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

**Yu Huang**[1], Kevin Leach[1], Zohreh Sharafi[1], Nicolas McKay[1], Tyler Santander[2], Westley Weimer[1]

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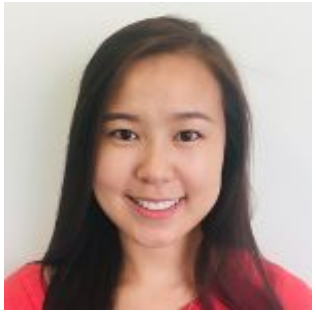
[2]University of California, Santa Barbara

COLLEGE OF ENGINEERING
COMPUTER SCIENCE & ENGINEERING
UNIVERSITY OF MICHIGAN

# Thank You to the Collaborators!



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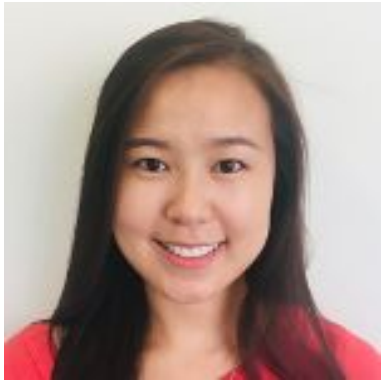
# On the Academic Job Market!



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


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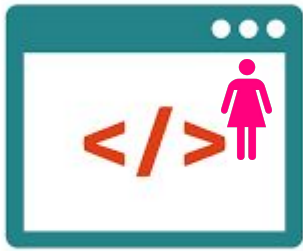

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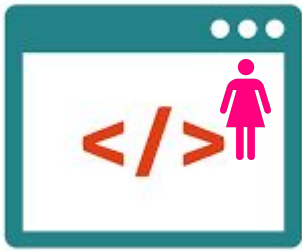
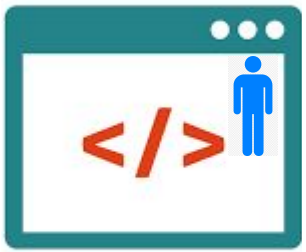
**Gender differences and bias in open source: pull request acceptance of women versus men**

Josh Terrell[1], Andrew Kofink[2], Justin Middleton[2], Clarissa Rainear[2], Emerson Murphy-Hill[2], Chris Parnin[2] and Jon Stallings[3]





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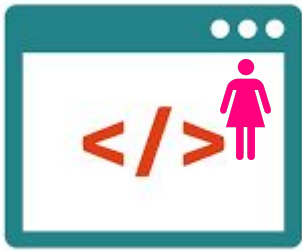

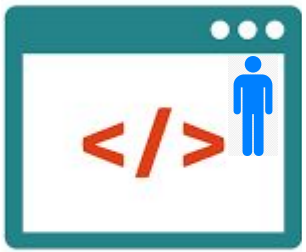

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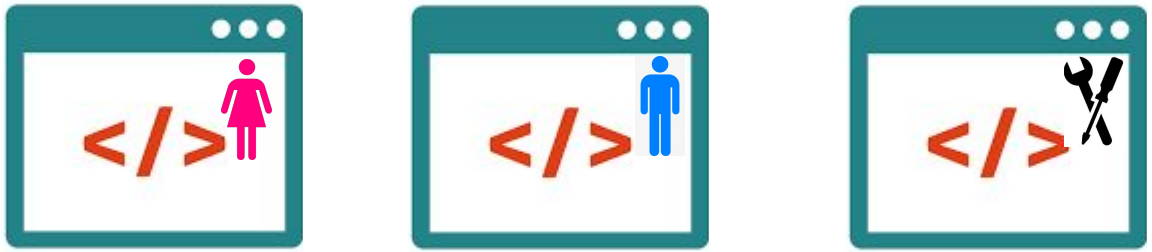

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Current challenges in auto

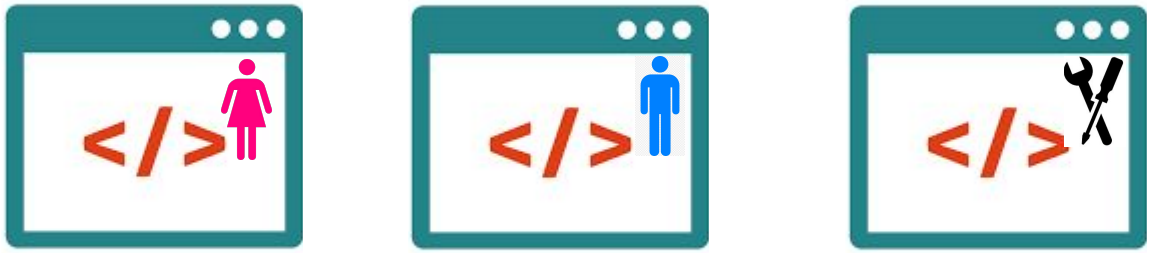
Claire Le Goues · Stephanie Forrest

Trust in Automated Software Repair

The Effects of Repair Source, Transparency, and Programmer Experience on Perceived Trustworthiness and Trust

Authors | Authors and affiliations

Tyler J. Ryan, Gene M. Alarcon, Charles Walter, Rose Gamble, Sarah A. Jessup, August Capiola, Marc D. Pfahler



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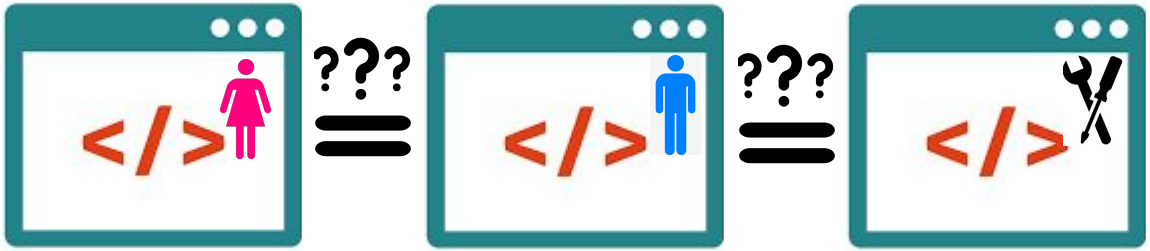
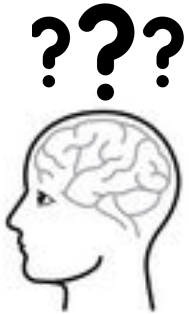
- Is there **bias** on **gender** and **identities** in code review? How do we characterize the bias?



