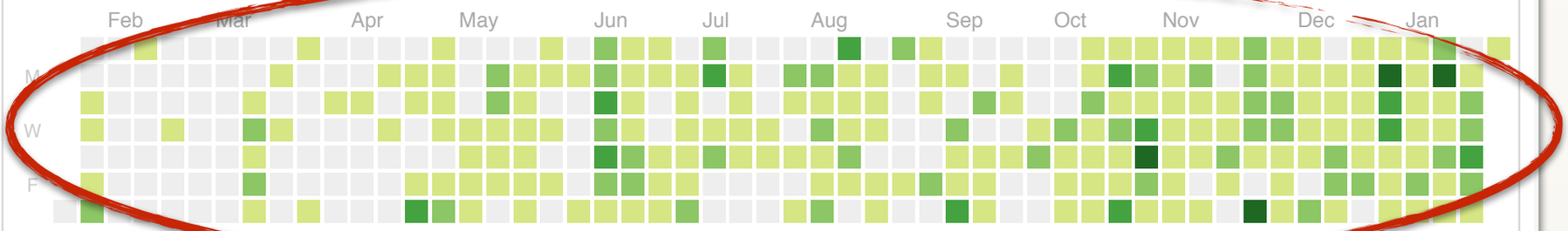
mozilla/**publish.webmaker.org** 2 ★
The teach.org publishing service for goggles a…

npm/**marky-markdown** 104 ★
npm's markdown parser

artisan-tattoo/**assistant-frontend** 5 ★
ember client for assistant-API

npm/**npm-camp** 1 ★
a community conference for all things npm

Public contributions



Summary of pull requests, issues opened, and commits. Learn how we count contributions.

Less More

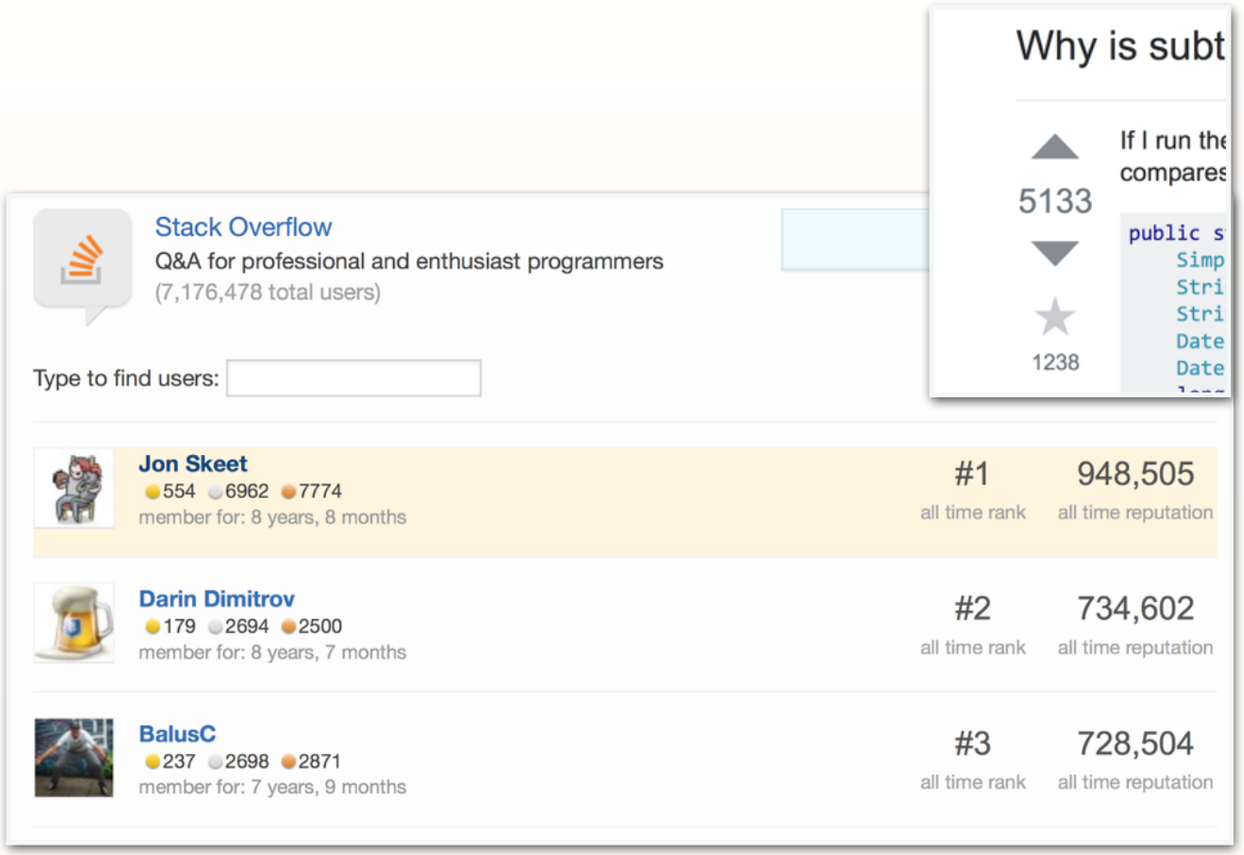
Contributions in the last year
1,886 total
Jan 24, 2015 – Jan 24, 2016

