

Biometrics

COMP 388-002/488-002 Computer Science Topics

Daniel Moreira
Fall 2023



LOYOLA
UNIVERSITY CHICAGO

Welcome

COMP 388-002/488-002 Computer Science Topics Biometrics

Daniel Moreira (Instructor)
Contact: dmoreira1@luc.edu
Office: 310 Doyle Center



Course Hours

Lectures: MON and WED, 4:15 to 5:30 PM, 218 Cuneo Hall
Office: MON and TUE evenings, 6 to 8 PM, and WED mornings, 8 AM to noon,
310 Doyle Center or Zoom, by appointment (<https://bit.ly/3KUUaND>)

Communication

Sakai: <https://sakai.luc.edu/x/gUHhNw>
Webpage: <https://danielmoreira.github.io/teaching/biometrics-aut23/>

Today you will...

Get to know what is ahead of you
in the course.

About me

Computer Scientist

PhD from the University of Campinas (Brazil)

Theme: Sensitive-Video Analysis

Loyola University Chicago

Assistant Professor

Joined on August 15, 2022



Research

Media Forensics, Biometrics, Computer Vision, Machine Learning

Webpage: <https://danielmoreira.github.io>

(see following slides)



LOYOLA
UNIVERSITY CHICAGO

Sensitive-Video Analysis

<https://danielmoreira.github.io/project/sma/>

The Problem

The New York Times
Teenager Is Accused of Live-Streaming a Friend's Rape

SOUTH FLORIDA

Miami Herald

Another girl hangs herself while streaming it live — this time in N

CNN BUSINESS Markets Tech Media Success Perspectives Video

Seven weeks later, videos of New Zealand attack still circulating on Facebook and Instagram

The Intersect

The Washington Post

A 12-year-old girl live-streamed her suicide.
It took two weeks for Facebook to take the

Man shot, killed while live-streaming

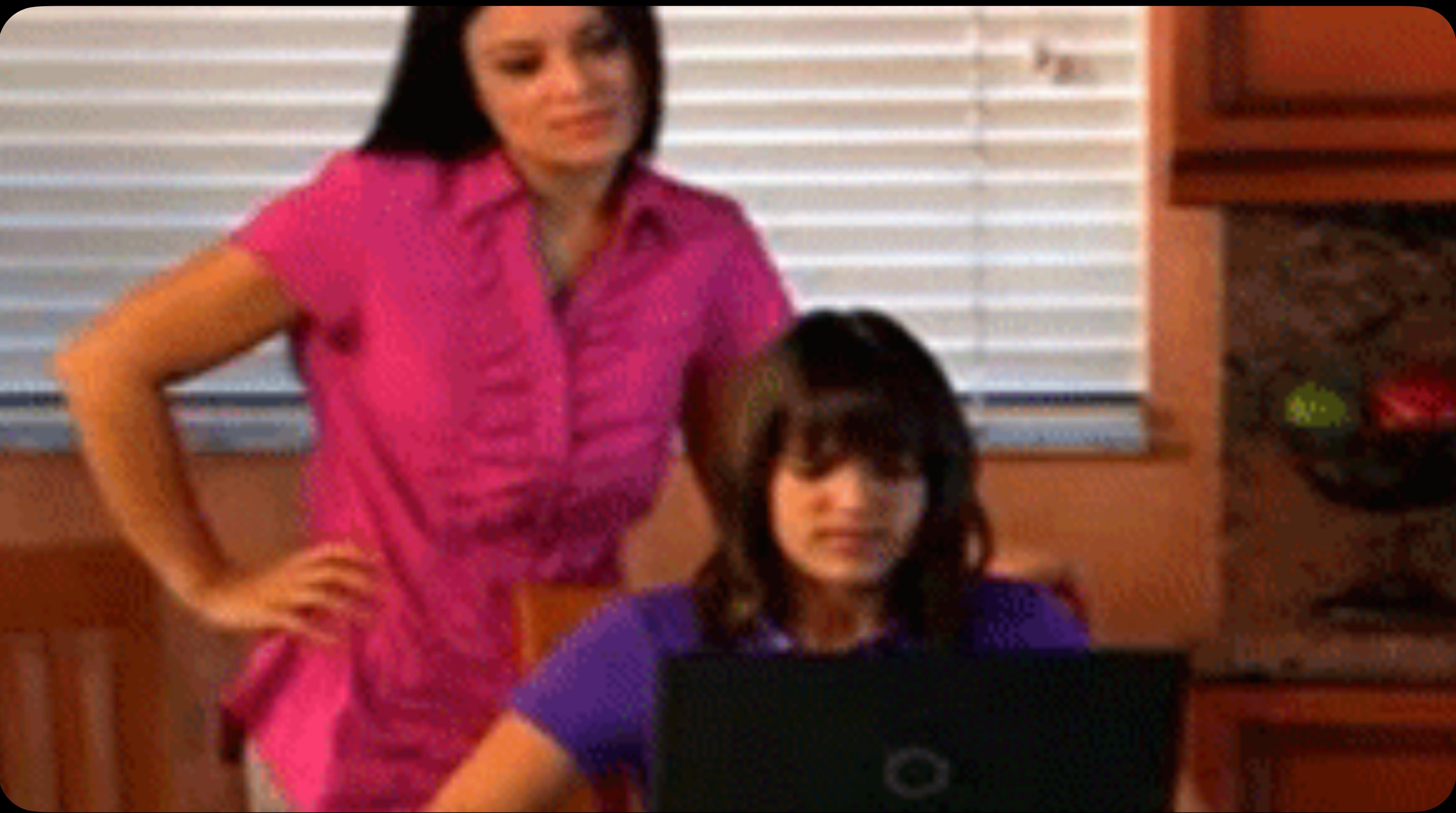


LOYOLA
UNIVERSITY CHICAGO

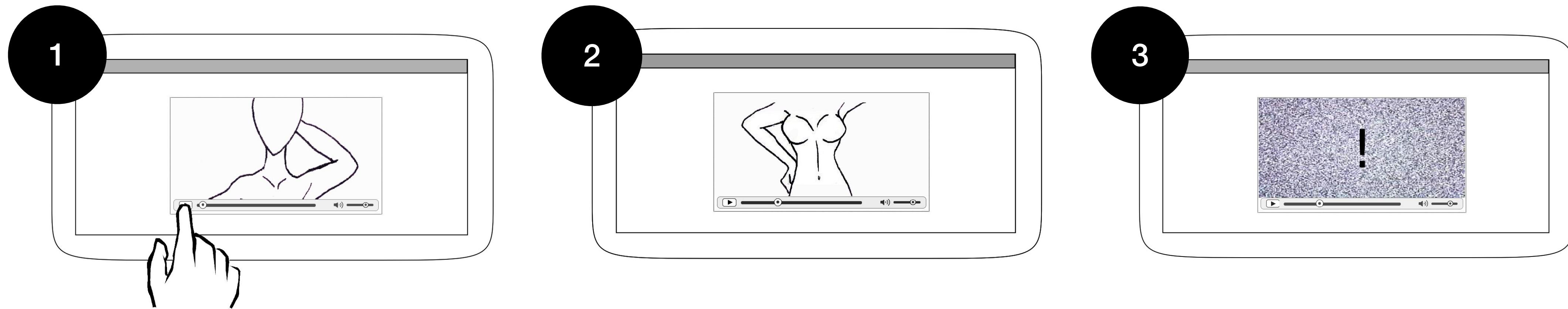
Sensitive Video

“Motion pictures whose content may inflict harm (e.g., trauma, shock, or fear) to particular audiences (e.g., children or unwary spectators), due to the inappropriateness of content.”





Can a computer localize sensitive scenes within a video timeline?





The Notorious B.I.G.
NY scene rapper

Media Forensics

<https://danielmoreira.github.io/project/medifor/>

Kurt Cobain
Grunge scene musician

The Problem

CNET

SCI-TECH

Spy reportedly used AI-generated photo to connect with targets on LinkedIn

A fake account had links to politically connected figures in Washington, the Associated Press reports.

BY STEVEN MUSIL | JUNE 13, 2019 5:13 PM PDT

Connect



Katie Jones

Russia and Eurasia Fellow

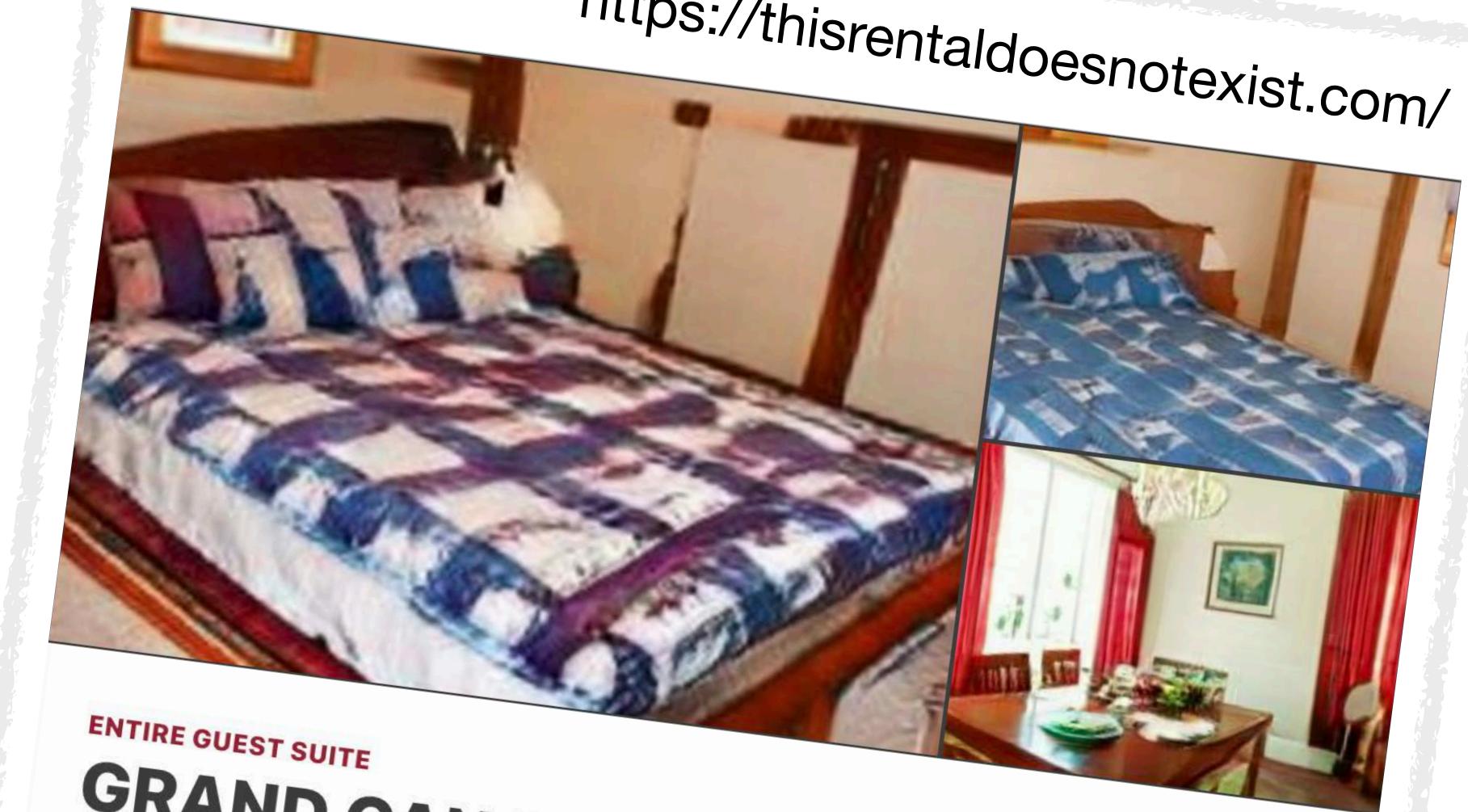
Center for Strategic and International Studies (CSIS) ·
University of Michigan College of Literature, Science...
Washington · 49 connections

