



# Human Factors and Human-Guided AI in SE

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# Final: April 17

- In-class exam
- Same format as midterm: Open book, open notes, open internet, No ChatGPT (gen AI).
- Everything included in the lectures is fair game, though we will focus a bit more on the second half of lectures
- **HW6b: due on Apr 20, no extension**

We want to **improve productivity** and  
**reduce cost** in software development  
and maintenance.

# What is software engineering?

## Programs

- Testing
- Fault localization
- Static analysis
- Dynamic analysis
- Debugging
- APR
- ...

## Programmers

- Will programmers use these tools? Why or why not?
- How do experts become experts?
- How to be productive?
- Biases?
- How to make a team function?
- How to estimate effort?
- ...

# The Human Aspect Matters



Captain Sully

Chesley (Sully) Sullenberger clarified vividly **the significance of the “human factor”** in our digital age. After saving 155 people by landing his disabled Airbus A320 in the Hudson River in January 2009, Sully became a national hero.



Sichuan Airlines Flight 8633

At the altitude of 9 km (30,000 ft; 9,000 m), the right front segment of the windshield separated from the aircraft followed by an uncontrolled decompression. The flight control unit was damaged, and the loud external noise made spoken communications impossible. Because the flight was within a mountainous region, the pilots were unable to descend to the required 8,000 ft (2,400 m) to compensate for the loss of cabin pressure. The sudden loss of pressure in the cockpit had caused multiple instruments to fail.

*The half-body of copilot was sucked out of the window and the pilot kept flown by manual and sight.* The three pilots were in short sleeves and suddenly it was -40°C in the cockpit. After 35 minutes, the crew made an emergency landing. 2 crew members were injured.

*“Epic-level diversion”.*

# The Human Aspect Matters

## 1. The Mariner 1 Spacecraft, 1962

The first entry in our rundown goes right back to the sixties.

Before the summer of love or the invention of the lava lamp, NASA launched a space mission to fly past Venus. It did not go to plan.

The [Mariner 1 space probe](#) barely made it out of Cape Canaveral before the rocket course. Worried that the rocket was heading towards a crash-landing on earth, a destruct command and the craft was obliterated about 290 seconds after launch.

## 5. EDS Child Support System, 2004

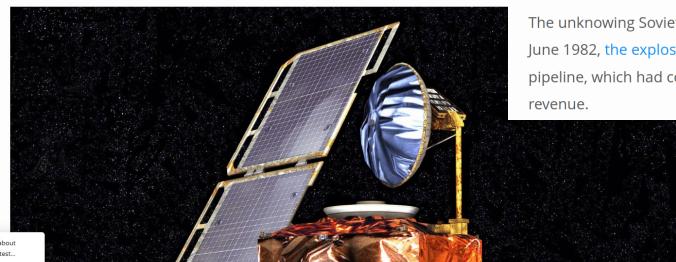
Back in 2004, the UK government introduced a new and complex system to manage the operations of the [Child Support Agency \(CSA\)](#). The contract was awarded to IT services company Electronic Data Systems (EDS). The system was called CS2, and there were problems as soon as it went live.

A leaked internal memo at the time revealed that the system was "badly designed, badly tested and badly implemented". The agency reported that CS2 "had over 1,000 reported problems, of which 400 had no known workaround", resulting in "around 3,000 IT incidents a week". The system was budgeted to cost around £450 million, but ended up costing an [estimated £768 million altogether](#). EDS, a Texas-based contractor, also announced a \$153 million loss in their subsequent financial results.

## 7. NASA's Mars Climate Orbiter, 1998

Losing \$20 from your wallet is probably enough to ruin your day — how would [spacecraft](#)? NASA engineers found out back in 1998 when the Mars Climate Orbiter got too close to the surface of Mars.

It took engineers several months to work out what went wrong. It turned out to be a mistake in converting imperial units to metric. According to the [investigation report](#), the software produced by Lockheed Martin used imperial measurements, while the one by NASA was programmed with SI metric units. The overall cost of the failed mission was \$125 million.



## 2. The Morris Worm, 1988

Not all costly software errors are born by big companies or government organizations. In fact, the [most costly software bugs](#) ever was caused by a single student. A Cornell University student created a worm as part of an experiment, which ended up spreading like wildfire and crashing tens of thousands of computers due to a coding error.

The computers were all connected through a very early version of the internet, making the Morris worm the first infectious computer virus. Graduate student Robert Tappan Morris charged and convicted of [criminal hacking and fined \\$10,000](#), although the cost of the damage was estimated to be as [high as \\$10 million](#).

History has forgiven Morris though, with the incident now widely credited for exposing the importance of IT security. These days, Morris is a professor at MIT and the worm's source code is on a floppy disc at the University of Boston.



## 8. Soviet Gas Pipeline Explosion, 1982

This error is a little bit different to the others, as it was deliberate (or so rumor has it). In fact, the Soviet gas pipeline explosion is alleged to be a [cunning example of cyber-espionage](#), carried out by the CIA.

Back in 1982, at the height of the cold war tensions between the USA and USSR, the Soviet government built a gas pipeline that ran on advanced automated control software. The Soviets planned to steal from a Canadian company that specialized in this kind of programming.

According to accounts, the CIA paid the Canadians to place deliberately faulty software in the Soviet pipeline.

The unknowing Soviets went about their business as usual. In June 1982, the explosion occurred, causing a massive fire at the gas pipeline, which had cost tens of millions of dollars in revenue.

## 10. ESA Ariane 5 Flight V88, 1996

Given the complexity and expense of space exploration, it's no wonder that the Ariane 5 launch is one of the most expensive missions on our list of all-time software errors. However, the European space agency's Ariane 5 launch was even harsher cautionary tale than the rest, as it was caused by more than just a software error.

Just 36 seconds after its maiden launch, the rocket engines failed due to a software error in the Ariane 4's flight software and a conversion error from 64-bit to 16-bit data.

The failure resulted in a \$370 million loss for the ESA, and a whole host of [subsequent investigations](#), including calls for improved software analysis and evaluation.

## 3. Pentium FDIV Bug, 1994

The [Pentium FDIV bug](#) is a curious case of a minor problem that turned into a major headache.

Thomas Nicely, a math professor, discovered a flaw in the Pentium's floating-point division algorithm. His response was to offer a replacement chip to anyone who could fix it.

The original error was relatively simple, with a problem in the floating-point division algorithm that caused tiny inaccuracies in calculations, but only very rarely. In fact,

## 6. Heathrow Terminal 5 Opening, 2008

Imagine prepping to jet off on your eagerly-awaited vacation or important business trip, only to find that your flight is grounded or and your luggage is nowhere to be seen.

This was exactly what happened to thousands of travelers when [Heathrow's Terminal 5 opened](#) back in [March 2008](#), and it was a major disaster. The new terminal performed well on its opening day, but then began experiencing problems with its luggage handling system.

British Airways also delayed several flights at the airport. Over the next 18 months, the system experienced numerous problems, including a [£16 million](#) cost overruns.

## 9. Knight's \$440M in bad trades, 2012

Losing \$440 million is a bad day at the office by anyone's standards. Even more so when it happens in just 30 minutes due to a software error that wipes 75% off the value of one of the biggest capital groups in the world.

Knight Capital Group had invested in new trading software that was supposed to help them make a killing on the stock markets. Instead, it ended up killing their firm. Several software errors combined to send Knight on a crazy buying spree, spending more than \$7 billion on 150 different stocks.

## 11. The Millennium Bug, 2000

The Millennium Bug, AKA the notorious [Y2K](#), was a massive concern in the lead-up to the year 2000. The concern was that computer systems around the world would not be able to cope with dates after December 31, 1999, due to the fact that most computers and operating systems only used two digits to represent the year, disregarding the 19 prefix for the twentieth century. Dire predictions were made about the implosion of banks, airlines, power suppliers and critical data storage. How would systems deal with the 00 digits?

The anticlimactic answer was "pretty well, actually". The millennium bug was a bit of a non-starter and didn't cause too many real-life problems, as most systems made adjustments in advance. However, the fear caused by the potential fallout throughout late 1999 cost thousands of considerable amounts of money in contingency planning and preparations, with institutions, businesses and even families expecting the worst.

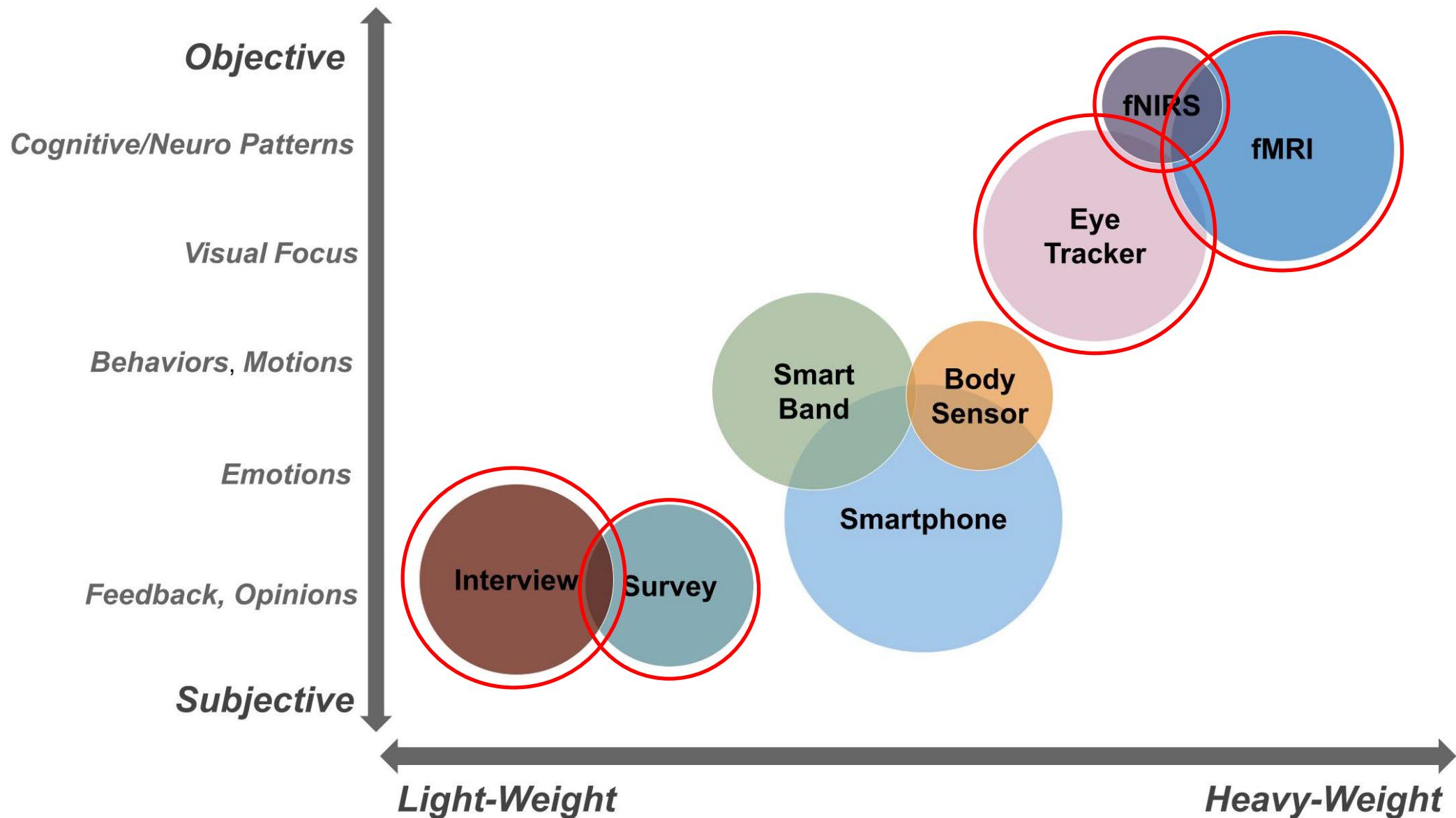
The [USA spent vast quantities](#) to address the issue, with some estimates [putting the cost at \\$100 billion](#).