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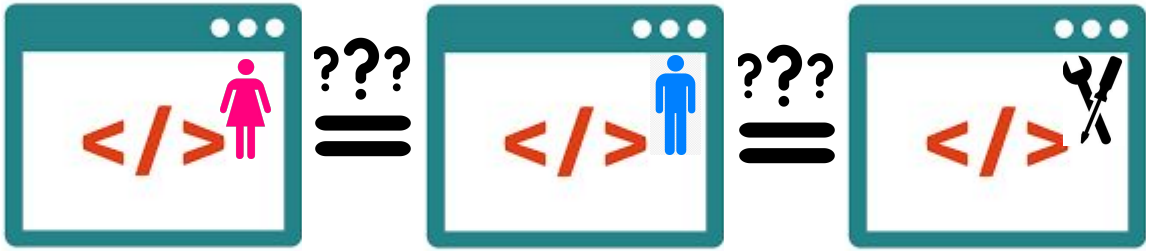


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**Behavioral Differences**

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**Neurological Differences**

# Outline

- Motivation
- High-level question
- **Experimental design**
- **Results**
- **Conclusions**

# Experimental Design: Code Review Tasks

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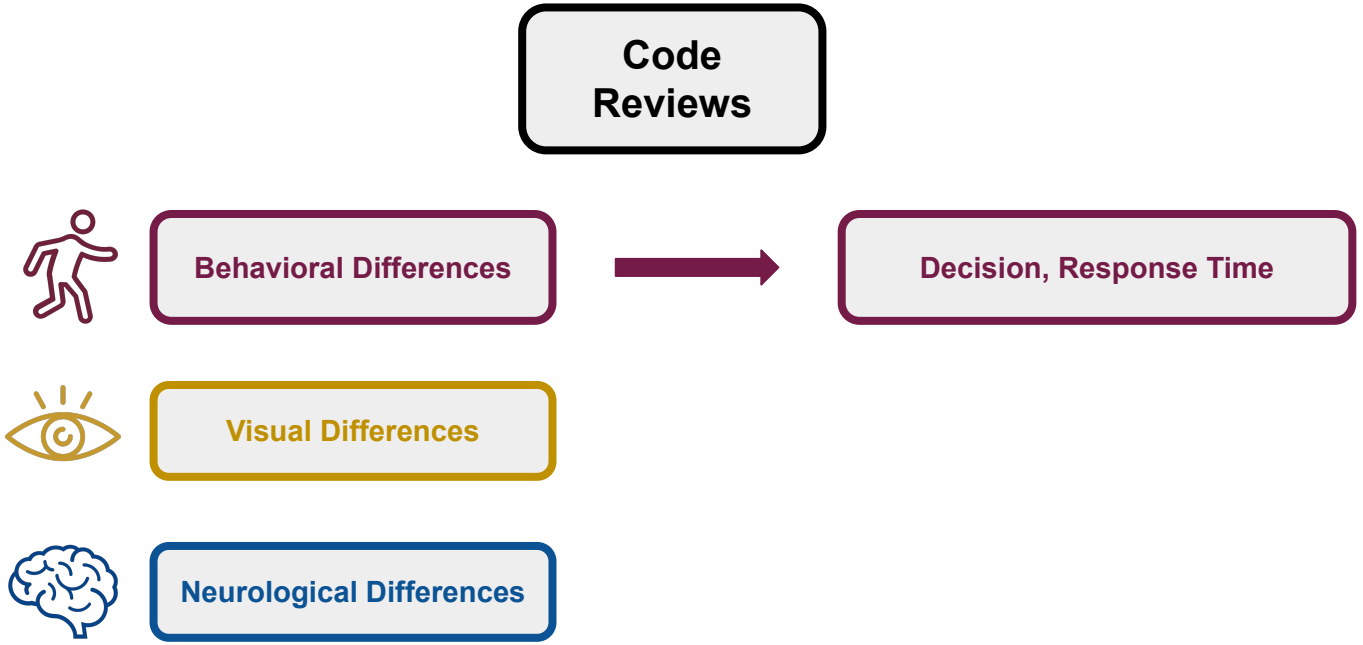

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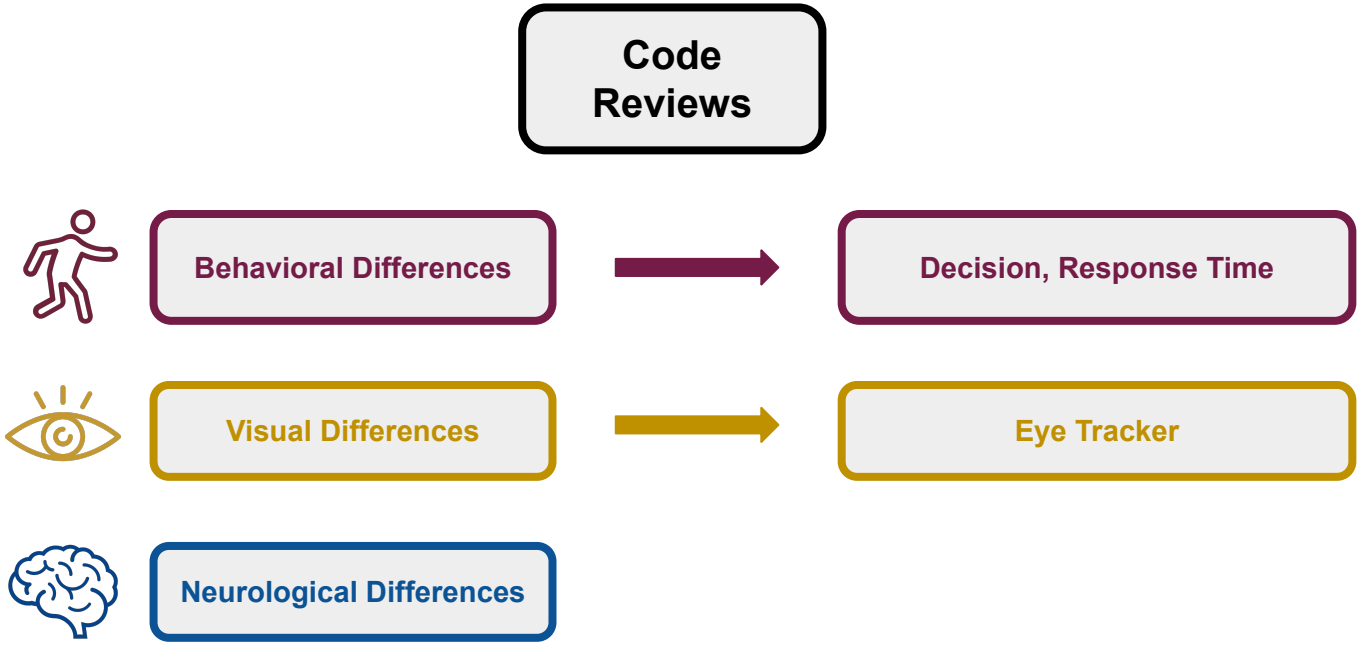