Adobe

Crafting new images with
photo manipulation.



<https://thisrentaldoesnotexist.com/>



[https://www.youtube.com/
watch?v=p7-B8S734T4](https://www.youtube.com/watch?v=p7-B8S734T4)



LOYOLA
UNIVERSITY CHICAGO

A composite image. On the left, a man wearing a red baseball cap with 'ROYAL' and 'S' on it is shown from the chest up. On the right, a portrait of Kurt Cobain, the lead singer of Nirvana, looking slightly upwards and to his right.

The Notorious B.I.G.
NY scene rapper

HANGING OUT?

Kurt Cobain
Grunge scene musician

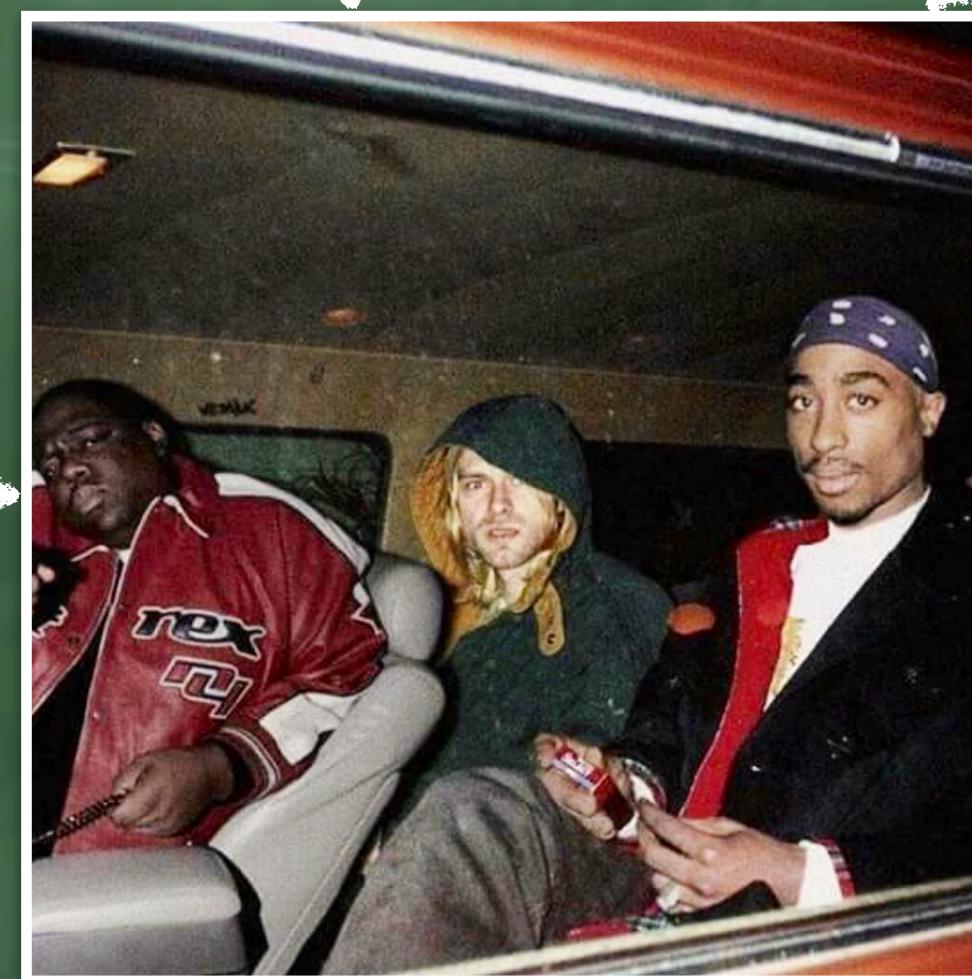
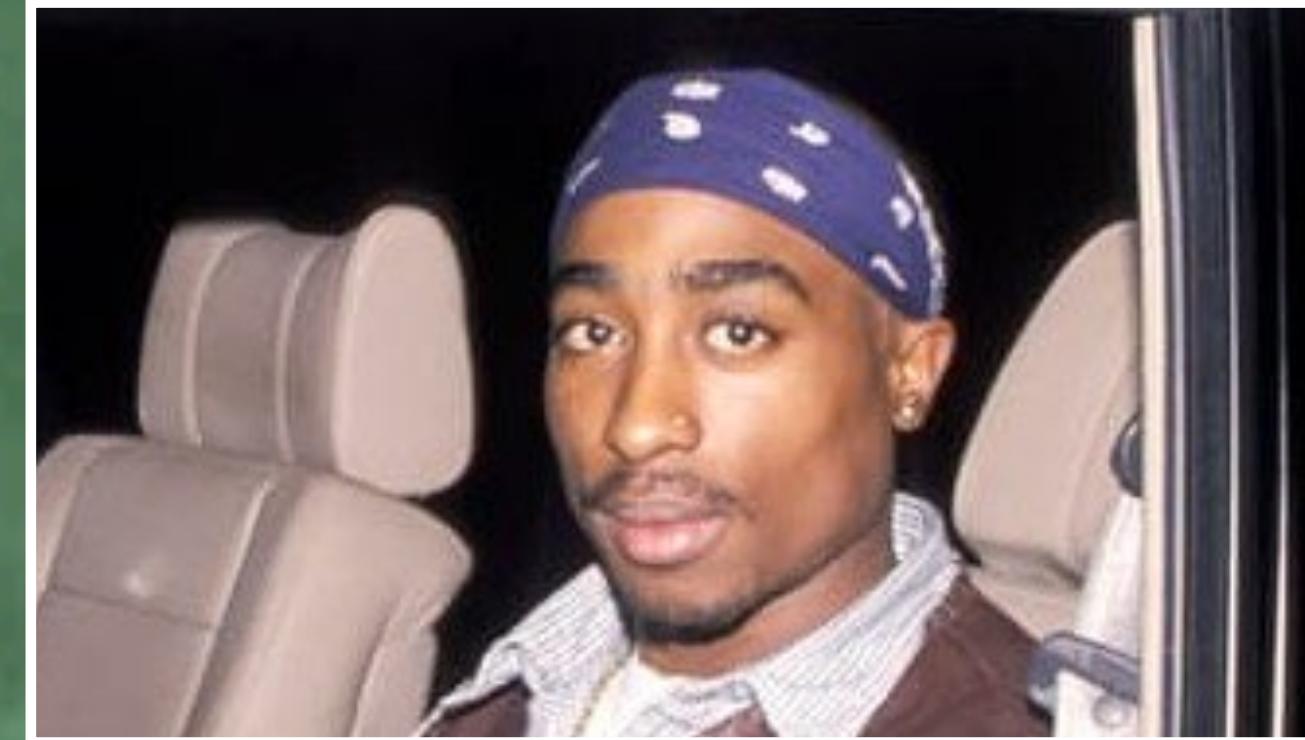
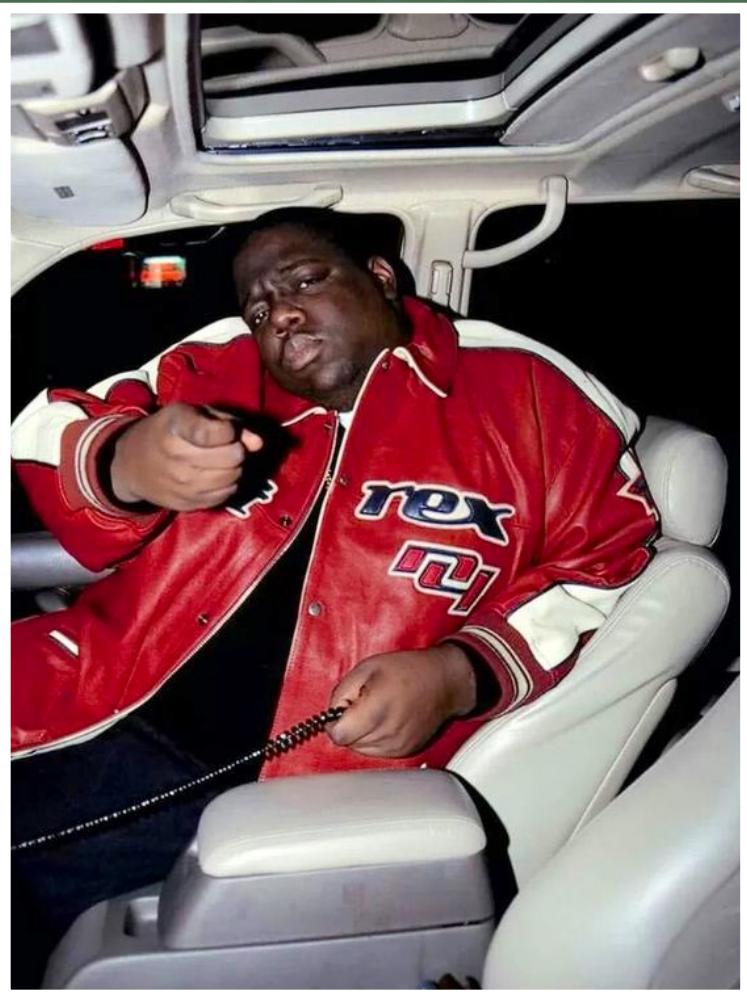


A collage of three images. On the left, a close-up of a person's face wearing a red baseball cap with 'RED' and 'DODGERS' on it. In the center, a woman with long blonde hair, wearing a green jacket over a yellow patterned top, looks directly at the camera. On the right, a portrait of Tupac Shakur looking slightly to the side.