# The Human Aspect Matters

- Early study of industrial developers found ***order-of-magnitude*** individual variations

Metric	Poorest	Best	Ratio
Debugging Hours Algebra	170	6	<b>28:1</b>
Debugging Hours Maze	26	1	<b>26:1</b>
CPU Seconds Algebra	3075	370	<b>8:1</b>
CPU Seconds Maze	541	50	<b>11:1</b>
Code Writing Hours Algebra	111	7	<b>16:1</b>
Code Writing Hours Maze	50	2	<b>25:1</b>
Program Size Algebra	6137	1050	<b>6:1</b>
Program Size Maze	3287	651	<b>5:1</b>
Run Time Algebra	7.9	1.6	<b>5:1</b>
Run Time Maze	8.0	0.6	<b>13:1</b>

# How to measure human aspects?



# fMRI vs. fNIRS

Measure brain activities by calculating the **blood-oxygen level dependent (BOLD)** signal

- Functional Magnetic Resonance Imaging
  - **Magnets**
  - **Strong** penetration power
  - Lying down in a magnetic tube:
    - **Cannot move**
- Functional Near-Infrared Spectroscopy
  - **Light**
  - **Weak** penetration power
  - Wearing a specially-designed cap:
    - **More freedom of movement**



# fMRI vs. fNIRS

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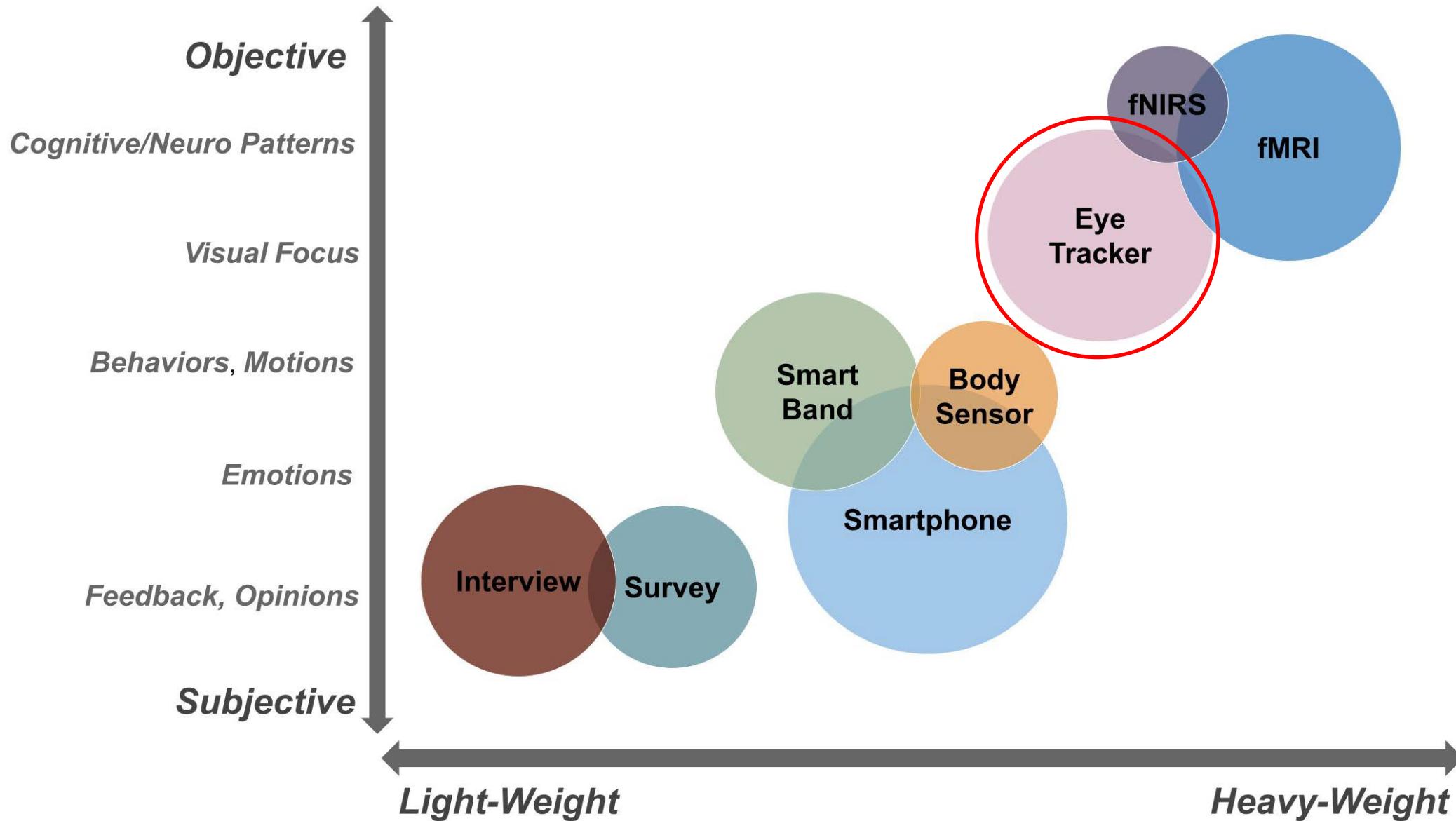


# Think in Terms of Contrasts!

- Controlled experimental design
  - Task A = “**balancing trees** + nervous + ...”
  - Task B = “**rotating 3D objects** + nervous + ...”
  - Contrast **A > B**: brain activations that vary between the tasks



# How to measure human aspects?



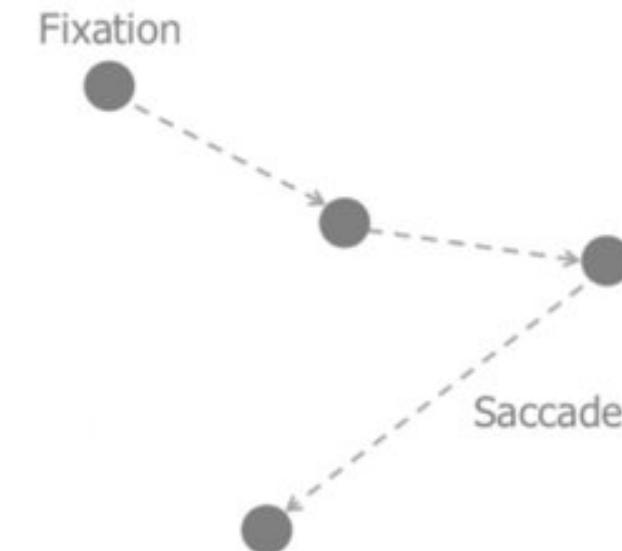
# Eye-tracking

- Collect participants' visual attention by recording **eye-gaze** data: what are you looking at? How do you look at it?



# Eye-tracking: how we "look"

- Fixation: a spatially stable eye-gaze that lasts for approximately 100-300ms
  - Most of the information acquisition and processing occur during fixations
  - Only a small set of fixations is necessary to process a complex visual stimulus
- Saccade: continuous and extremely rapid eye movements, within 40-50ms, that occur between fixations
- Pupil size
  - Dilation is associated with cognitive work load

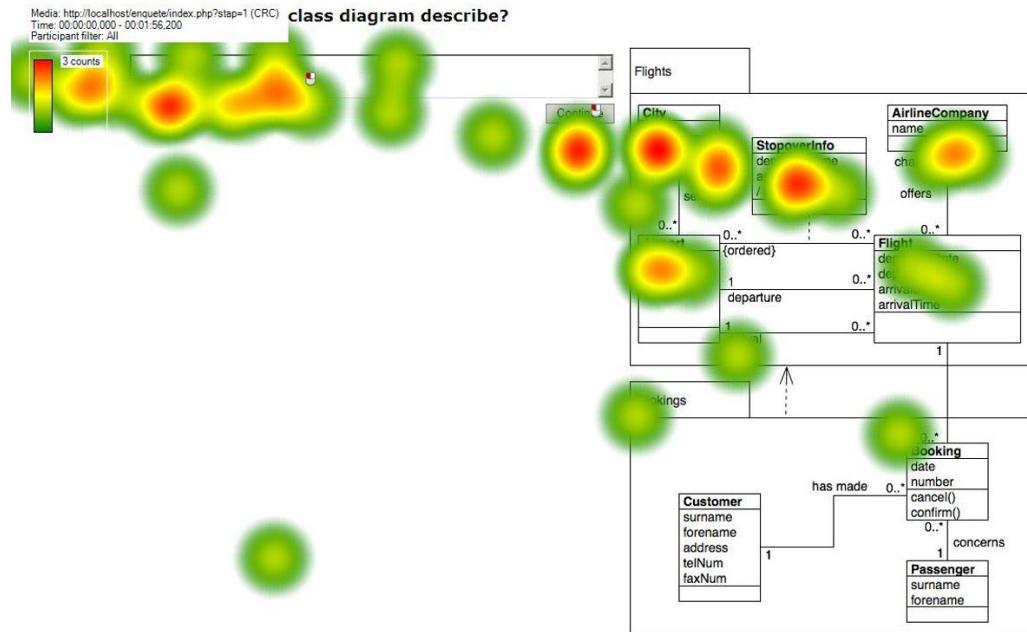
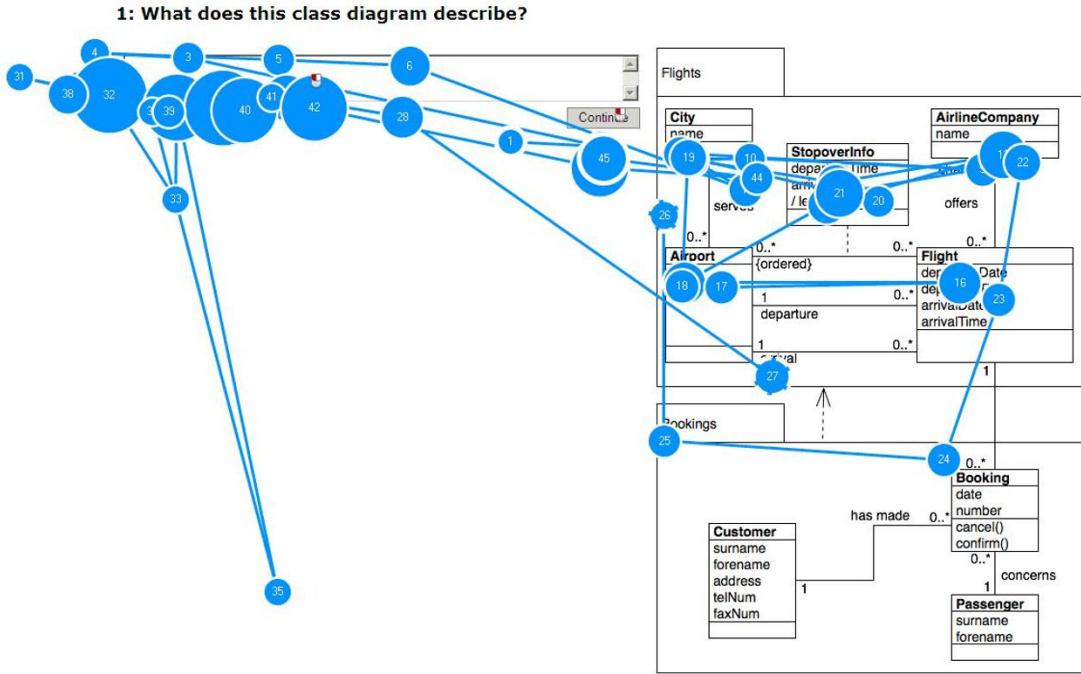