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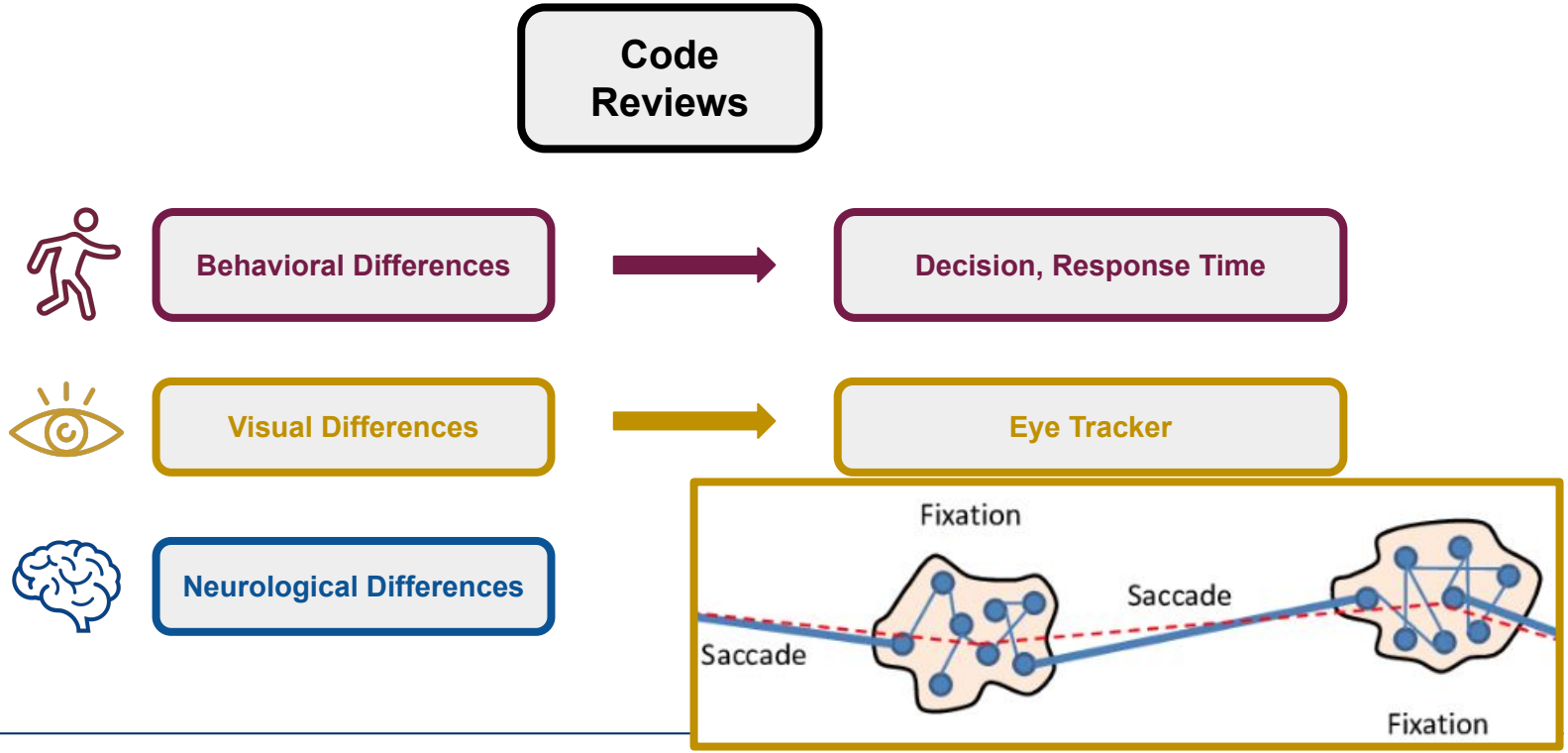