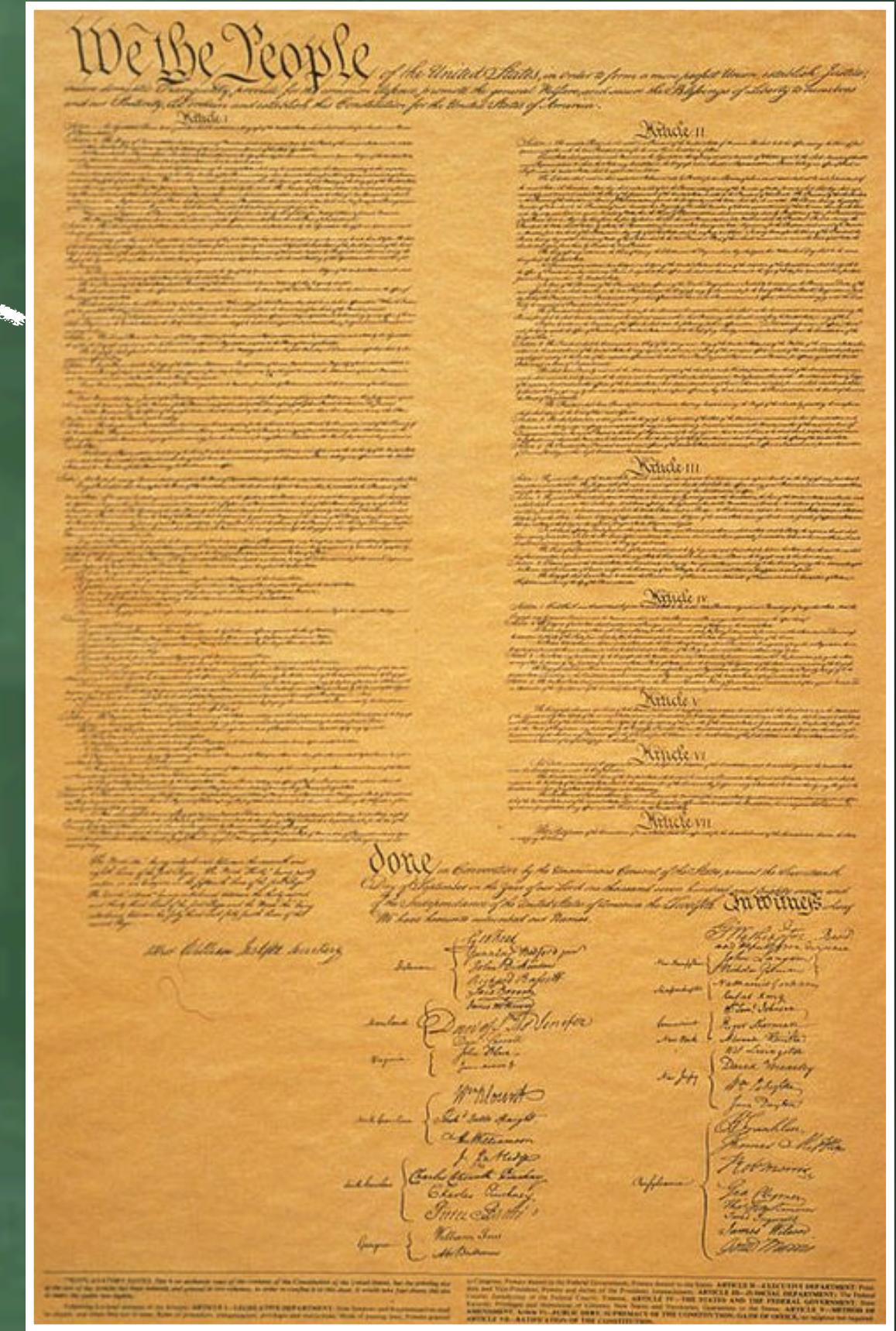
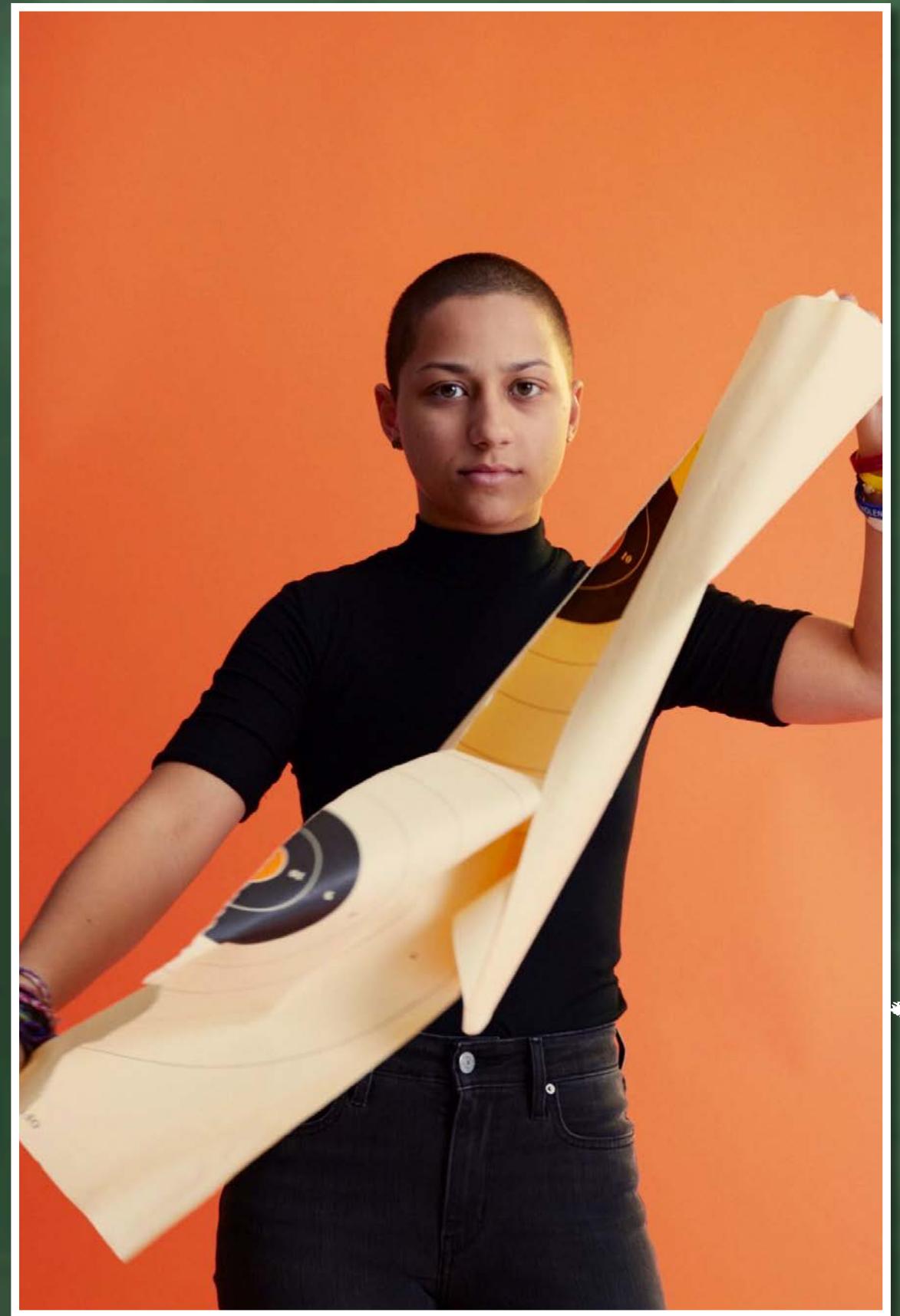
Tupac Shakur
LA scene rapper



Provenance Graph











Scientific Integrity

<https://danielmoreira.github.io/project/sciint/>



Jesse Springer
(@SpringerToons)

The Problem

The screenshot shows a retraction note from the journal **nature**. The note is dated April 15, 2015, and discusses a paper published in **Nature** on October 9, 2002. The retraction is due to inappropriate image manipulation in the published figures. The affected figure panels are Figure 1b, d, Figure 2b, e, Figure 3a, and Figure 4d. The note states that **nature** has not received a response from the authors or the University of [REDACTED] to approve the retraction. To the right of the text, there is a gel electrophoresis image with four lanes labeled 1, 2, 3, and 4. The lanes are grouped under two headings: "Paper 5 Fig 1B" and "Paper 6 Fig 1b". The lanes show bands of varying intensity, with lane 1 being the most prominent in both groups.

nature

Retraction Note | Published: 15 April 2015

Retraction Note: Histone methylation by the *Drosophila* epigenetic transcriptional regulator Ash1