# Eye-tracking: assumptions

- The immediacy assumption (Just and Carpenter, 1980):
  - The comprehension begins as soon as a participant sees a stimulus, e.g., as soon as a reader reads a word
- The eye-mind assumption:
  - The participant fixates her attention on a part of the stimulus until she understands that part

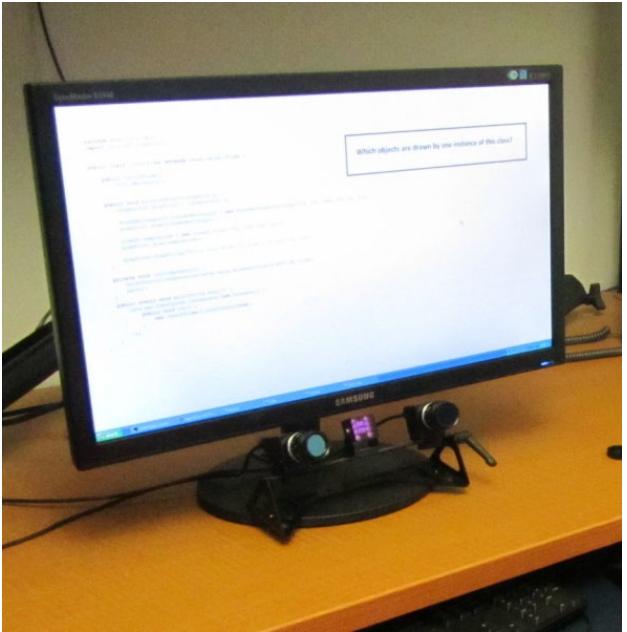


# Eye-tracking: gaze plot, heat map, and raw data



Slide, Code, Number, x, y, Pupil X, Pupil Y, Time
Slide, Code, Number, x, y, Pupil X, Pupil Y, Start Time, End Time, Duration
C:\diagrams\1-M.png, K Space U, 3, 0, 0, 0.000000, 0.000000, 0.000, 0.000, 0.000
C:\diagrams\1-M.png, G, 1, 751, 1063, 39.000000, 38.000000, 0.297
C:\diagrams\1-M.png, G, 2, 688, 918, 39.000000, 38.000000, 0.314
C:\diagrams\1-M.png, G, 3, 688, 918, 39.000000, 38.000000, 0.331
C:\diagrams\1-M.png, G, 4, 688, 918, 39.000000, 38.000000, 0.347
C:\diagrams\1-M.png, G, 5, 684, 911, 39.000000, 38.000000, 0.364
C:\diagrams\1-M.png, G, 6, 683, 906, 39.000000, 38.000000, 0.381
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C:\diagrams\1-M.png, G, 8, 683, 906, 39.000000, 38.000000, 0.414
C:\diagrams\1-M.png, G, 9, 681, 900, 39.000000, 38.000000, 0.431
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# Eye-tracking: eye trackers

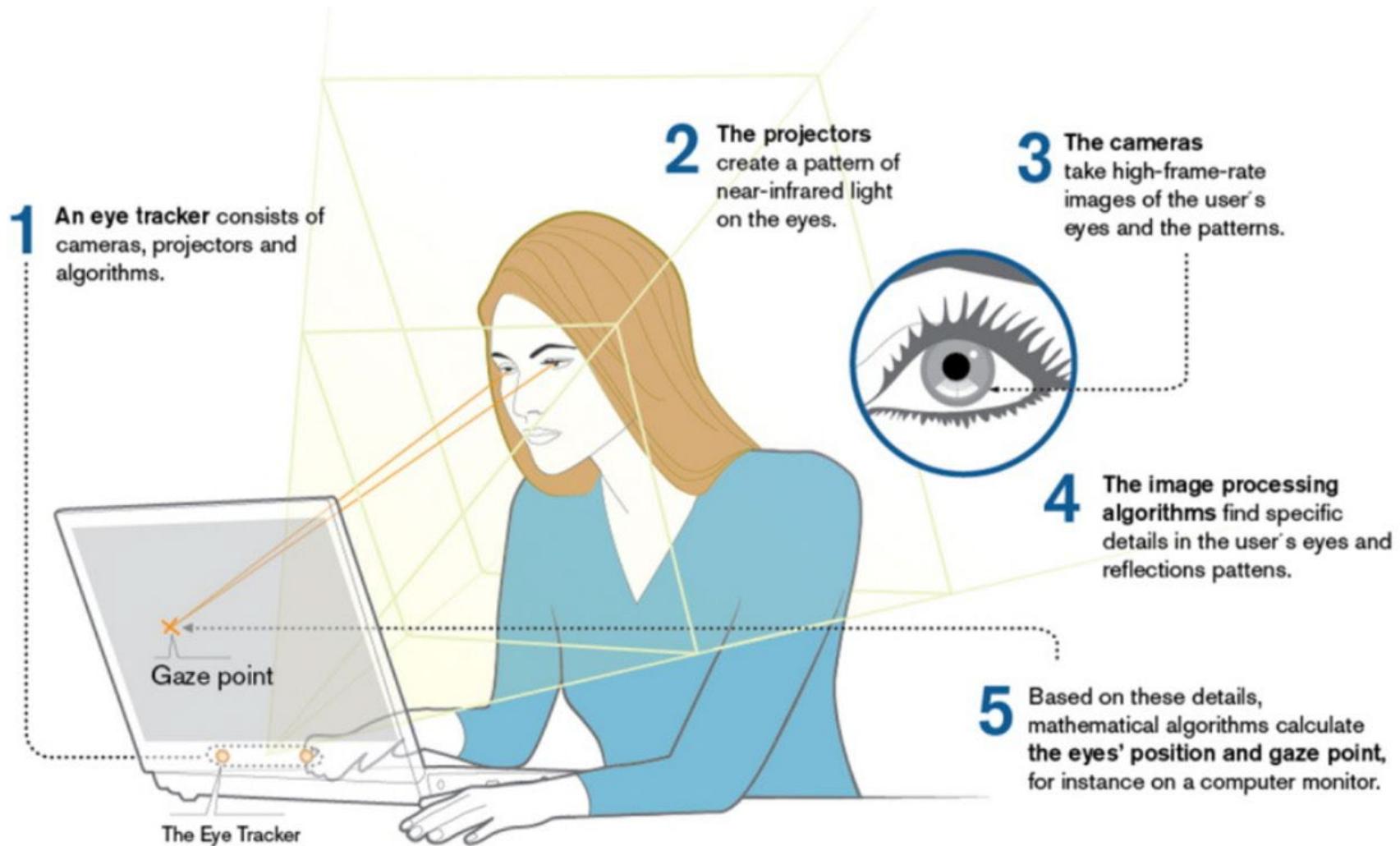


<https://www.tobiipro.com/>



<https://www.tobiipro.com/>

# Eye-tracking: how does an eye tracker work?



# Eye-tracking: truth?

- Eye tracking allows you to know what people are thinking

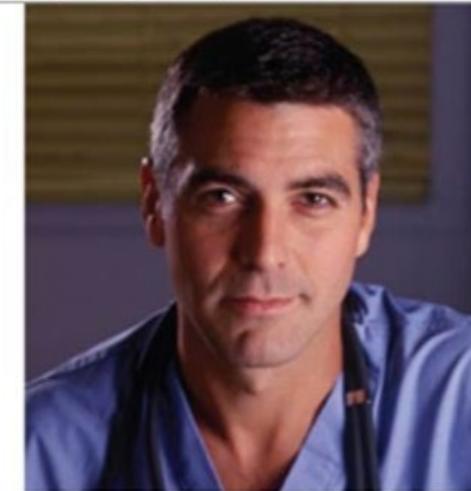
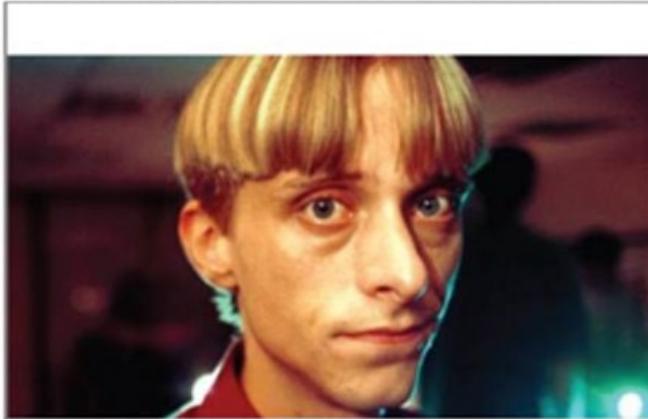
Clooney or Crook: which one do people prefer?



# Eye-tracking: truth?

- Eye tracking allows you to know what people are thinking

Clooney or Crook: which one do people prefer?