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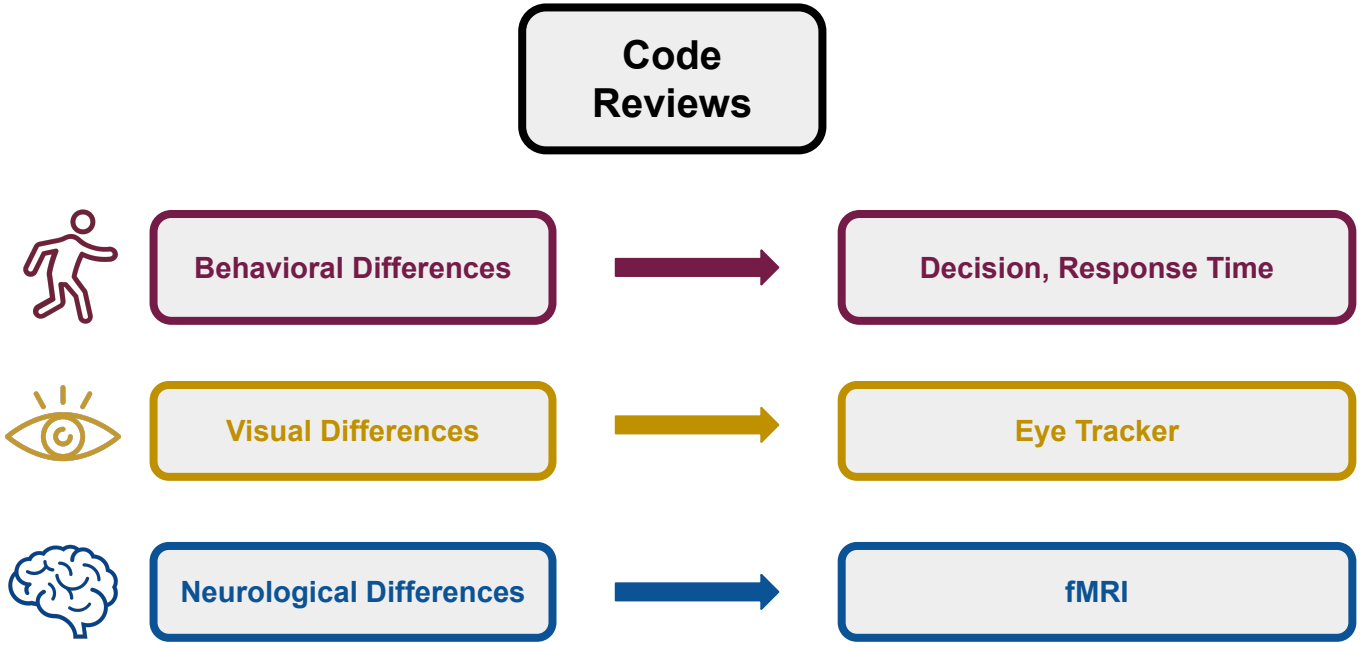

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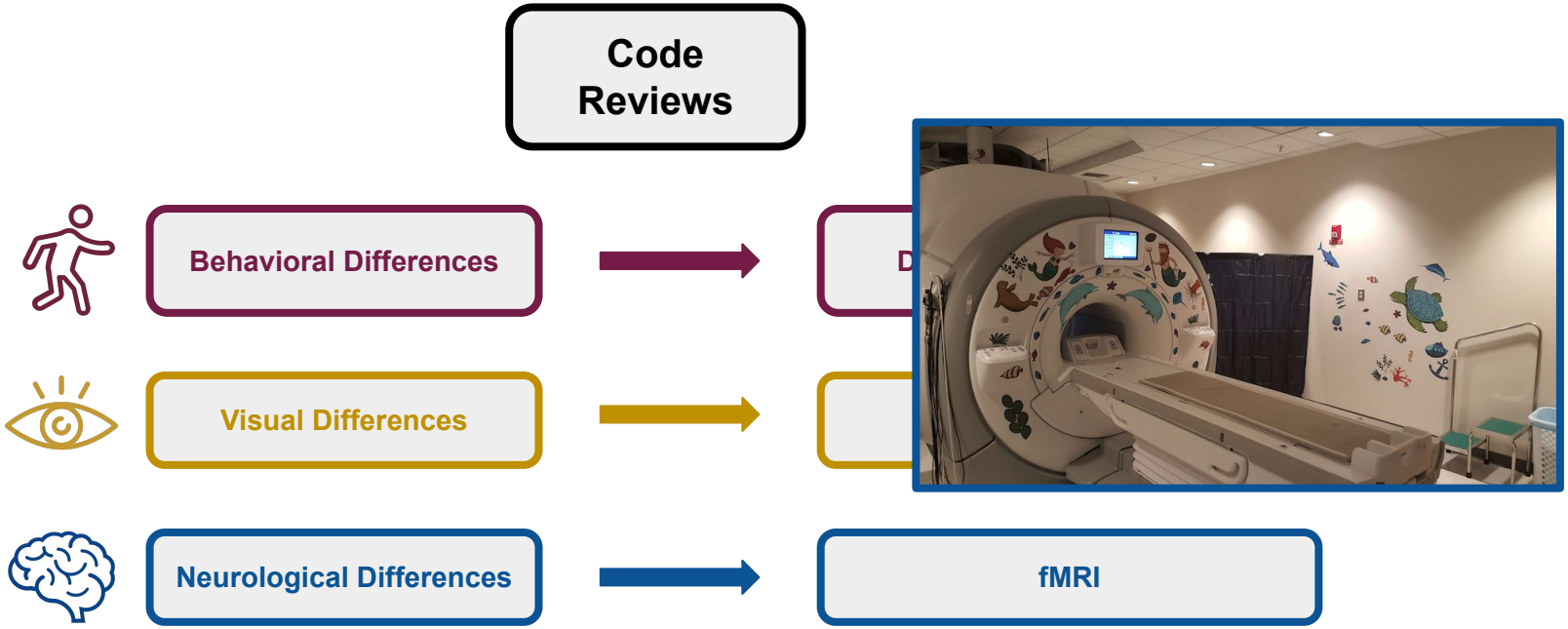