Nature 521, 110 (2015) | Cite this article

27k Accesses | 34 Altmetric | Metrics

The Original Article was published on 09 October 2002

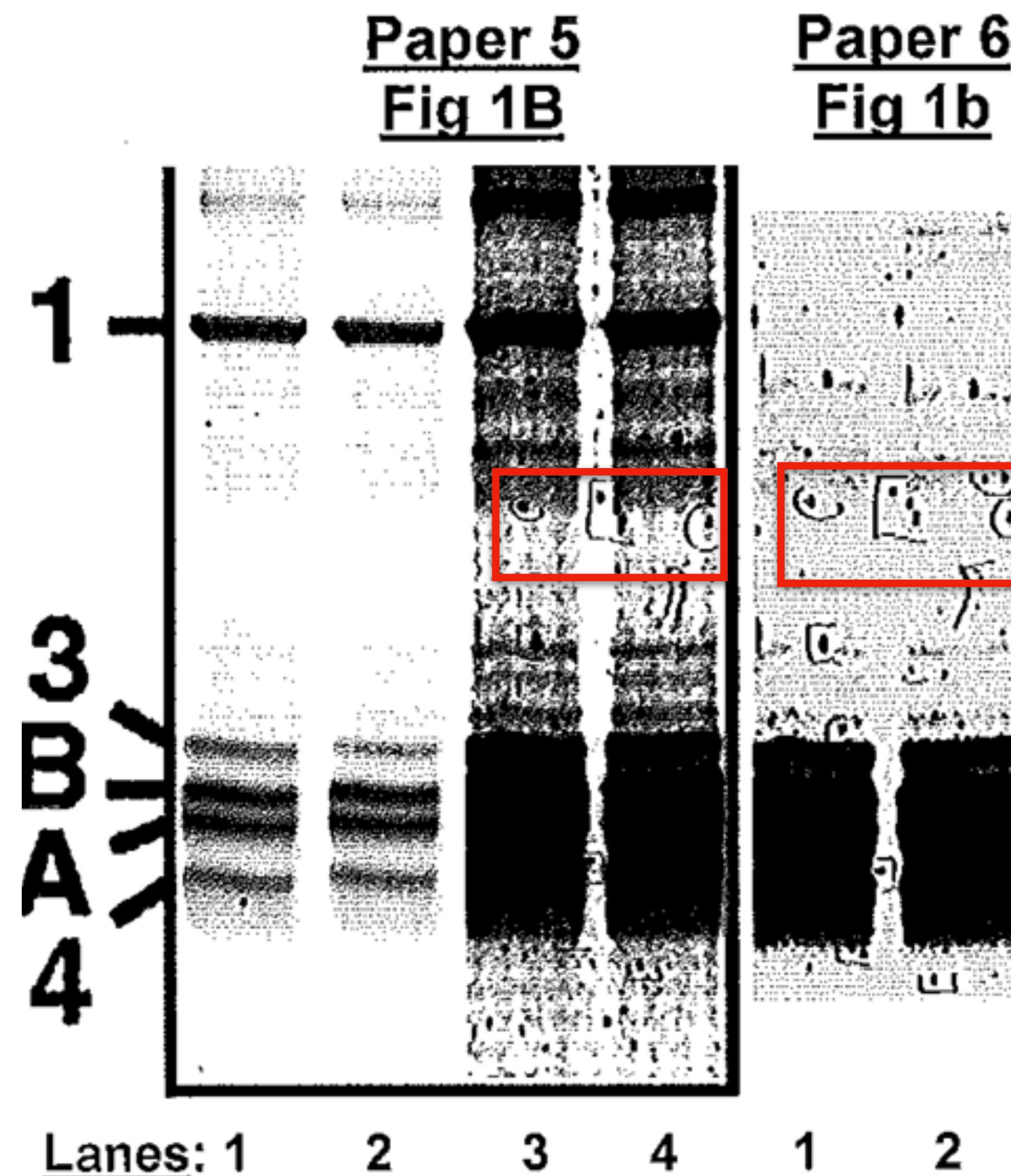
The authors and the University of [REDACTED] wish to retract this letter owing to inappropriate image manipulation in the published figures. The figure panels affected are Figure 1b, d, Figure 2b, e, Figure 3a and Figure 4d. *Nature* has not received a response from [REDACTED] to approve this retraction.

Paper 5 Fig 1B

Paper 6 Fig 1b

1 2 3 4 1 2

Lanes: 1 2 3 4 1 2



CORRECTIONS & AMENDMENTS

RETRACTION

doi:10.1038/nature14421

Retraction: Histone methylation by the *Drosophila* epigenetic transcriptional regulator Ash1

Nature 419, 857–862 (2002); doi:10.1038/nature01126

The authors and the University of [REDACTED] wish to retract this Letter owing to inappropriate image manipulation in the published figures. The figure panels affected are Figure 1b, d, Figure 2b, e, Figure 3a and Figure 4d. *Nature* has not received a response from [REDACTED] to approve this retraction.

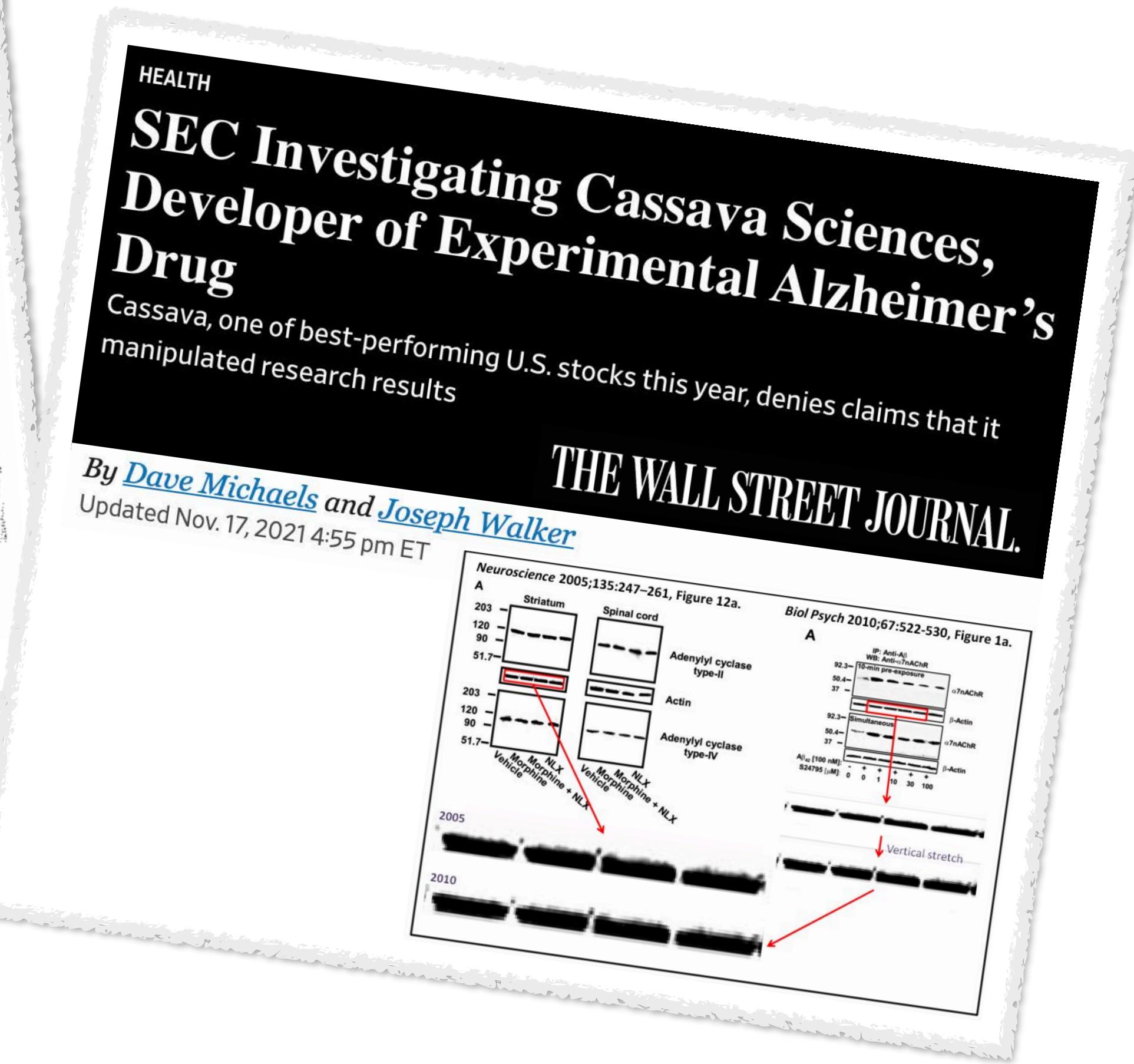
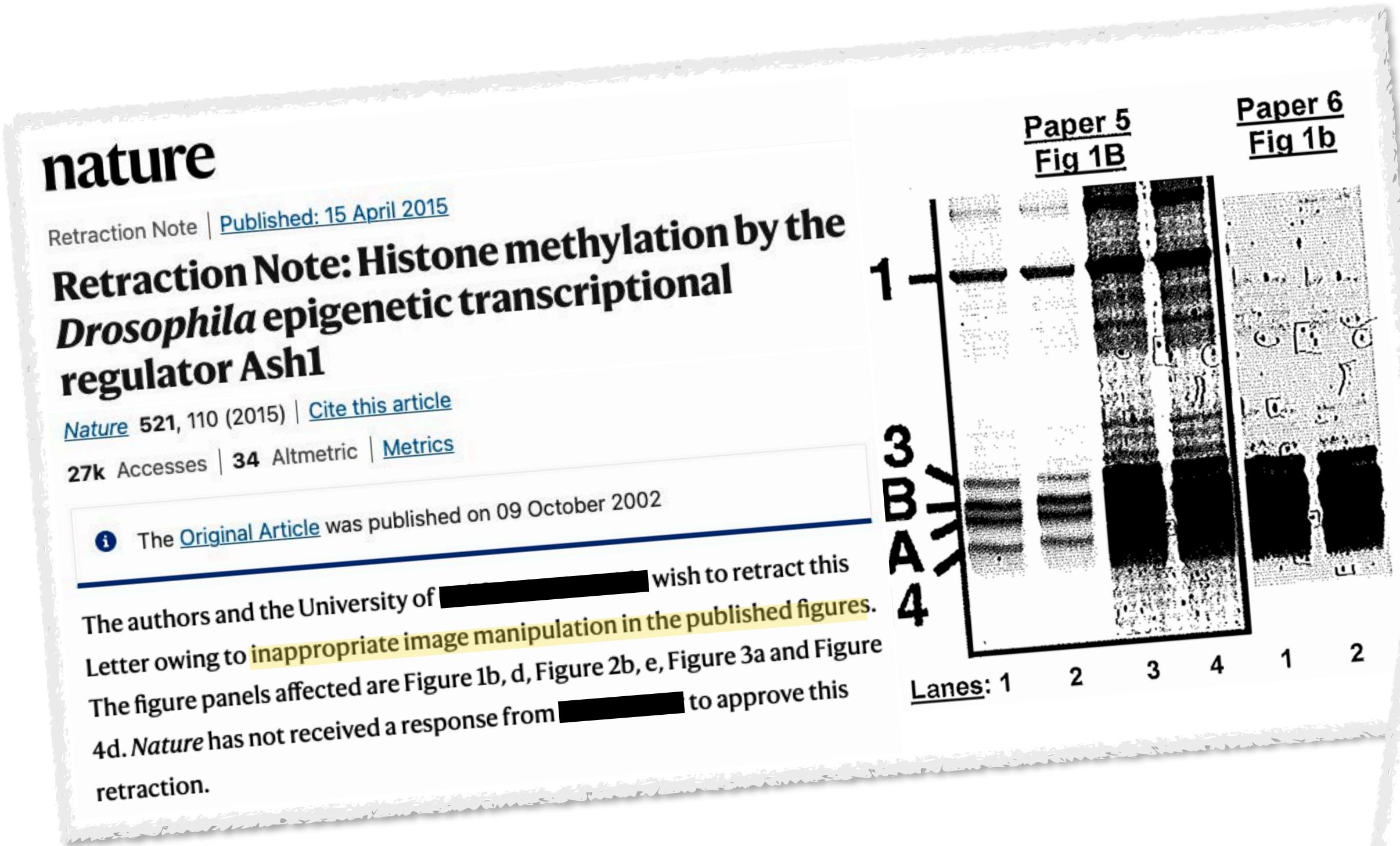
Additional information