# Eye-tracking: truth?

## ~~Misconception~~

### ~~Truth about eye tracking~~

- Eye tracking allows you to know what people are thinking

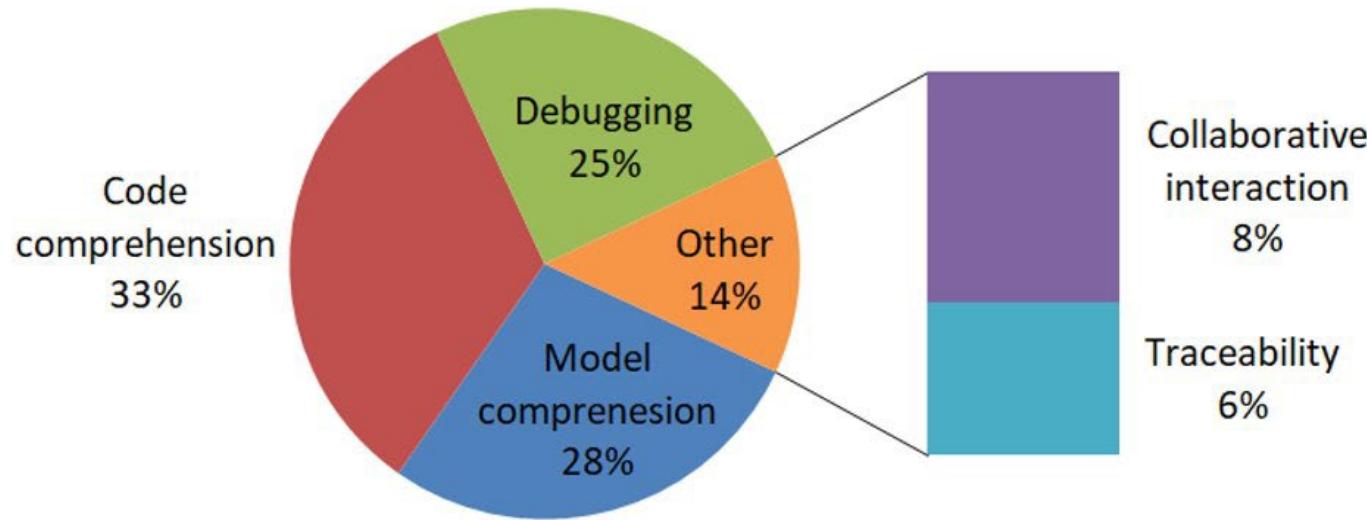
**Fact:** Eye tracking will give you evidence of  
**what people look at**

**Not** what they **think, understand, or like**



# Eye-tracking: for software engineering

Classification of SE eye tracking papers based on category (2015)



Code					Model				English text		Other
Pascal	C/C++	Java	C#	Python	UML	ER	Tropos	BPMN			
2	3	16	1	1	7	1	1	1	2		3 applications

# Eye-tracking: for software engineering

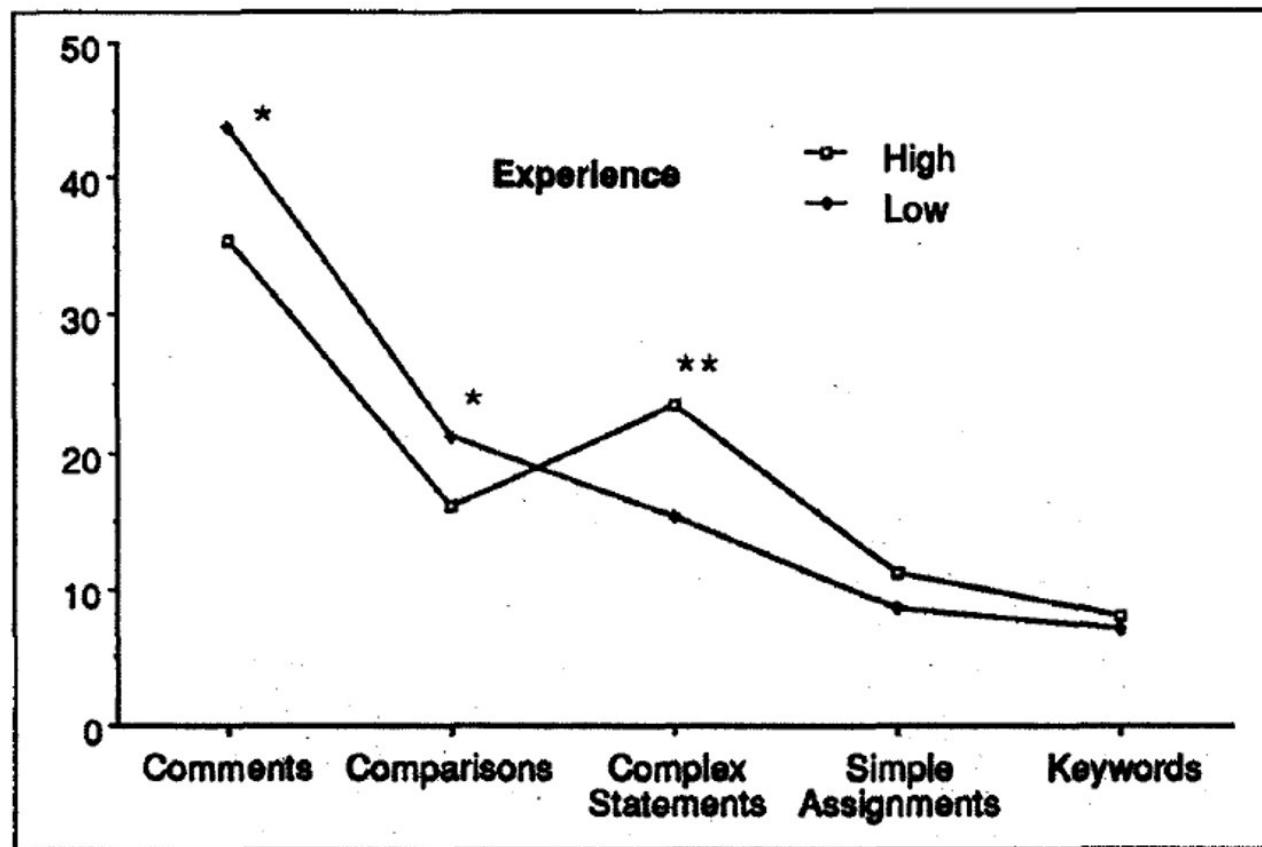
Types of SE questions in eye tracking experiments

Category	Type of Questions
Finding the Areas of Interest	<p>What items or what parts of artifact (X), do participants view while performing task (Y)?</p> <p>Example: Does experience influence a participants focus on critical areas of the algorithm? (Crosby and Stelovsky, 1990)</p>
Navigation Strategies	<p>How do participants navigate through artifact/system (X) while performing task (Y)?</p> <p>Does the type of artifact (X) impact the participants' navigation strategies while they perform task (Y)?</p>
	<p>Do the participants' individual characteristics (Z) impact their strategies while they perform task (Y)?</p> <p>Example: Do the viewing patterns of experienced participants differ from those of novices?</p>

# Eye-tracking: for software engineering

Martha Crosby 1990

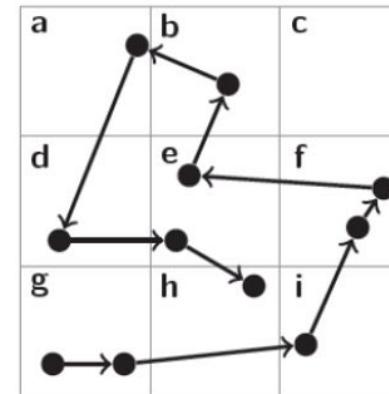
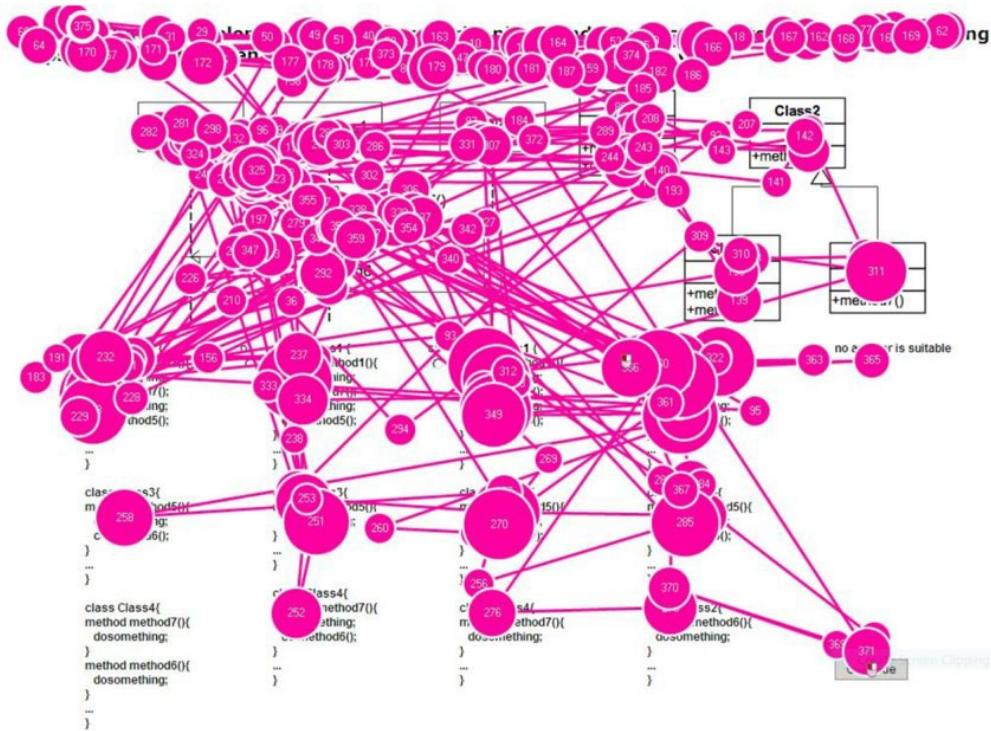
Algorithm areas viewed: novices vs. experts



# Eye-tracking: for software engineering

## Scan path analysis

- A series of fixations or visited AOIs (Area of Interest) in chronological order.



# Eye-tracking: for software engineering

Recent work:

- combined with other measures, e.g., medical imaging
- Investigate human biases in SE activities: e.g., gender, social info

## Biases and Differences in Code Review using Medical Imaging and Eye-Tracking: Genders, Humans, and Machines

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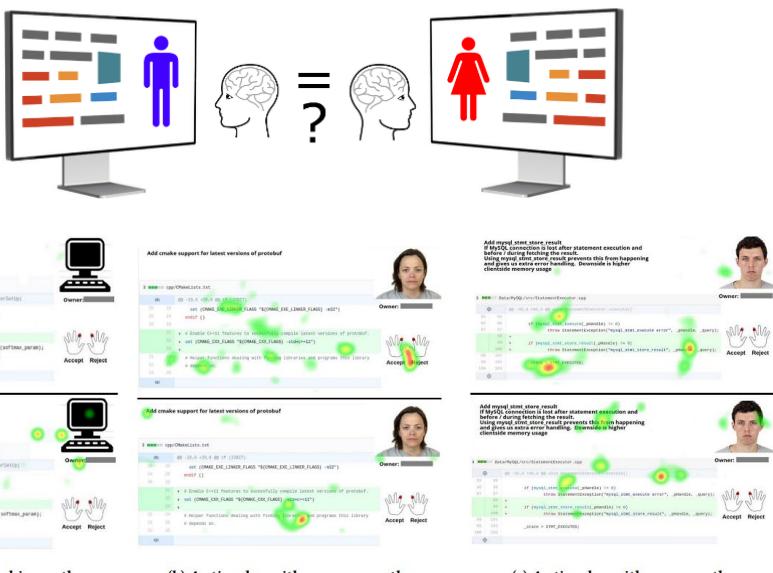
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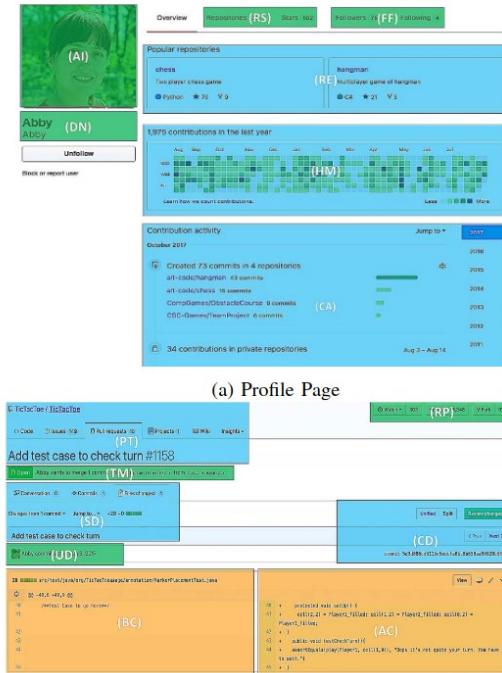