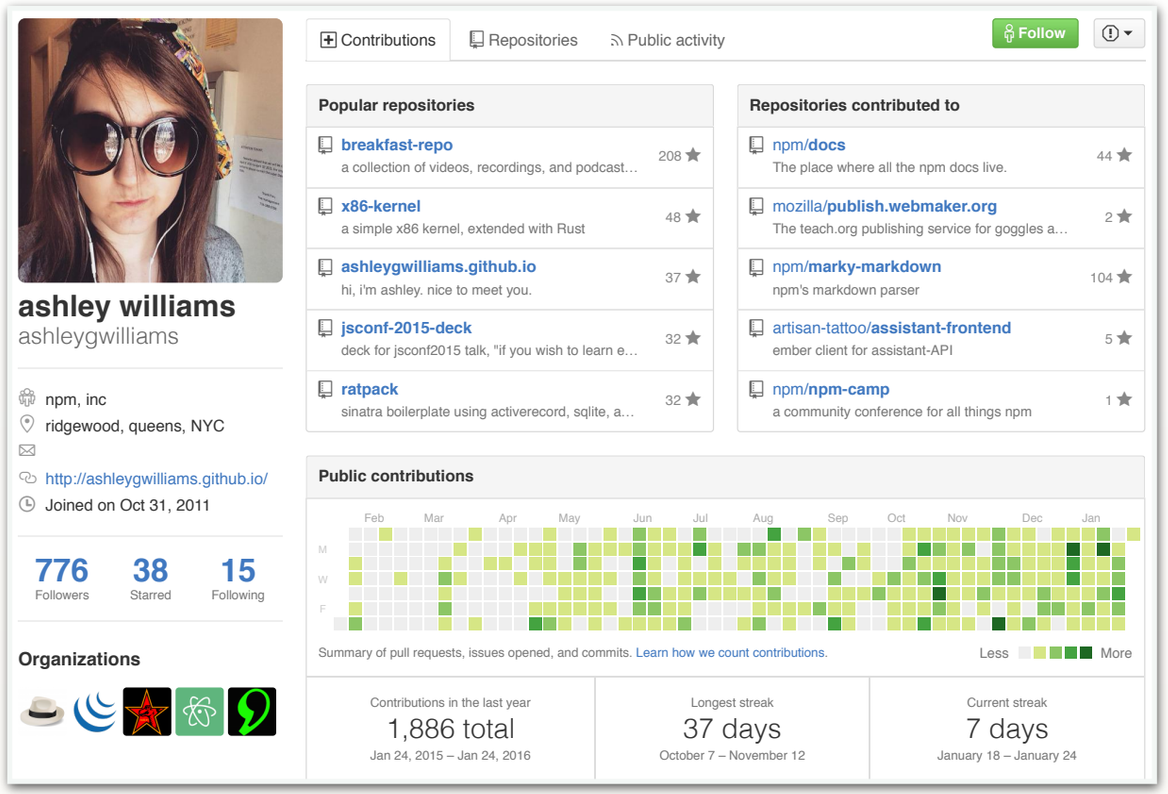
Longest streak
37 days
October 7 – November 12

Current streak
7 days
January 18 – January 24

https://github.com/ashleygwilliams

INCLUSIVENESS – GAMIFICATION?