The online version of the original article can be found at [10.1038/nature01126](https://doi.org/10.1038/nature01126)



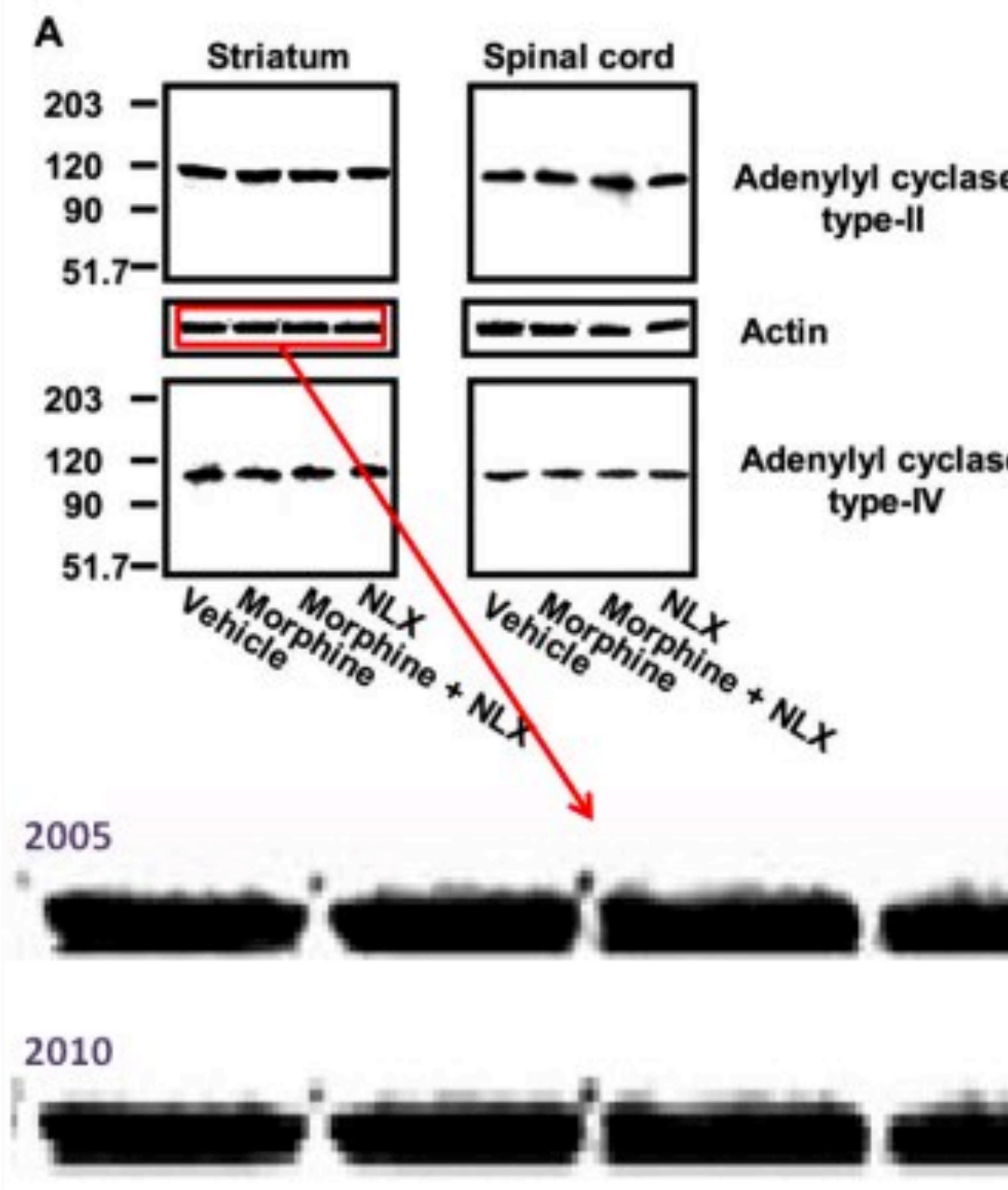
LOYOLA
UNIVERSITY CHICAGO

The Problem

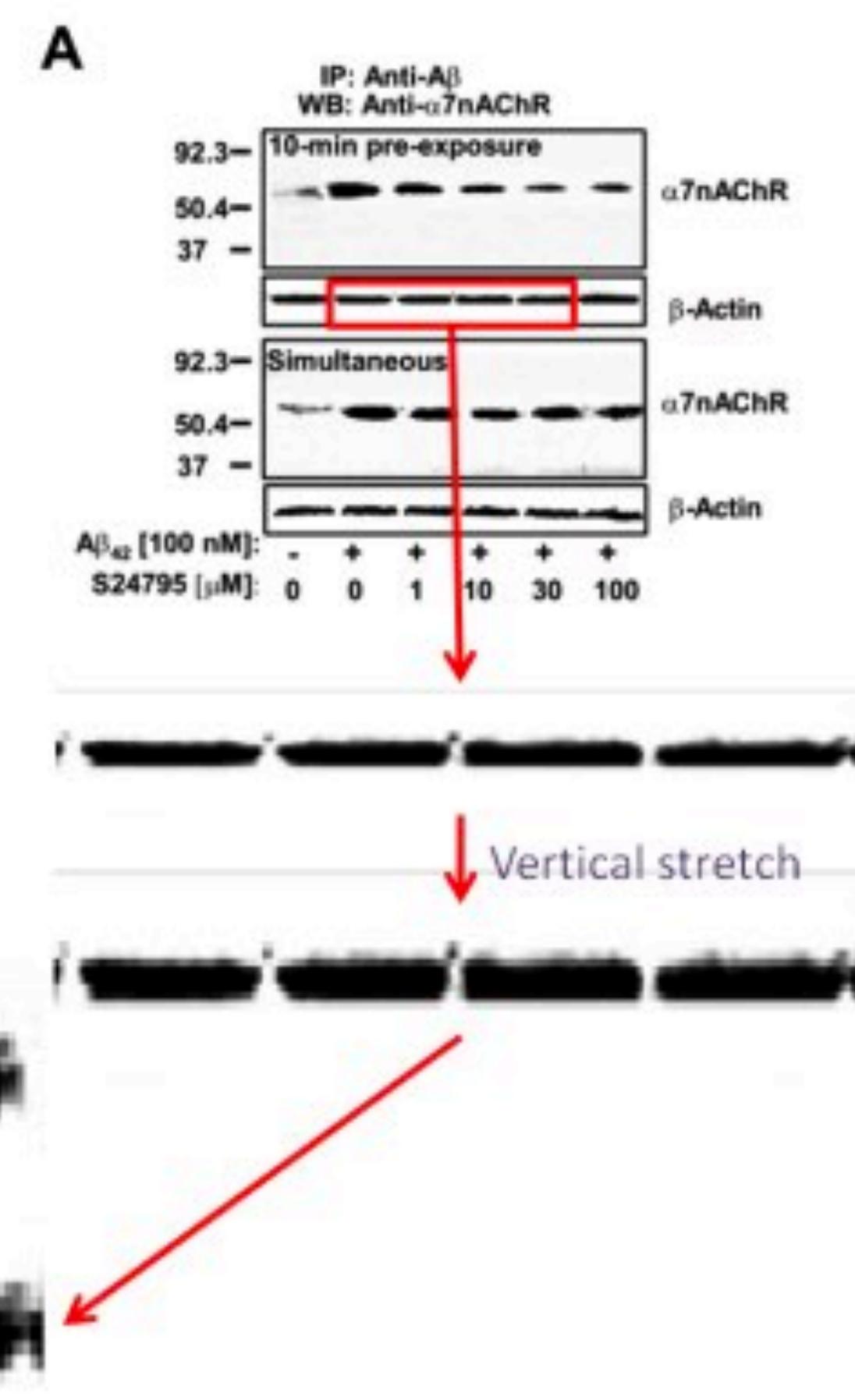


LOYOLA
UNIVERSITY CHICAGO

Neuroscience 2005;135:247–261, Figure 12a.



Biol Psych 2010;67:522-530, Figure 1a.



HEALTH

SEC Investigating Cassava Sciences, Developer of Experimental Alzheimer's Drug

Cassava, one of best-performing U.S. stocks this year, denies claims that it manipulated research results

THE WALL STREET JOURNAL.