## Beyond the Code Itself: How Programmers *Really* Look at Pull Requests

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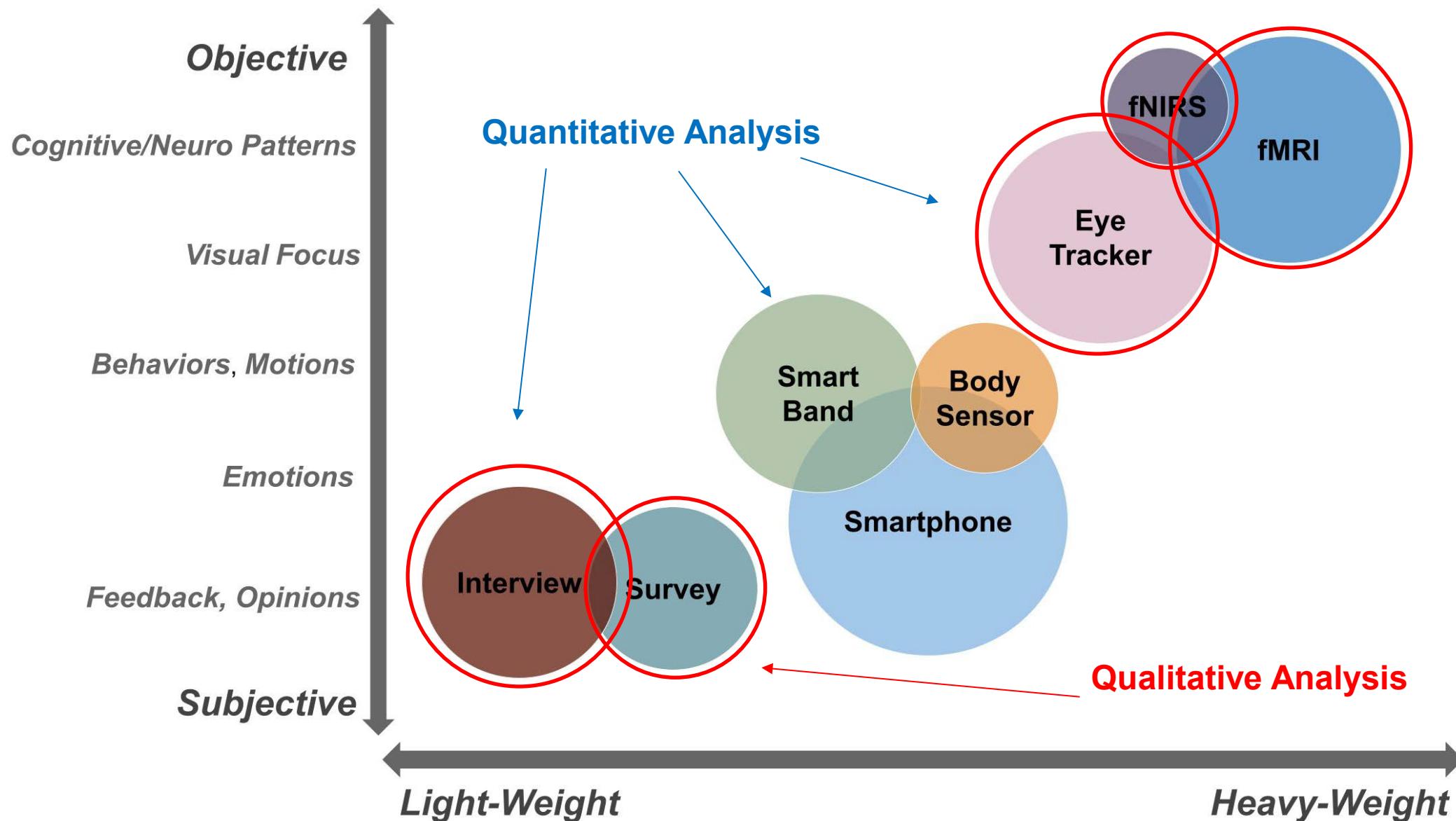


(a) A stimulus with a machine author

(b) A stimulus with a woman author

(c) A stimulus with a man author

# How to analyze human aspects?



# How to analyze human aspects: qualitative analysis

- Verbally-acquired data
  - Information that is gathered via speech, think-aloud protocol, oral retrospection, formal or informal interviews and surveys

With appropriate care in data gathering and analysis, **verbal data can provide impactful insights in software engineering research.**

# How to analyze human aspects: qualitative analysis

- Verbally-acquired data
  - Information that is gathered via speech, think-aloud protocol, oral retrospection, formal or informal interviews and surveys
- Classic example: the "Sillito et al." Questions, published in FSE '06, cited over 350 times

them. Participants in the second study (E1...E16) were observed working on code with which they had experience. In both studies

During each session an audio recording was made of discussion between the pair of participants, a video of the screen was captured,

To structure our data collection and the analysis of our results, we have used a *grounded theory* approach which has been described as an emergent process intended to support the production of a theory that "fits" or "works" to explain a situation of interest [5, 19]. In

## Questions Programmers Ask During Software Evolution Tasks

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about the source code on which we observed them working. We report on 44 kinds of questions we observed our participants asking. These questions are generalized versions of the specific ques-

Results are useful directly (a structured answer to a fundamental question) and also as artifacts (re-used by later projects as indicative developer queries)

# Qualitative Analysis: Metrics

- Establishing **validity** in qualitative research

- Using multiple validity procedures
  - Member checking
  - Clarify bias
  - Spend prolonged time in the field
- Using qualitative reliability
  - Document your procedures (scripts, codebook, etc.)
  - No drift in the definition of codes
  - Cross-check codes developed by different researchers



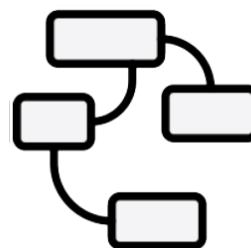
Showing Prompts



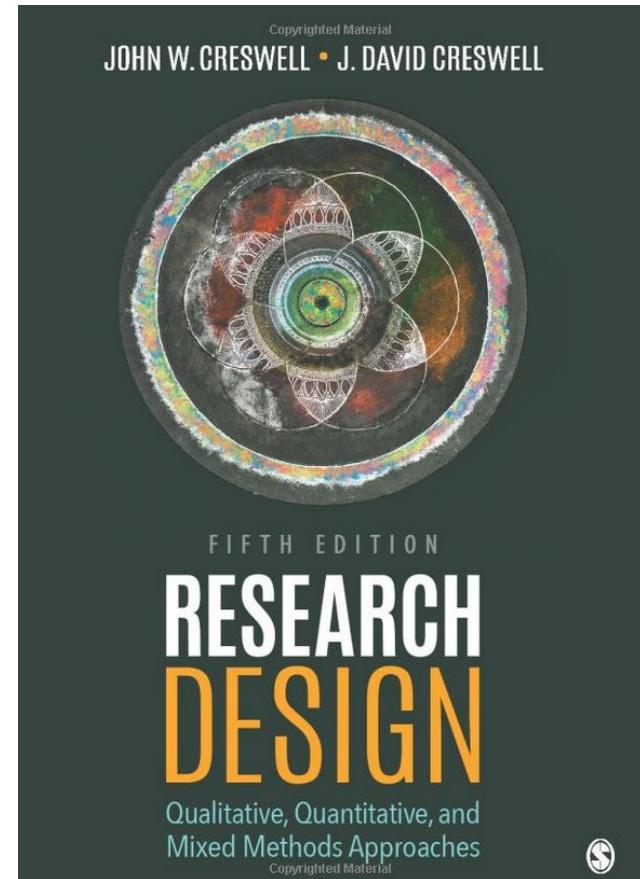
Audio Recording



Transcribing



Qualitative analysis



# Qualitative Analysis: Useful Techniques

- Grounded theory in SE
- Similar to socio-technical studies, qualitative research can have a lot of variance
  - How can we mitigate that variance?
- Grounded Theory is a systematic methodology for qualitative research for constructing hypotheses via inductive (not deductive) reasoning
  - Method
    - Empirical/evidence based
  - Outcome
    - Key patterns of the data
    - Relationships between patterns

**“It is not in your mind; it is in your data.”**

# Qualitative Analysis: Useful Techniques

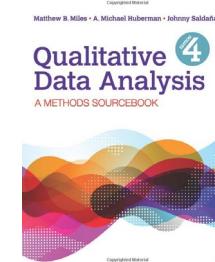
- Grounded theory in SE
- Inductive Thematic Analysis
  - Thematic exploration
    - Codes and the relationships
    - E.g. Tesch's Eight-Step Coding Process
  - Evaluation metrics
    - **Saturation**
    - **Agreement**
- Inter Rater Reliability (IRR) or Inter Rater Agreement (IRA)
  - Statistics as evidence
    - Cohen's kappa, Fleiss' kappa, etc.

## Leaving My Fingerprints: Motivations and Challenges of Contributing to OSS for Social Good

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Category	Code	Description
motivation	motivation-helpuser	help end users
	motivation-helpdev	help developers
	motivation-longterm	how to keep yourself engaged in the project for a long time
	motivation-giveback	altruism
	motivation-impact	want to make impact
	motivation-better-programmer	want to look good in the community, improving skills, build up portfolio
	motivation-hobby	I feel happy/fun, e.g., as a hobby.
	motivation-work	This is my job, or school projects, etc

## Codebook Example

**“It is not in your mind; it is in your data.”**

# Qualitative Analysis: Combining Verbal and Nonverbal Data

- Strength of verbal data
  - Richness and holism
  - Discovery
    - New ideas, hypothesis
- Weakness of verbal data
  - Hard to evaluate the analysis (i.e., no “equations”)
  - Human biases
- Combining verbal and nonverbal data makes a strong and interesting case
  - Supplement, validate, or illuminate each other
  - Contrast: surprising knowledge!

# Qualitative Analysis: Combining Verbal and Nonverbal Data

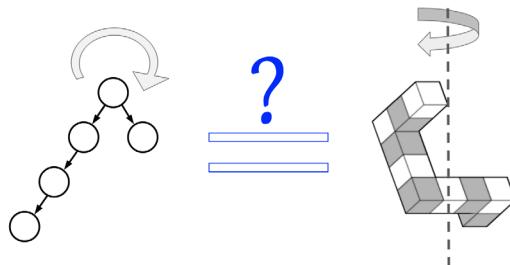
- What do we learn from nonverbal data (medical imaging)?
  - Data structure manipulations do use the **same** parts of the brain as rotating 3D objects
- Nonverbal data can be powerful!
  - You cannot just ask humans: “what do your brain patterns look like?”
- What do we learn from verbal data (audio / interviews)?
  - 70% of participants report **no similarity** between data structure manipulation and 3D object rotation

## Distilling Neural Representations of Data Structure Manipulation using fMRI and fNIRS

Yu Huang<sup>1</sup>, Xinyu Liu<sup>1</sup>, Ryan Krueger<sup>1</sup>, Tyler Santander<sup>2</sup>, Xiaosu Hu<sup>1</sup>, Kevin Leach<sup>1</sup> and Westley Weimer<sup>1</sup>

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<sup>2</sup>t.santander@psych.ucsb.edu, University of California, Santa Barbara



# Qualitative Analysis: Combining Verbal and Nonverbal Data

- What do you think about pull requests generated by machines

- "Machine generated code is worse on readability!"