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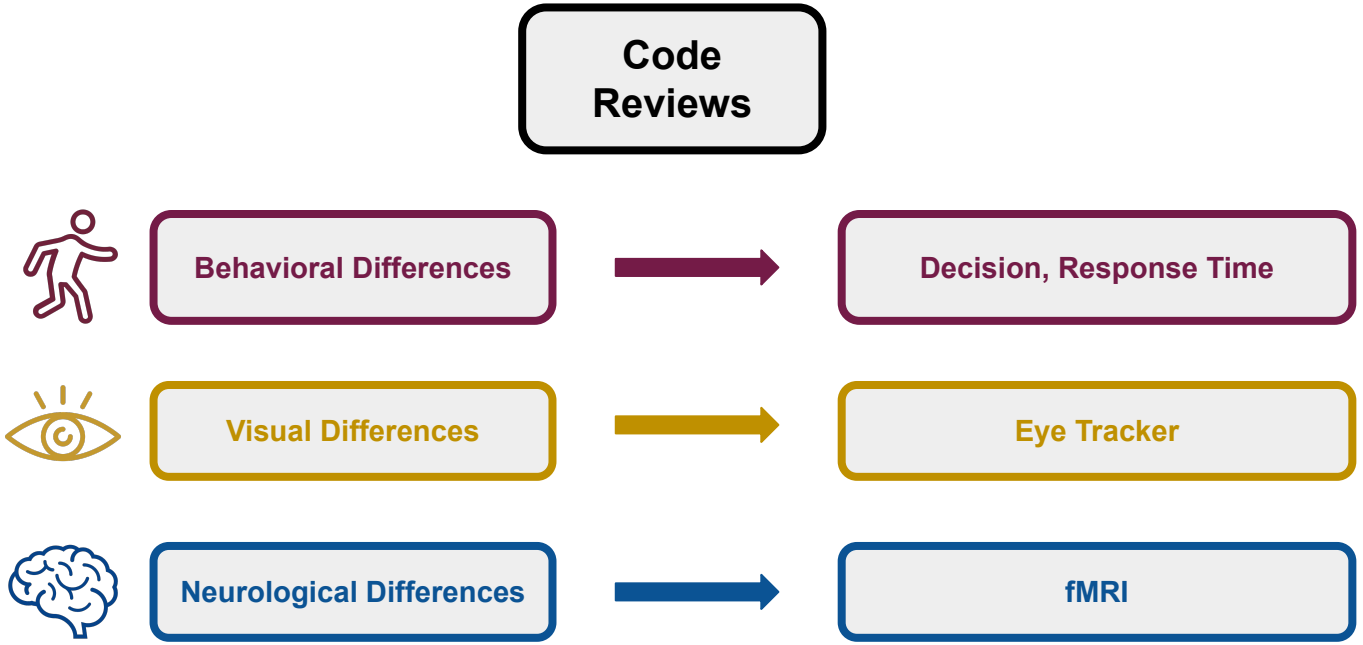

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  - 40 from the top 60 starred C/C++ projects


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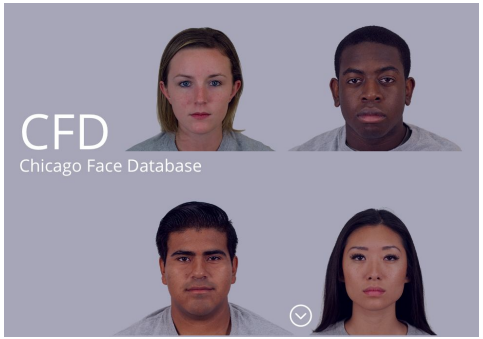
      - Age, race, attractiveness, facial expression

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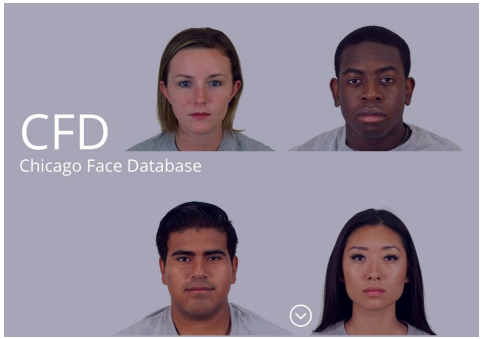


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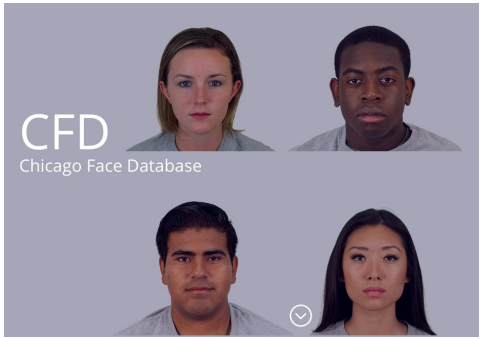


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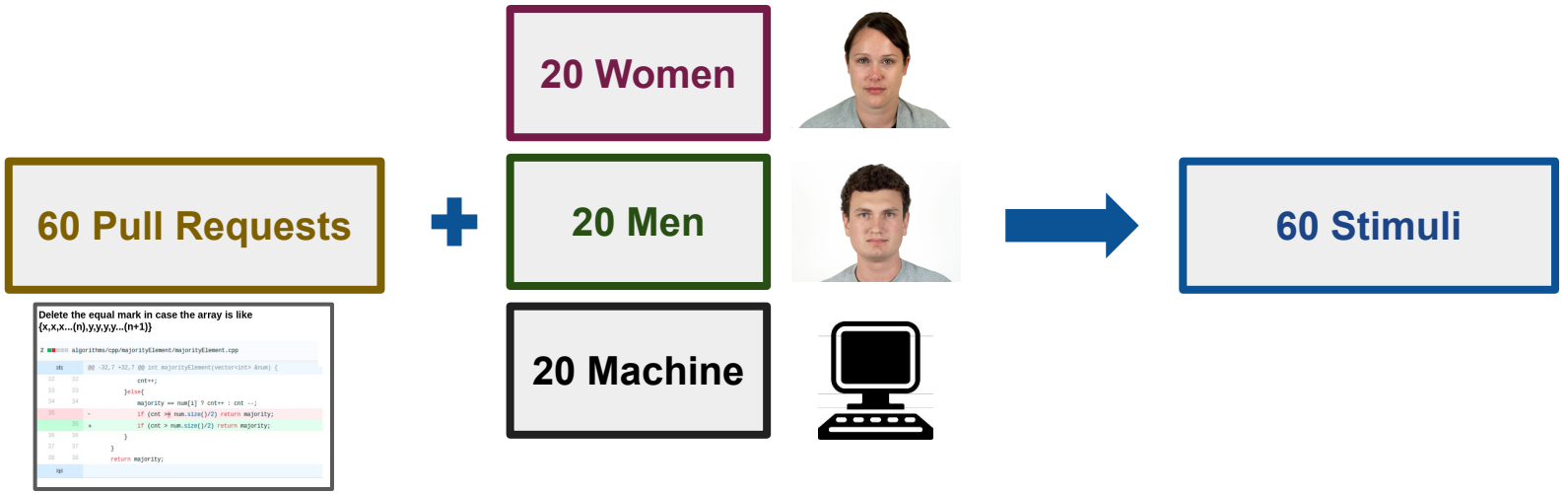