By [Dave Michaels](#) and [Joseph Walker](#)

Updated Nov. 17, 2021 4:55 pm ET



LOYOLA
UNIVERSITY CHICAGO

The Problem

nature
Retraction Note | Published: 15 April 2015
Retraction Note: Histone methylation by the *Drosophila* epigenetic transcriptional regulator Ash1
Nature 521, 110 (2015) | Cite this article
27k Accesses | 34 Altmetric | Metrics

The Original Article was published on 09 October 2002

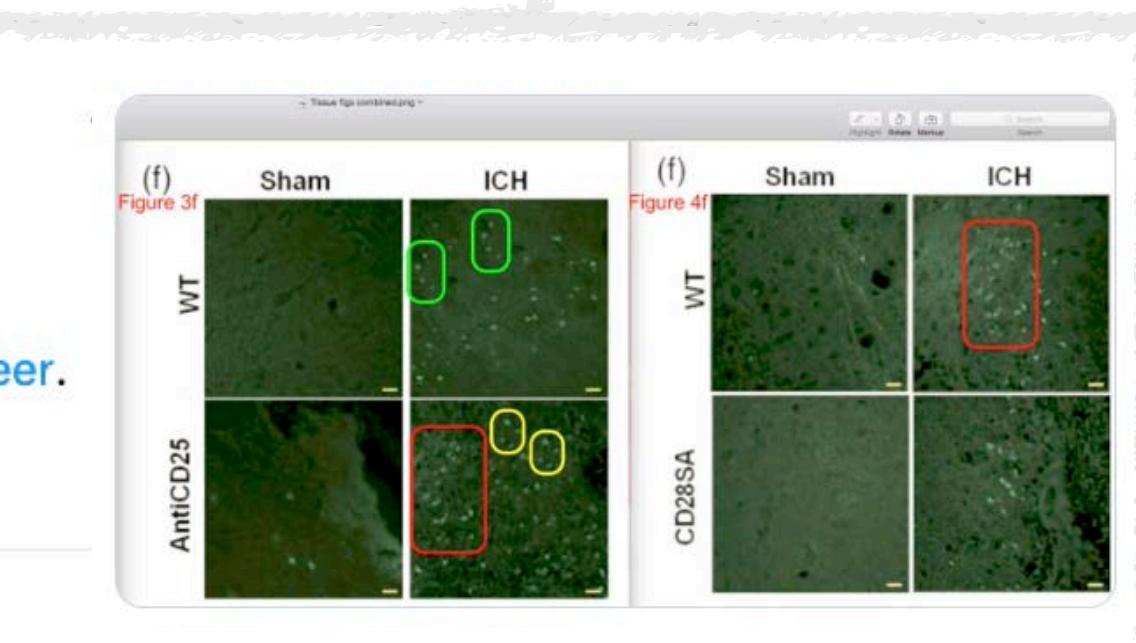
The authors and the University of [REDACTED] wish to retract this Letter owing to inappropriate image manipulation in the published figures. The figure panels affected are Figure 1b, d, Figure 2b, e, Figure 3a and Figure 4d. *Nature* has not received a response from [REDACTED] to approve this retraction.

Elisabeth Bik @MicrobiomDigest

Retraction of a paper by authors of The Third Military Medical University, Zhengzhou University, and @JohnsHopkins, 5 months after posting this to @PubPeer. pubpeer.com/publications/4...

3:17 PM · Oct 2, 2022 · Twitter Web App

3 Retweets 41 Likes



SEC Investigating Cassava Sciences, Developer of Experimental Alzheimer's Drug
Cassava, one of best-performing U.S. stocks this year, denies claims that it manipulated research results

By [Dave Michaels](#) and [Joseph Walker](#)
Updated Nov. 17, 2021 4:55 pm ET

THE WALL STREET JOURNAL.

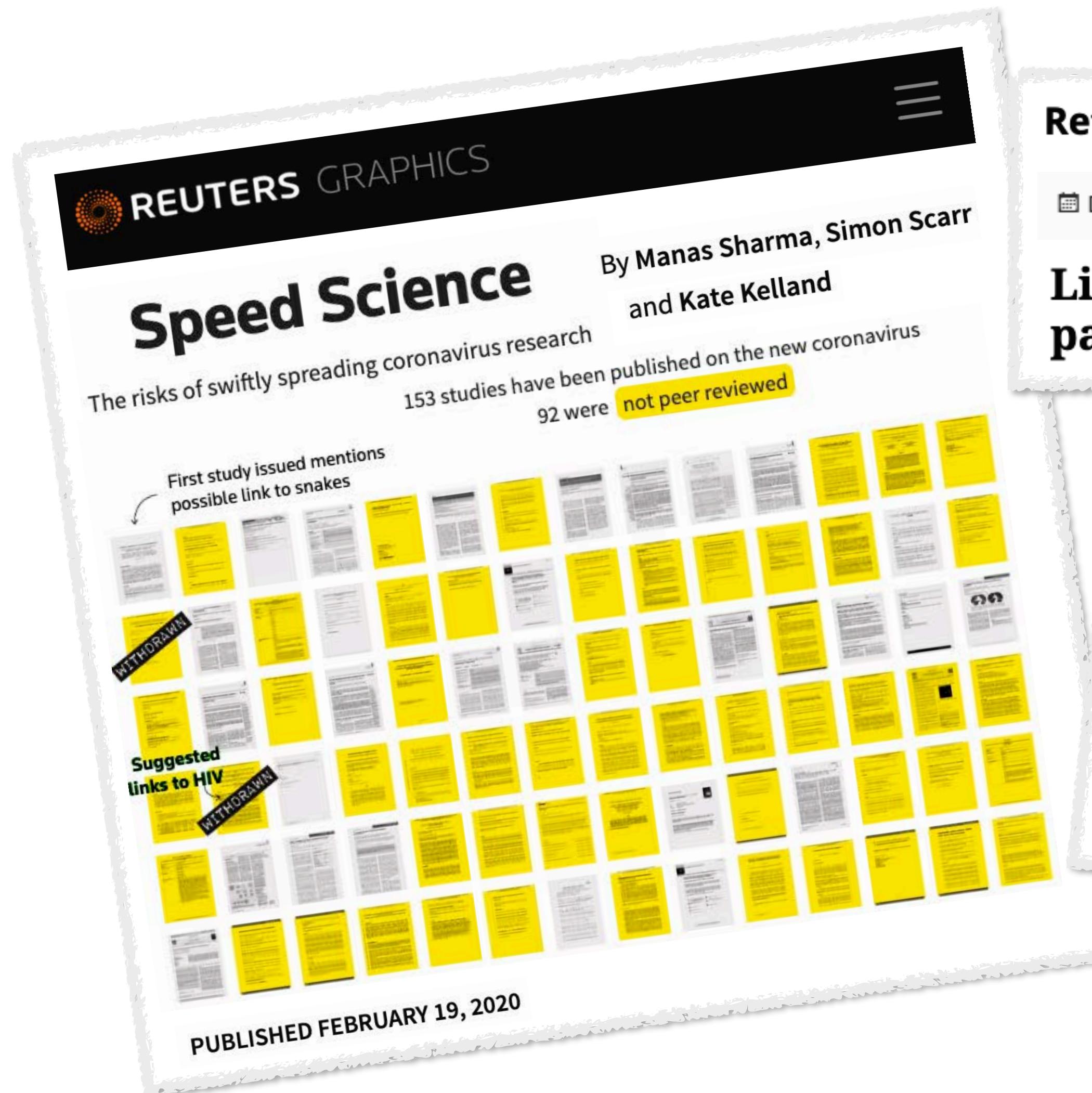
Neuroscience 2005;135:247-261, Figure 12a.
A Striatum Spinal cord
203 120 90 51.7
IP: Anti-AChR WB: Anti- α 7nAChR
Adenyl cyclase type-II Actin

Biol Psych 2010;67:522-530, Figure 1a.
A Simultaneous 92.3 50.4 37
IP: Anti-AChR WB: Anti- α 7nAChR
Adenyl cyclase type-IV β -Actin
2005 2010
Vertical stretch