**But all pull requests were written by humans! (We deceived you!)**

- Do you think women and men write pull request differently

- "There is no difference between pull requests written by men and women"

**But there *is* a significant difference on your behavior! Both response time and final decisions are affected!**

## Biases and Differences in Code Review using Medical Imaging and Eye-Tracking: Genders, Humans, and Machines

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Nicholas McKay

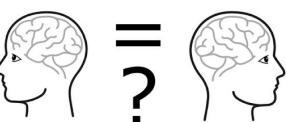
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Tyler Santander

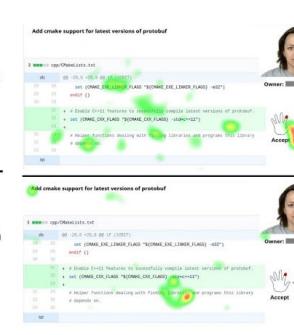
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t.santander@psych.ucsb.edu

Westley Weimer

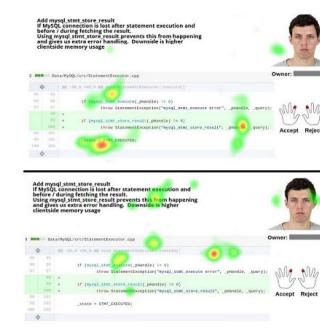
Univ. of Michigan  
Ann Arbor, MI, USA  
weimerw@umich.edu



(a) A stimulus with a machine author



(b) A stimulus with a woman author



(c) A stimulus with a man author

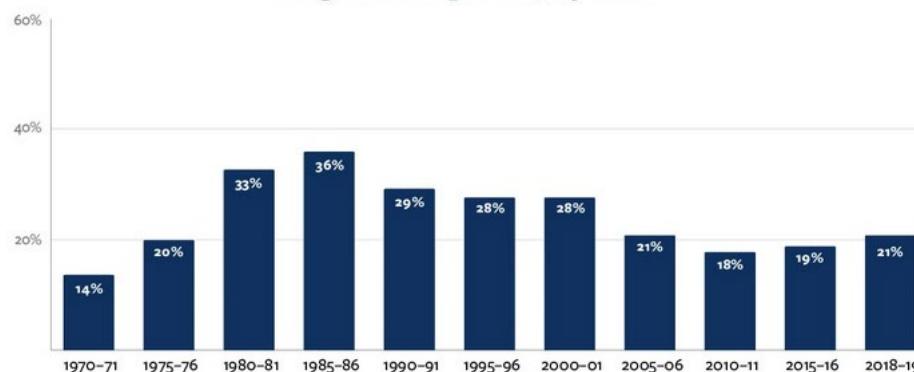
# More on Biases and Diversity (endless)...

## Gender differences and bias in open source: pull request acceptance of women versus men

Josh Terrell<sup>1</sup>, Andrew Kofink<sup>2</sup>, Justin Middleton<sup>2</sup>, Clarissa Rainear<sup>2</sup>, Emerson Murphy-Hill<sup>2</sup>, Chris Parnin<sup>2</sup> and Jon Stallings<sup>3</sup>

Surprisingly, our results show that women's contributions tend to be accepted more often than men's. However, for contributors who are outsiders to a project and their gender is identifiable, men's acceptance rates are higher. Our results suggest that although women on GitHub may be more competent overall, bias against them exists nonetheless.

Percentage of Female Computer Science Degree Recipients, by Year



Sources:

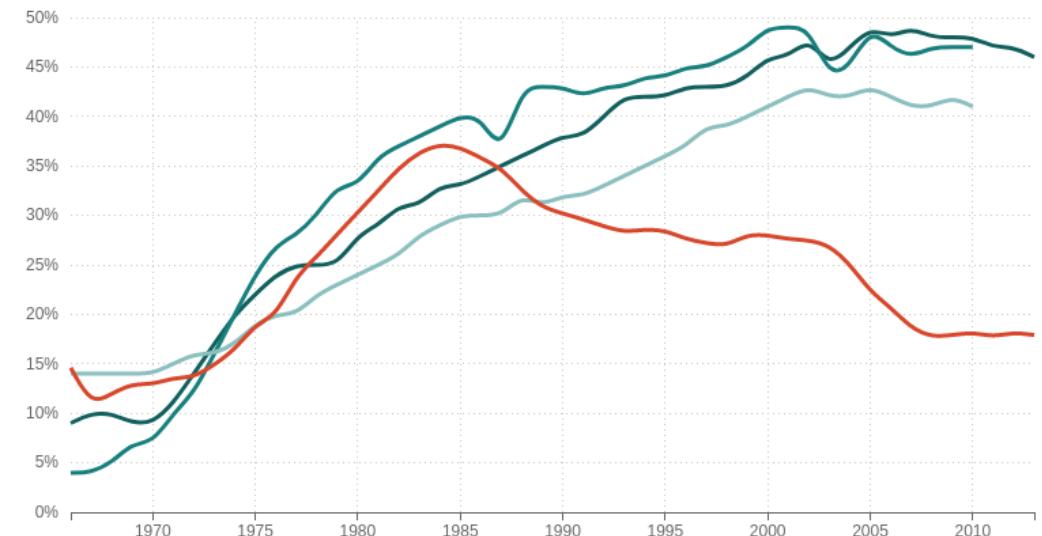
Bachelor's degrees conferred to females by postsecondary institutions, by race/ethnicity and field of study, National Center for Education Statistics. Accessed April 20, 2021.

[https://nces.ed.gov/programs/digest/d20/tables/dt20\\_322\\_50.asp?current=yes](https://nces.ed.gov/programs/digest/d20/tables/dt20_322_50.asp?current=yes)

### What Happened To Women In Computer Science?

% Of Women Majors, By Field

Medical School Law School Physical Sciences Computer science



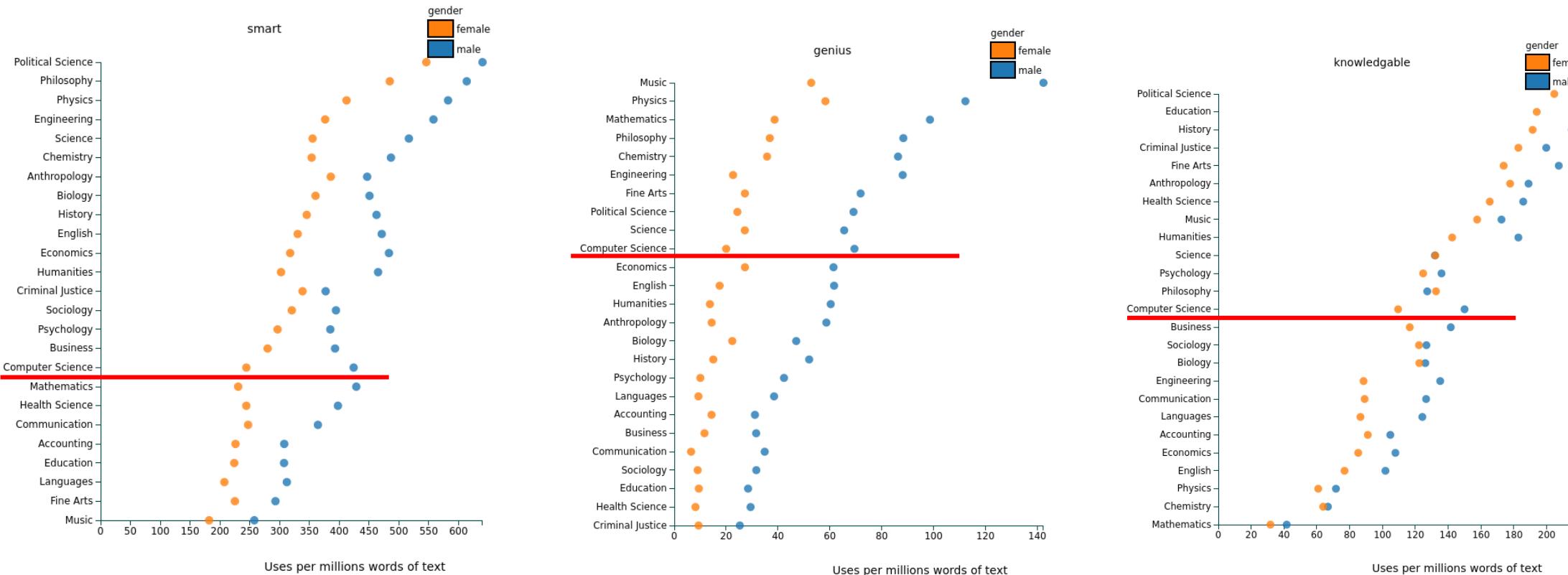
Source: National Science Foundation, American Bar Association, American Association of Medical Colleges

Credit: Quoctrung Bui/NPR

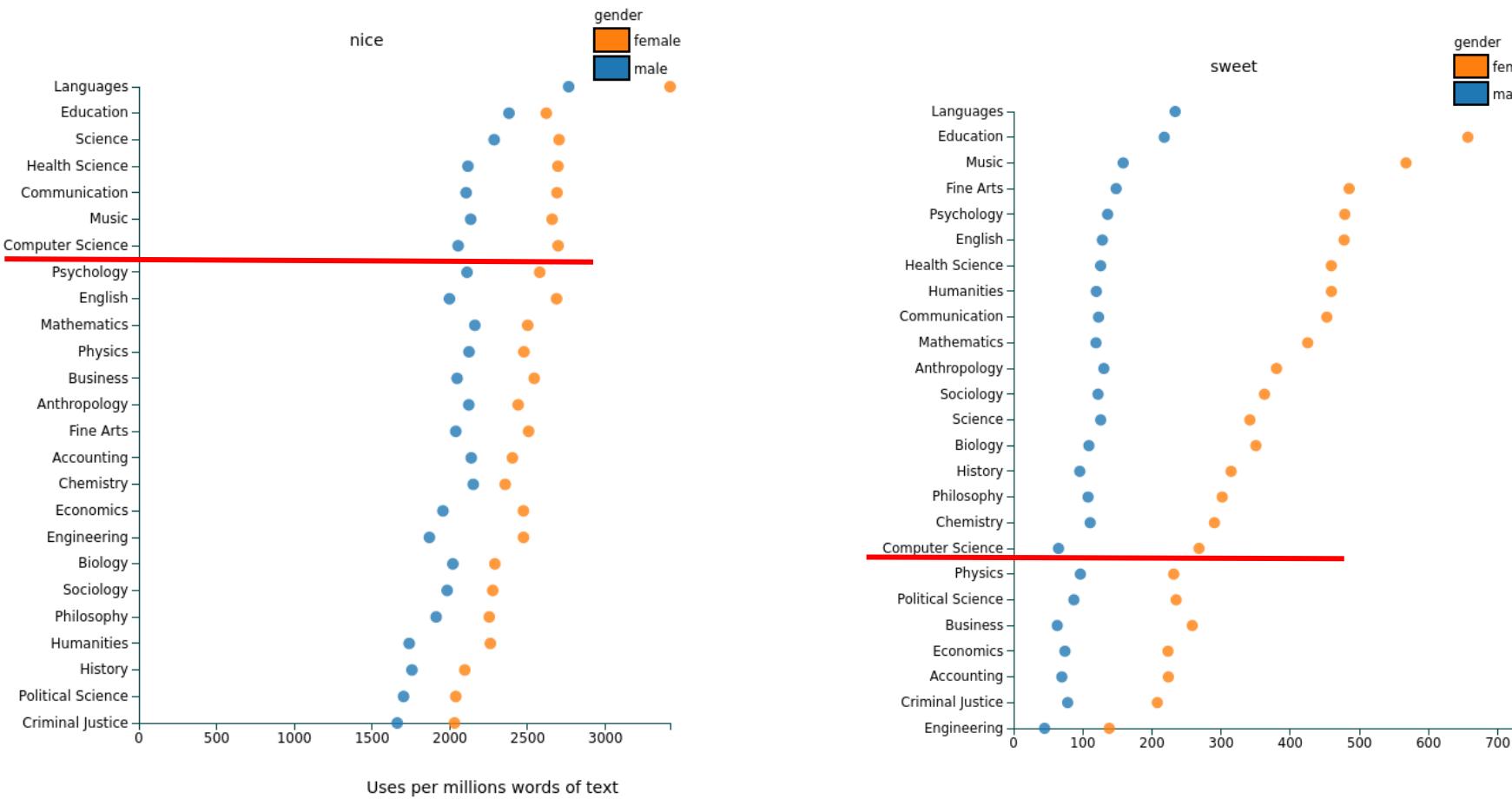
# More on Biases and Diversity (endless)...