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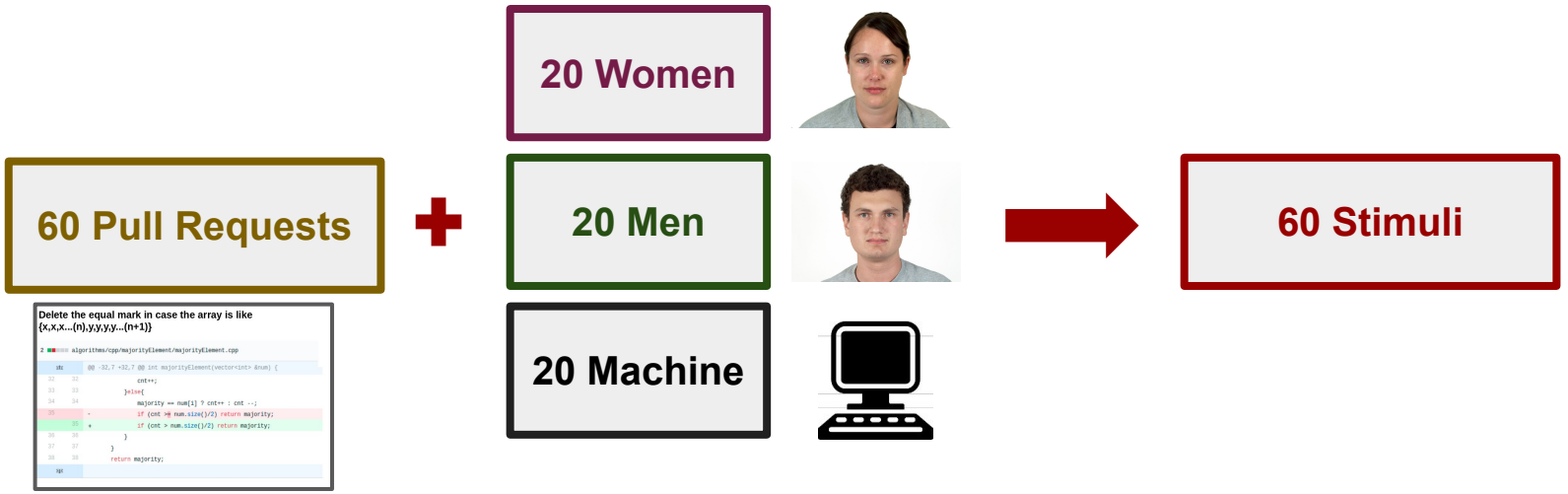

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60 Stimuli: V1

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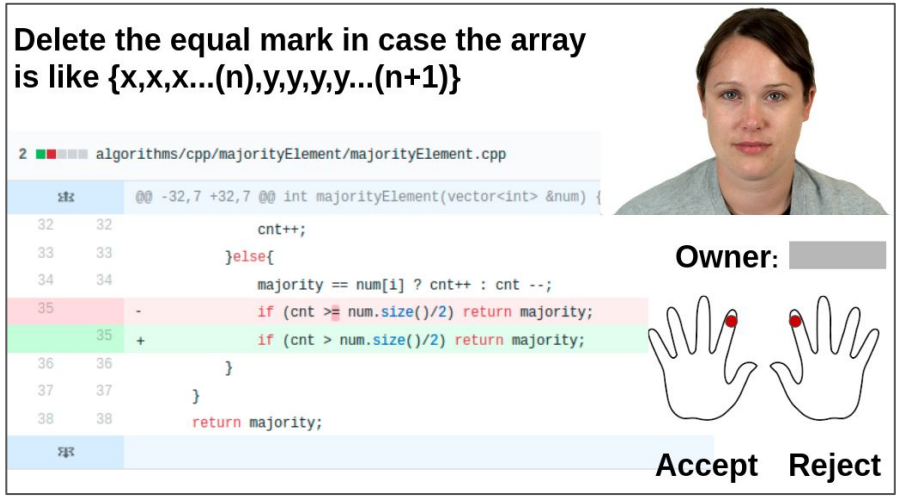

# Experimental Design: Code Review Tasks

- 60 C/C++ pull requests from GitHub
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Please wait for the next pull request submitted by this programmer:

Name:
Affiliation:
Title:

Next pull request is loading ...

Delete the equal mark in case the array is like {x,x,x...(n),y,y,y,y...(n+1)}

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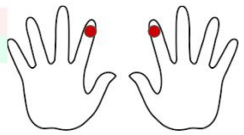
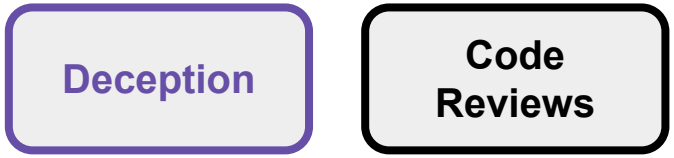


Accept Reject

# Experimental Design


**Social desirability bias**

# Experimental Design: Deception




*"This study is to investigate how software developers conduct code reviews."*

*"All of the pull requests are from real-world software projects and development teams."*

*"Some of the pull requests are generated by computer programs."*

# Experimental Design: Deception


*"Sorry."*

*"Actually, this study is to check biases on genders and identities of authors in code review."*

*"All of the pull requests are made by human developers. None is generated by machines."*

*"All the profile pictures are randomly assigned."*

# Experimental Design: Recruitment

**Recruitment** | **Deception** | **Code Reviews** | **Debriefing**

- **37 participants**
  - Native English speakers
  - Left-handed

| Demographic | Number of Participants | | |
|---|---|---|---|
| | Total | Version I | Version II |
| Men | 21 | 11 | 10 |
| Women | 16 | 7 | 9 |
| Undergraduate | 26 | 11 | 15 |
| Graduate | 11 | 7 | 4 |

# Experimental Design: Post Survey


- How would you **compare** the machine-generated code changes(i.e., by automated repair tools) with the human-generated changes?
- Do you think there are any difference between code written by men and women?