LOYOLA
UNIVERSITY CHICAGO

The Problem



Retraction Watch Tracking retractions as a window into the scientific process

December 30, 2020 · Ivan Oransky · RW announcements

List of retracted COVID-19 papers grows past 70 343

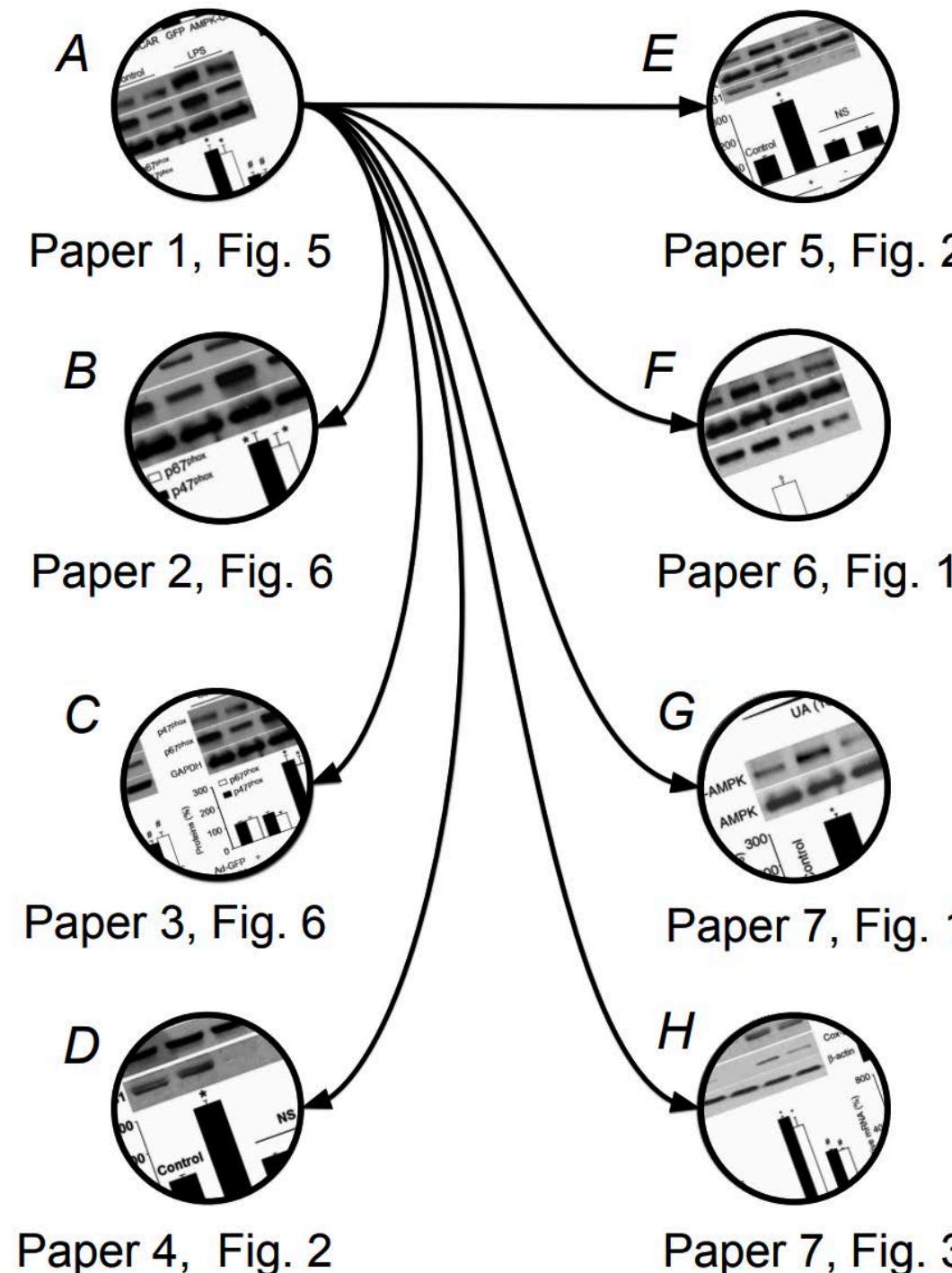


LOYOLA
UNIVERSITY CHICAGO

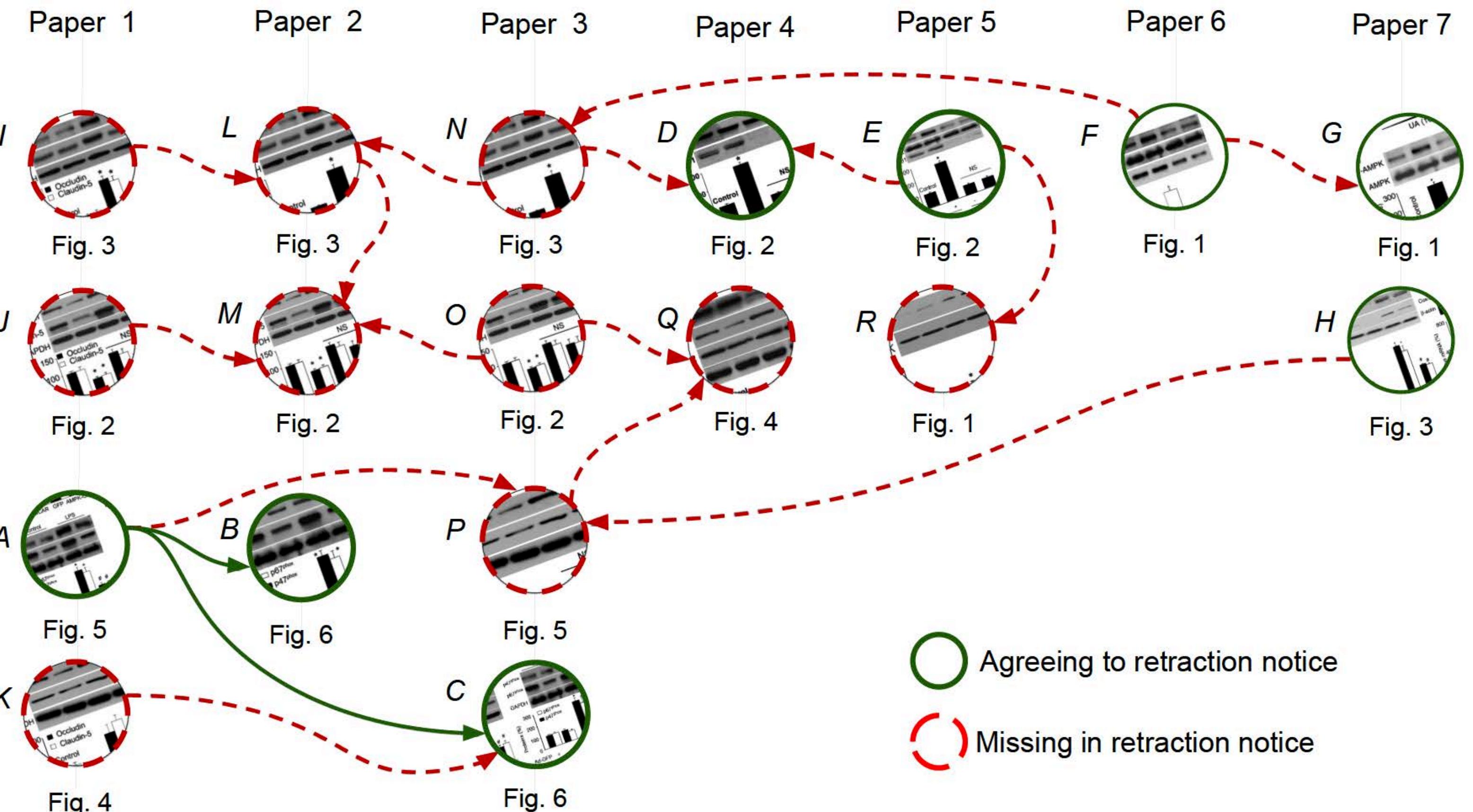
Provenance Analysis

Ground truth

(according to retraction notice)