- Ratemyprofessors.com
- 14 million reviews
- A new tool allows those being rated (or anyone) to see the way students tend to use different words when rating male and **female** professors -- **generally to the disadvantage of the latter.**

# More on Biases and Diversity (endless)...



# More on Biases and Diversity (endless)...



**Recall:**

We want to **improve productivity** and  
**reduce cost** in software development  
and maintenance.

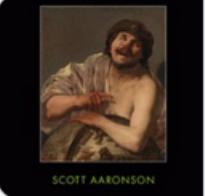
# Can we design AI models to help with SE tasks?



ALPHA CODE

 Hacker News  
@newsycombinator

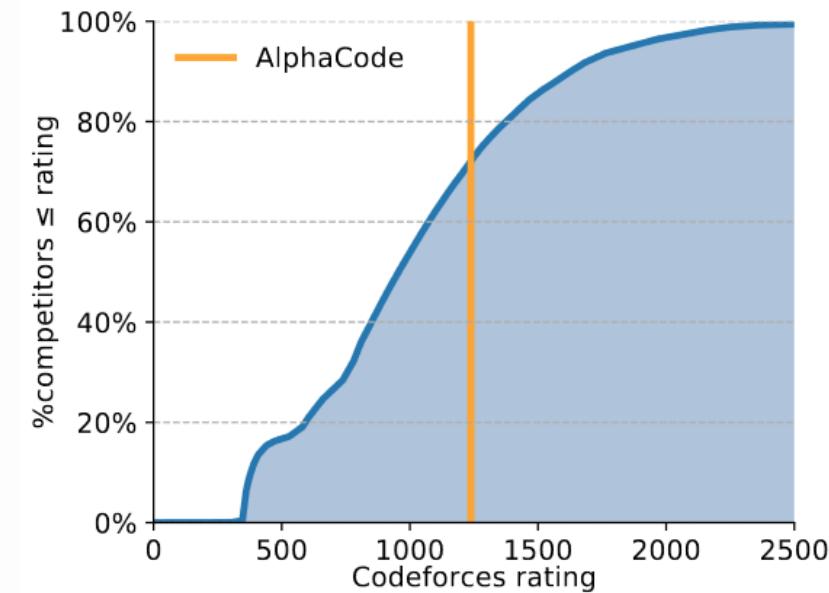
 AlphaCode as a dog speaking mediocre English

 scottaaronson.blog  
AlphaCode as a dog speaking mediocre English  
Tonight, I took the time actually to read DeepMind's  
AlphaCode paper, and to work through the example...

8:01 AM · Feb 6, 2022

 13   Explore what's happening on Twitter

programming problems, or else retrieving and copying existing solutions. As part of [DeepMind's mission](#) to solve intelligence, we created a system called AlphaCode that writes computer programs at a competitive level. [AlphaCode achieved an estimated rank within the top 54% of participants in programming competitions by solving new problems that require a combination of critical thinking, logic, algorithms, coding, and natural language understanding.](#)

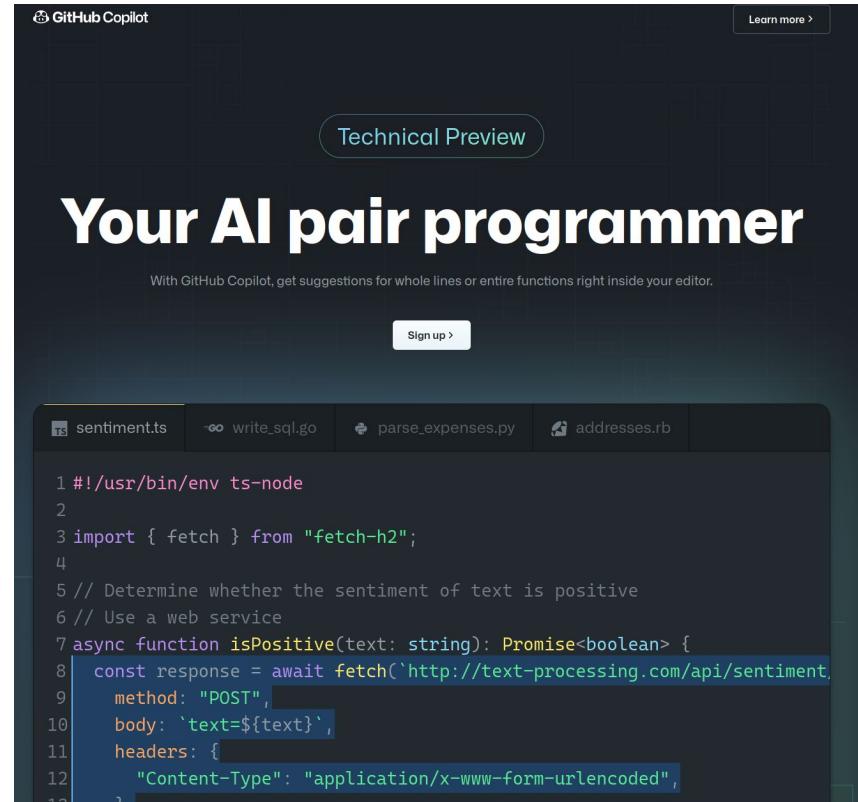


(b) AlphaCode's estimated rating

# Can we design AI models to help with SE tasks?



**GitHub**  
Copilot



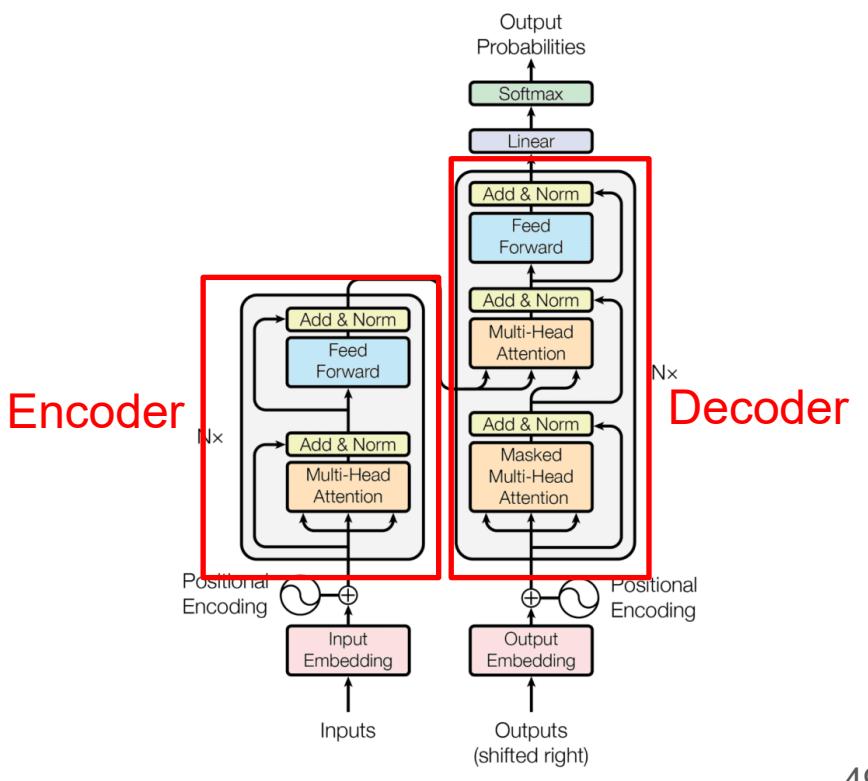
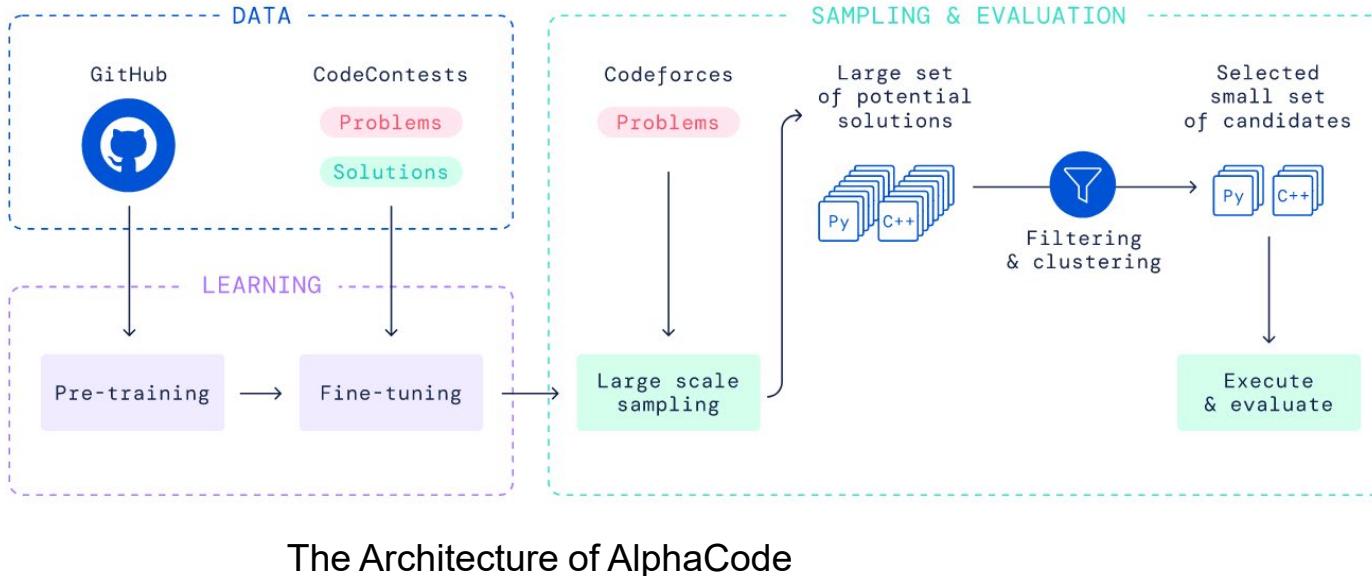
# AI4SE: Downstream Tasks in SE