# Research Questions

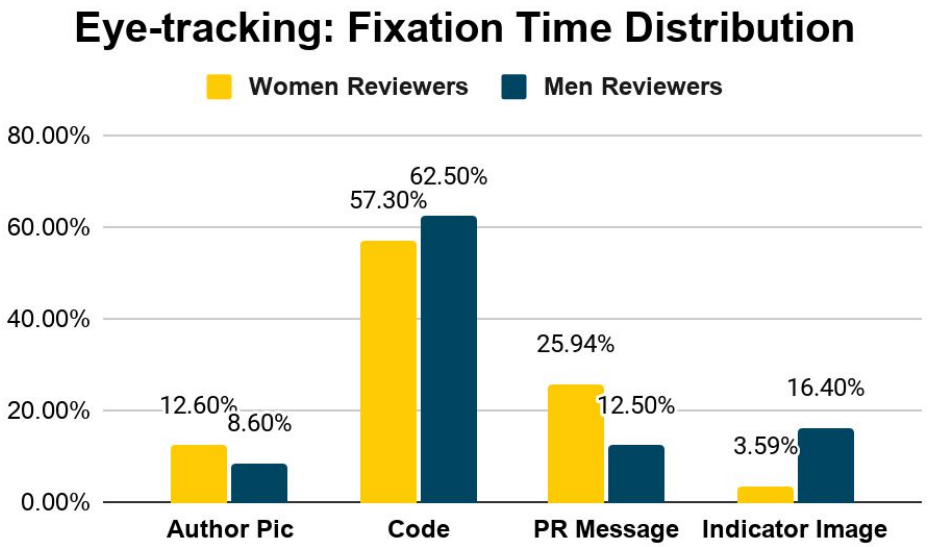
- **RQ1:** How do the identities of code **reviewers** and **authors** change or bias the code review process behaviorally?
- **RQ2:** Can we differentiate the gender identities of code **reviewers** based on their **visual attention patterns**?
- **RQ3:** Can we classify the gender identities of code **reviewers** based on patterns of **brain activity**?
- **RQ4:** How do **self-reports** of the role of identity in code review **align with reality**?

# Results:

- **RQ1:** How do the identities of code **reviewers** and **authors** change or bias the code review process behaviorally?
  - Behaviorally, men and women conduct code reviews differently
    - LMM, statistical tests
  - All participants spend ***less time*** evaluating the Pull Requests of ***women*** ($p<0.01$)
  - All participants are ***less likely to accept*** the Pull Requests of ***machines*** ($p<0.05$)
  - ***Women reviewers*** spent ***less time*** on all Pull Requests than men ($p<0.0001$)

# Results

- **RQ2:** Can we differentiate the gender identities of code reviewers based on their visual attention patterns?
  - Men and women participants employ ***different high-level problem-solving strategies*** in code review.
    - Men fixated more frequently ($p<0.001$), while women spent significantly more time analyzing Pull Requests messages and author pictures.



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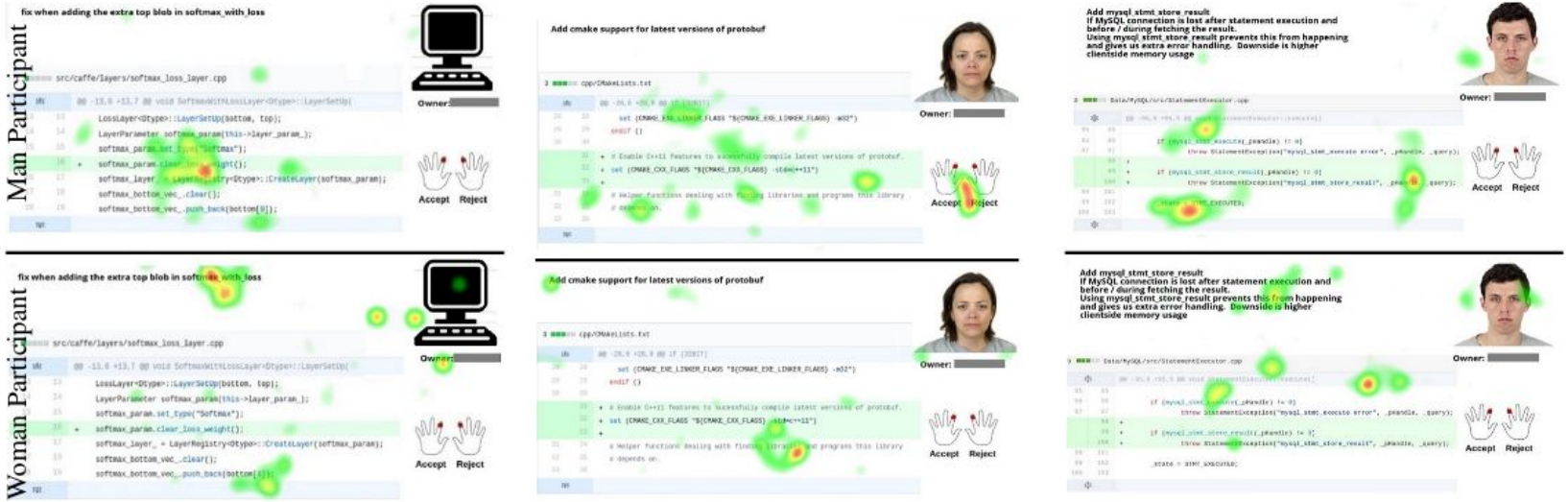



(a) A stimulus with a machine author

(b) A stimulus with a woman author

(c) A stimulus with a man author

# Results

- **RQ3:** Can we classify the gender identities of code **reviewers** based on patterns of **brain activity**?
  - Relative to women reviewers, ***men*** show ***less consistent differences*** in their responses to woman- vs. man-authored Pull Requests.
    - Gaussian Process Classification
  - It is possible to ***distinguish*** women and men conducting code review at a neurological level (BAC=68.59%,p=0.016).

# Results

- **RQ4:** How do **self-reports** of the role of identity in code review **align with reality**?
  - Although humans exhibit biases in their acceptance rates of identical code labeled as written by women vs men vs. machines , participant self-reports **only acknowledge the bias against machines(23 : 8) but do not acknowledge a gender bias**.
  - When Pull Request author information changes, participants report **seeing quality differences where none exist** (reported: machines-generated code has lower quality).