Women disengage quicker.

Gender, representation and online participation: A quantitative study.
Vasilescu, B., Capiluppi, A., and Serebrenik, A. *Interacting with Computers 2014*

Women shy away from competition and men embrace it.

Muriel Niederle and Lise Vesterlund. **Do women shy away from competition? Do men compete too much?** The Quarterly Journal of Economics, 122(3):1067–1101, 2007.

ACKNOWLEDGEMENTS

- Baishakhi Ray
- Alexander Serebrenik
- Vladimir Filkov
- Prem Devanbu
- Daryl Posnett
- Mark van den Brand

NWO Netherlands Organisation for Scientific Research

NSF

AFOSR AIR FORCE OFFICE OF SCIENTIFIC RESEARCH

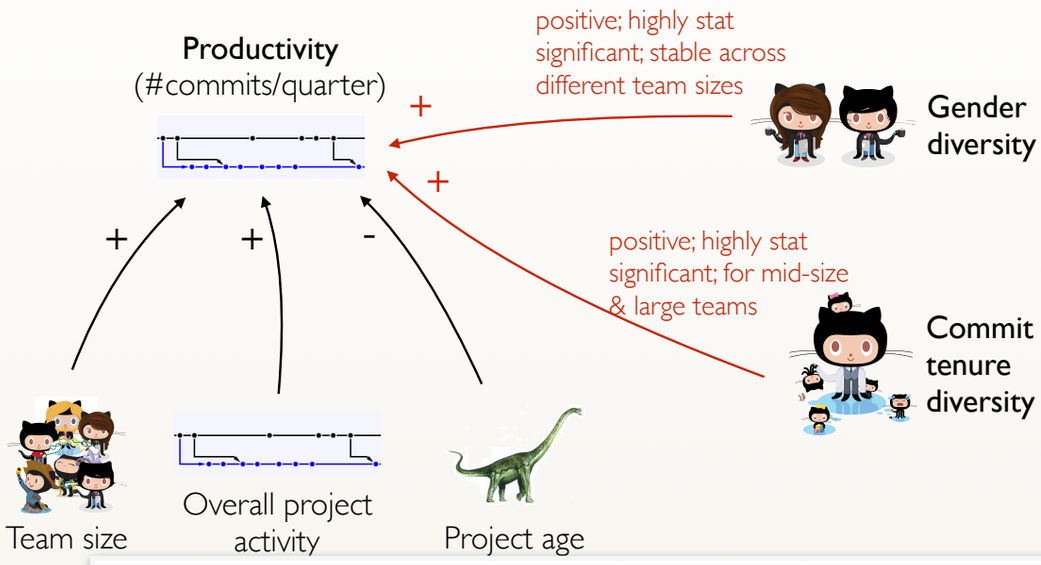
UCDAVIS UNIVERSITY OF CALIFORNIA

TU/e Technische Universiteit Eindhoven University of Technology

GENDER DIVERSITY IN ONLINE SOFTWARE TEAMS

#Istand withCEU #aCEUvalvagyok

INCREASED DIVERSITY CORRELATES TO HIGHER PRODUCTIVITY



HOW CAN WE IMPROVE THINGS?

open source 10.9% | Google 18% | Microsoft 17%

stackoverflow 5.8% | github SOCIAL CODING ~5%

Community culture + Platform design

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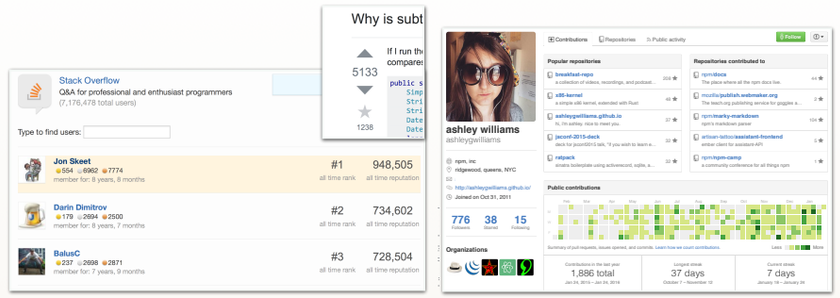

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