- "The task you actually want to solve" -- NLP
- Code generation
- Code summarization
- ... ...
- What can we talk about in 15 minutes?
  - Current work for AI4SE
  - Human-centered AI for SE
  - SE4AI

# AI4SE: AlphaCode

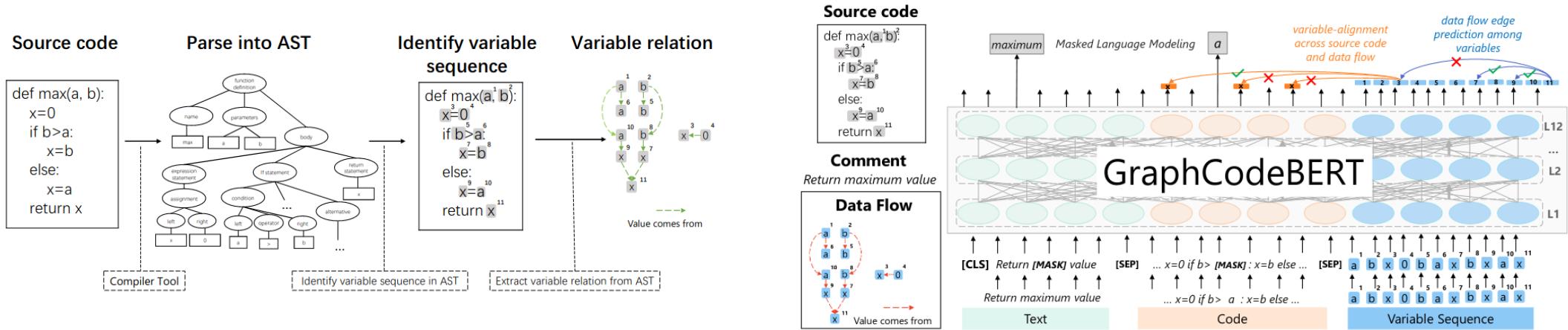
AlphaCode: Transformer-based architecture

Transformer: handle sequential input data; a deep learning model that adopts the mechanism of self-attention, differentially weighting the significance of each part of the input data. It is used primarily in the fields of natural language processing (NLP) and computer vision (CV)



# AI4SE: GraphCodeBERT

- BERT (Bidirectional Encoder Representations from Transformers) + "graph" representation of source code
- Focus on pre-training code representations with data flow
- Includes many topics you have learned in this course!



Pre-training embeddings of code are used in downstream tasks:  
Code clone detection, code translation, natural language code search, etc.

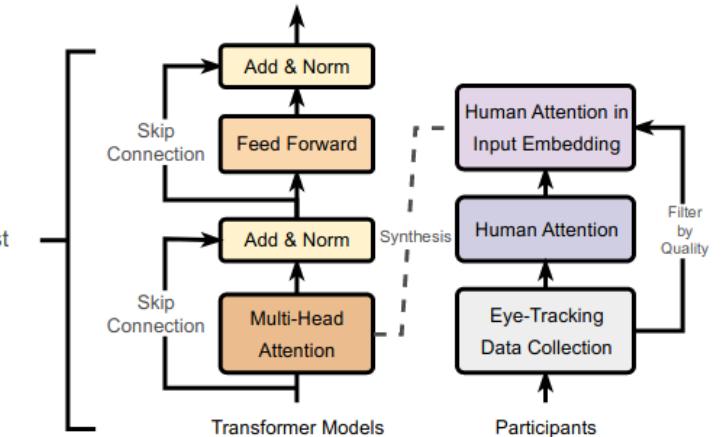
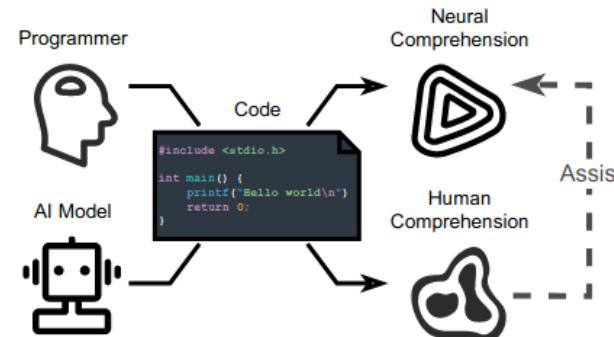
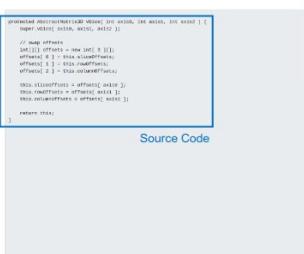
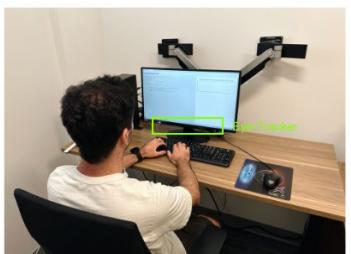
**AI4SE: it is doable and happening!**  
**Can we leverage developers' cognition to**  
**empower AI models for SE?**  
**"So what" for human aspects research in**  
**SE?**

# Human-Centered AI for SE

## EyeTrans: Merging Human and Machine Attention for Neural Code Summarization

YIFAN ZHANG, Vanderbilt University, USA  
 JILiang LI, Vanderbilt University, USA  
 ZACHARY KARAS, Vanderbilt University, USA  
 AAKASH BANSAL, University of Notre Dame, USA  
 TOBY JIA-JUN LI, University of Notre Dame, USA  
 COLLIN MCMILLAN, University of Notre Dame, USA  
 KEVIN LEACH, Vanderbilt University, USA  
 YU HUANG, Vanderbilt University, USA

Accepted at FSE 2024



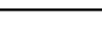
Metrics	MAF1@1				MAP@1				MAR@1			
	(R <sub>1</sub> , N <sub>1</sub> )	(R <sub>2</sub> , N <sub>1</sub> )	(R <sub>1</sub> , N <sub>2</sub> )	(R <sub>2</sub> , N <sub>2</sub> )	(R <sub>1</sub> , N <sub>1</sub> )	(R <sub>2</sub> , N <sub>1</sub> )	(R <sub>1</sub> , N <sub>2</sub> )	(R <sub>2</sub> , N <sub>2</sub> )	(R <sub>1</sub> , N <sub>1</sub> )	(R <sub>2</sub> , N <sub>1</sub> )	(R <sub>1</sub> , N <sub>2</sub> )	(R <sub>2</sub> , N <sub>2</sub> )
Transformer (Original)	96.90	64.62	90.47	49.70	96.53	61.90	88.46	46.85	97.74	71.29	92.90	57.74
EYETRANS (Original)	99.61	70.31	93.10	56.43	99.56	68.14	92.26	53.85	99.68	76.13	94.84	63.55
Improvement	+2.80%	+8.79%	+2.91%	+13.52%	+3.15%	+10.11%	+4.29%	+14.95%	+1.98%	+6.80%	+2.09%	+10.06%
Transformer (Filtered)	92.78	53.94	75.78	42.59	91.90	51.58	73.67	39.99	94.47	60.43	80.43	50.21
EYETRANS (Filtered)	96.09	58.44	89.74	54.40	95.61	56.01	88.74	51.95	97.02	65.11	91.92	61.28
Improvement	+3.56%	+8.35%	+18.42%	+27.82%	+4.03%	+8.59%	+20.51%	+29.91%	+2.71%	+7.73%	+14.33%	+22.03%
Transformer (Strict)	82.92	52.76	76.54	46.70	81.36	49.21	74.11	42.95	86.45	61.29	81.94	55.48
EYETRANS (Strict)	95.68	55.58	83.87	49.48	95.15	52.15	82.32	45.71	96.77	63.87	87.10	58.71
Improvement	+15.38%	+5.33%	+9.58%	+5.96%	+16.94%	+5.97%	+11.05%	+6.43%	+11.95%	+4.21%	+6.30%	+5.80%

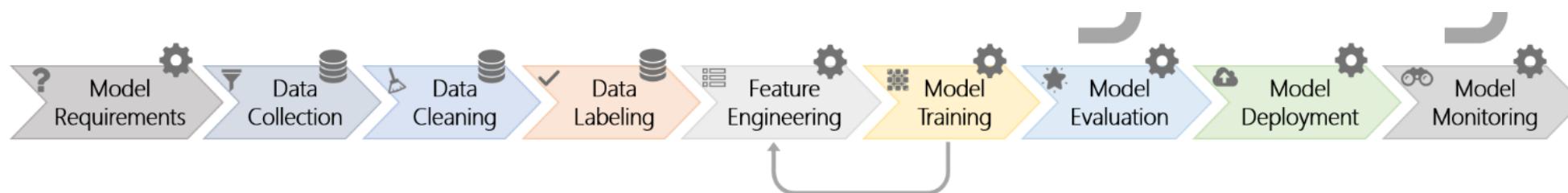
# Software Engineering for AI

- All the ML/AI/NLP/DM tasks are software engineering tasks!
- What can SE do to assist them?

## Software Engineering for Machine Learning: A Case Study

Saleema Amershi <i>Microsoft Research</i> Redmond, WA USA samershi@microsoft.com	Andrew Begel <i>Microsoft Research</i> Redmond, WA USA andrew.begel@microsoft.com	Christian Bird <i>Microsoft Research</i> Redmond, WA USA cbird@microsoft.com	Robert DeLine <i>Microsoft Research</i> Redmond, WA USA rdeline@microsoft.com	Harald Gall <i>University of Zurich</i> Zurich, Switzerland gall@ifi.uzh.ch
Ece Kamar <i>Microsoft Research</i> Redmond, WA USA eckamar@microsoft.com	Nachiappan Nagappan <i>Microsoft Research</i> Redmond, WA USA nachin@microsoft.com	Besmira Nushi <i>Microsoft Research</i> Redmond, WA USA besmira.nushi@microsoft.com	Thomas Zimmermann <i>Microsoft Research</i> Redmond, WA USA tzimmer@microsoft.com	

Challenge	Frequency			Rank		
	Medium vs. Low	High vs. Low	Trend	Low	Experience Medium	High
Data Availability, Collection, Cleaning, and Management	-2%	60%		1	1	1
Education and Training	-69%	-78%		1	5	9
Hardware Resources	-32%	13%		3	8	6
End-to-end pipeline support	65%	41%		4	2	4
Collaboration and working culture	19%	69%		5	6	6
Specification	2%	50%		5	8	8
Integrating AI into larger systems	-49%	-62%		5	16	13
Education: Guidance and Mentoring	-83%	-81%		5	21	18
AI Tools	144%	193%		9	3	2
Scale	154%	210%		10	4	3
Model Evolution, Evaluation, and Deployment	137%	276%		15	6	4



The nine stages of the ML workflow

**SE4AI: there is so much to do!**

# **CS 4278/5278 Principles of Software Engineering**

## **SP 2025**

**Please take the course evaluation**

**Thank you and good luck!**