***"Machine-generated changes are IMO less readable, a little worse in quality, capable in fewer scopes"***

# Summary

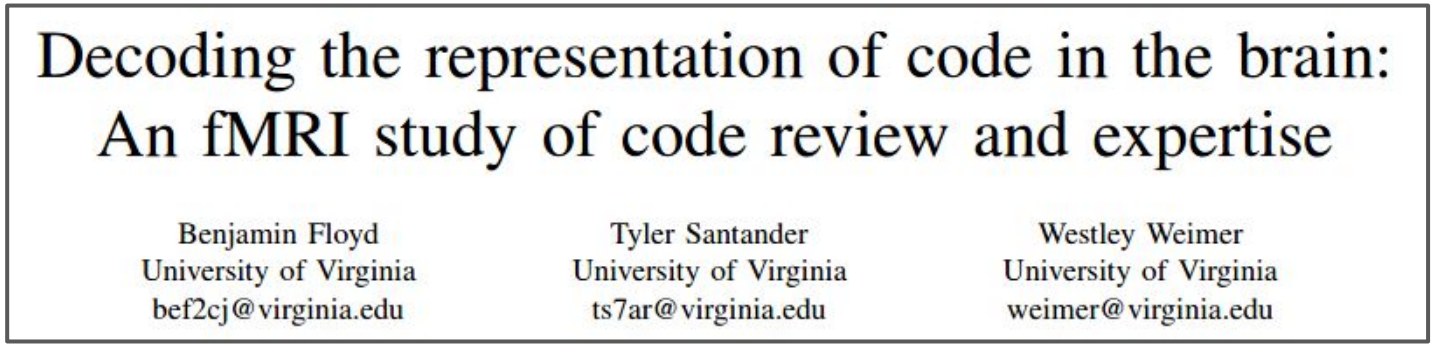



- We present a **controlled experiment** using both medical imaging and eye-tracking to investigate **biases and differences** in code review.
  - Genders, humans, machines
- We find **universal biases** in how all participants treat code reviews as a function of the **reviewers' gender** and **apparent author:**
  - **Behavioral difference**
  - **Visual difference**
  - **Neurological difference**
- We find participants' **self-reported perception** of decision making in code review **do not align** with the objective observations.
  - Bias against machines exists
  - Do not realize the existence of difference on gender

# Bonus

# Motivation

- Code review is critical for software development
  - Systematic inspection, analysis, evaluation, and revision of code.
  - Latent defect discovery rate of formal code review can be 60%-65%



Decoding the representation of code in the brain:
An fMRI study of code review and expertise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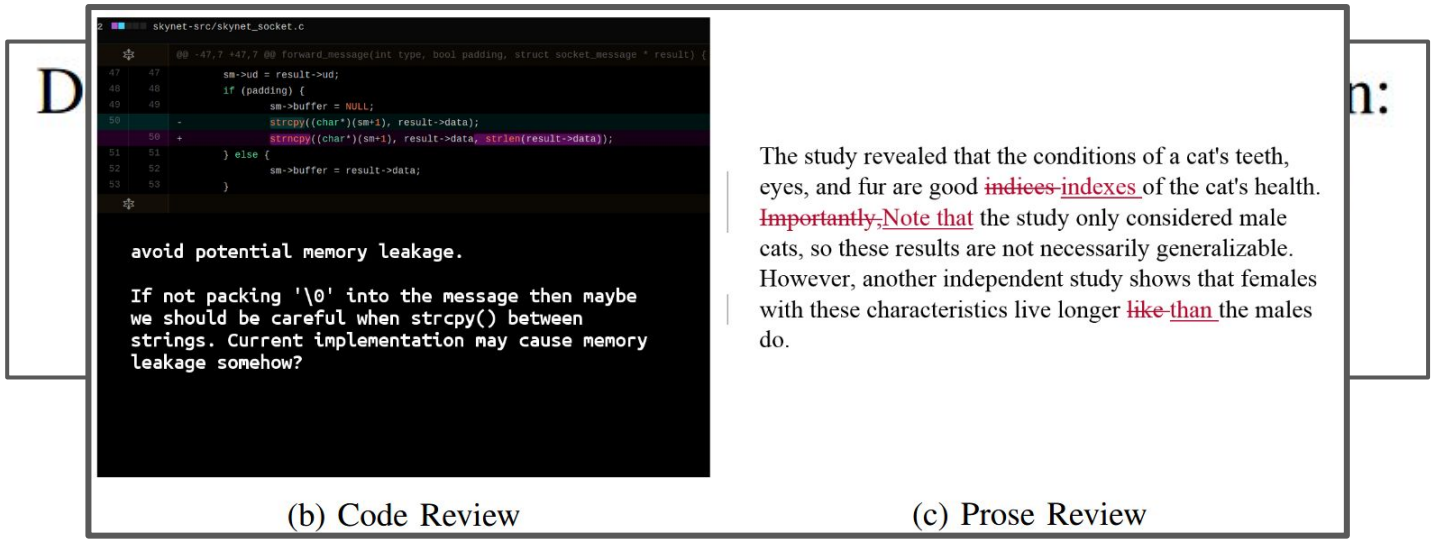


(b) Code Review (c) Prose Review

# Results

- **RQ1:** How do the identities of code reviewers and authors change or bias the code review process? **Behavioral Difference**
- **Behaviorally, men and women conduct code reviews differently**
  - LMM, statistical tests

| Author Label | Woman | Man | Machine |
|---|---|---|---|
| Response Time (s) | 20.8 | 21.7 | 21.7 |

| Reviewer's Gender | Woman | Man |
|---|---|---|
| Response Time (s) | 20.5 | 22.1 |

| Author Label | Woman | Man | Machine |
|---|---|---|---|
| Acceptance Rate | 84.36% | 79.68% | 78.03% |

# Results

- **RQ2:** Can we classify the gender identities of code reviewers based on patterns of brain activity? **Neurological Difference**
  - Relative to women reviewers, men show less consistent differences in their responses to woman- vs. man-authored Pull Requests.
    - Gaussian Process Classification
  - It is possible to distinguish women and men conducting code review at a neurological level (BAC=68.59%,p=0.016). Men and women conduct code reviews differently in terms of associated cognitive processes and patterns of neural activation