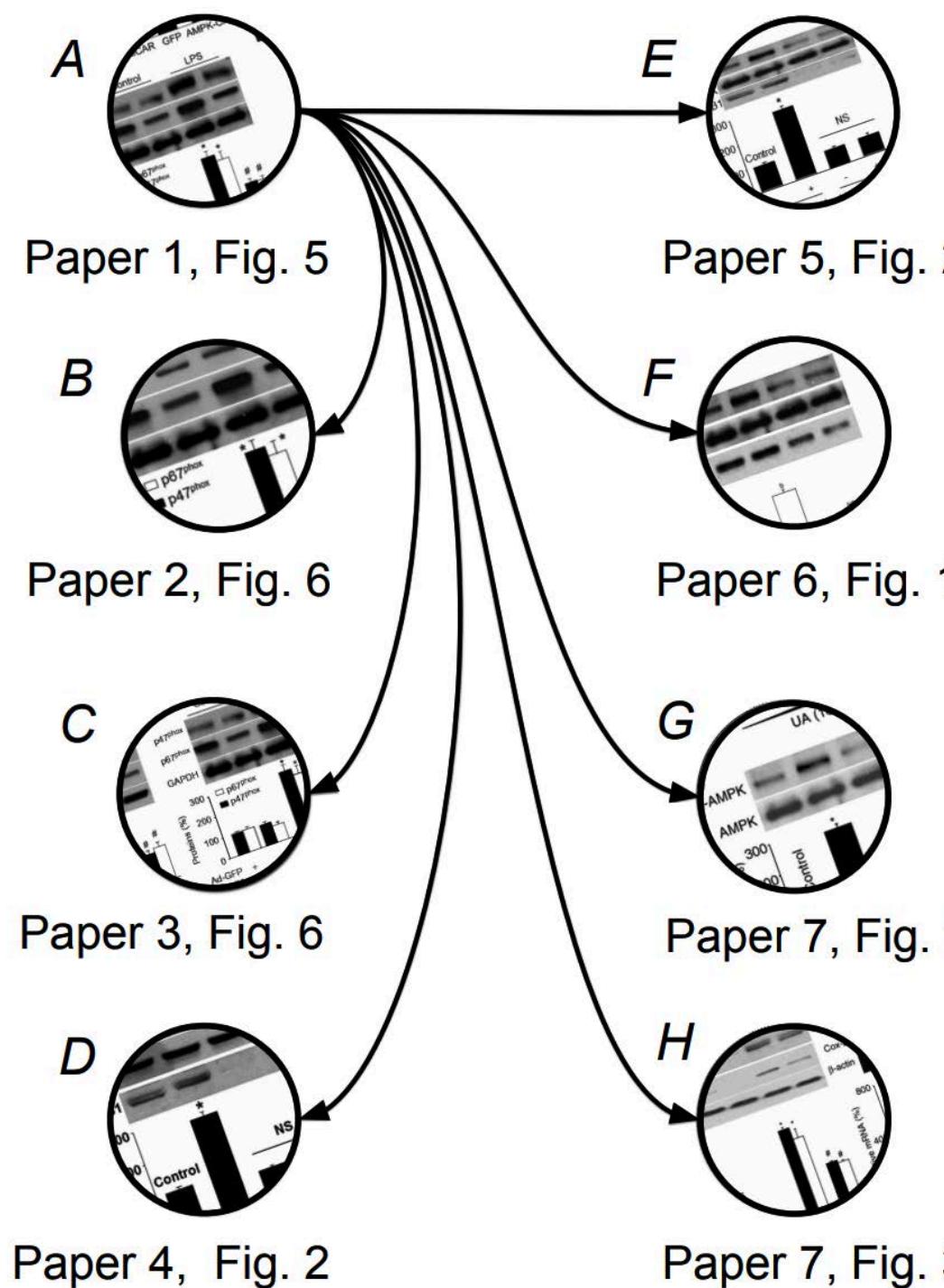
Our findings



Provenance Analysis

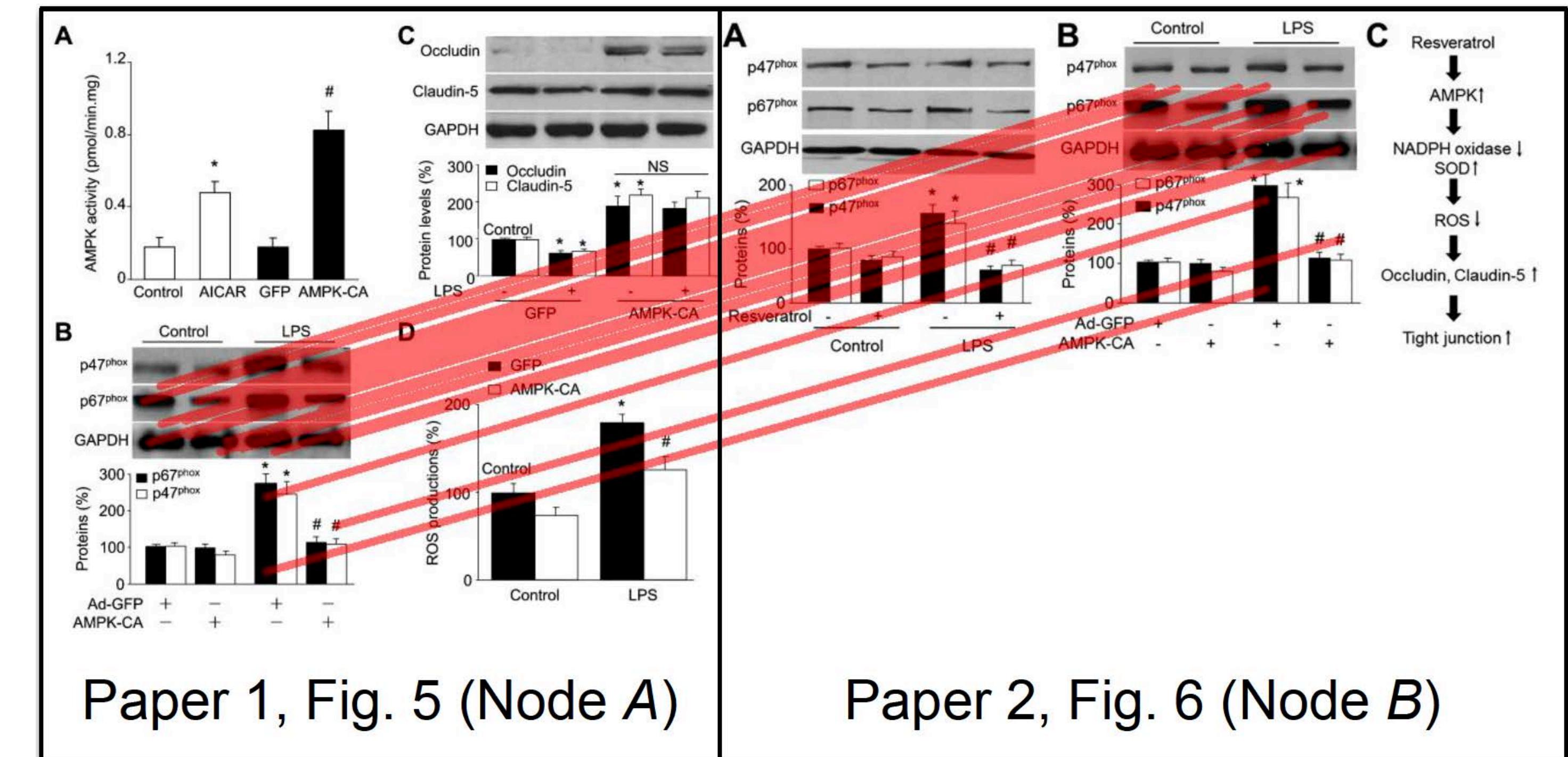
Ground truth

(according to retraction notice)



Our findings

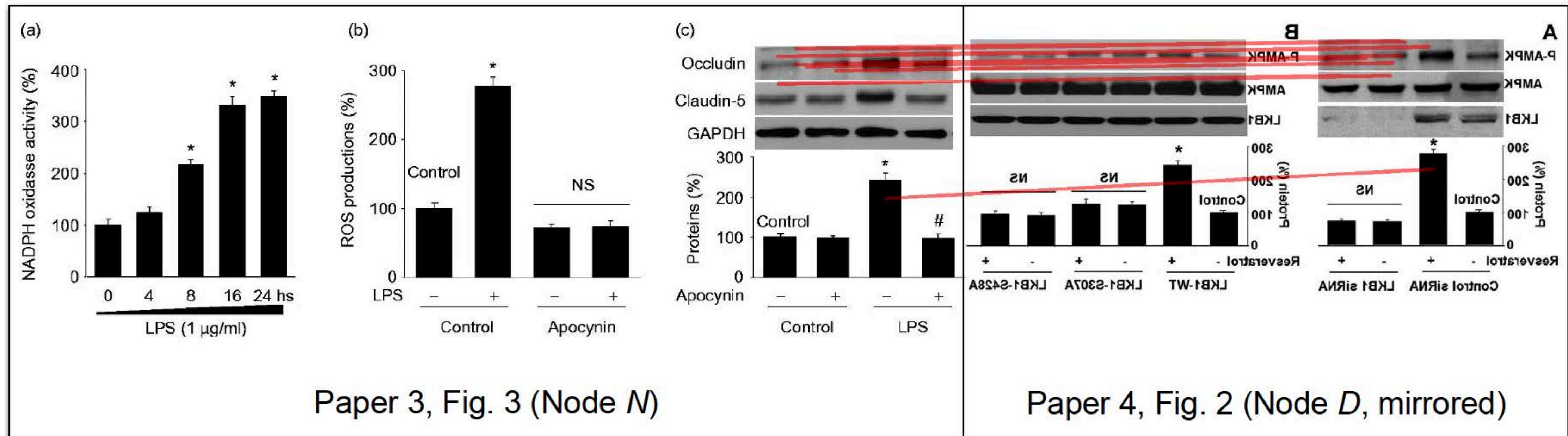
(in accordance with retraction notice)



Provenance Analysis

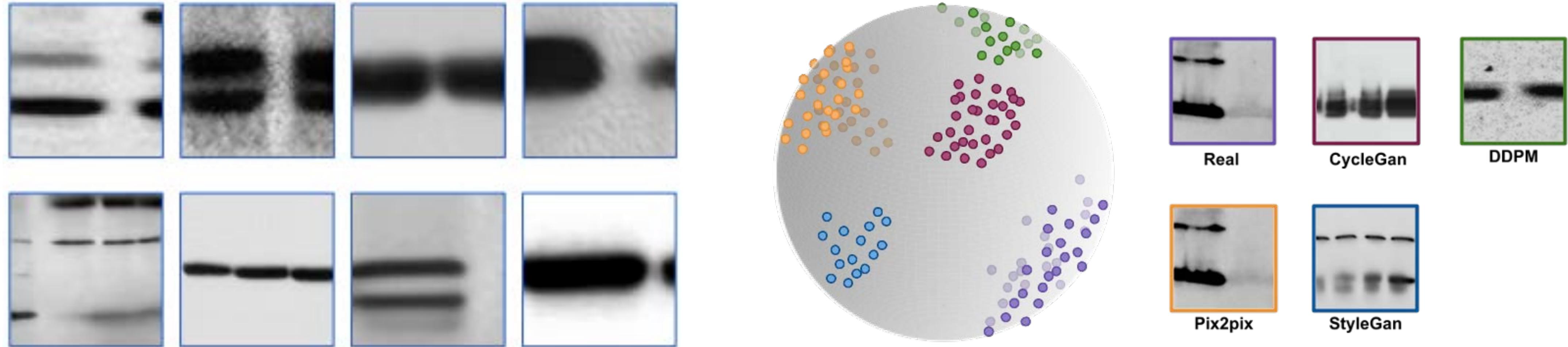
Our findings

(not reported in the retraction notice)



10.1371/journal.pone.0190562

Synthetic Image Detection



Mandelli et al.
Forensic Analysis of Synthetically Generated Western Blots
IEEE Access

Synthesis of Realistic Example Faces

<https://danielmoreira.github.io/project/srefv/>

Does this person
exist?



Yes
(original)



No
(nose and
mouth
replaced)

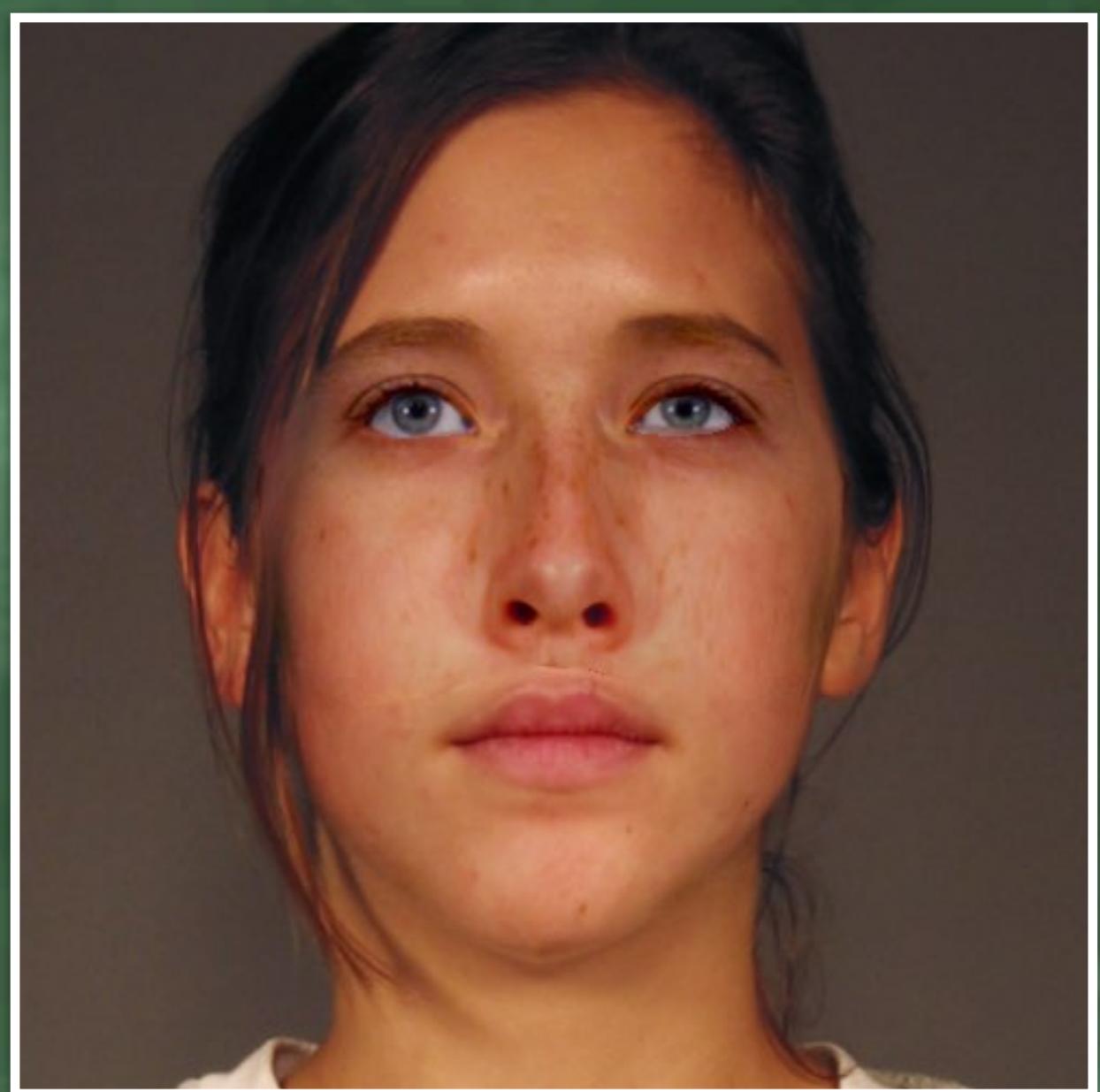
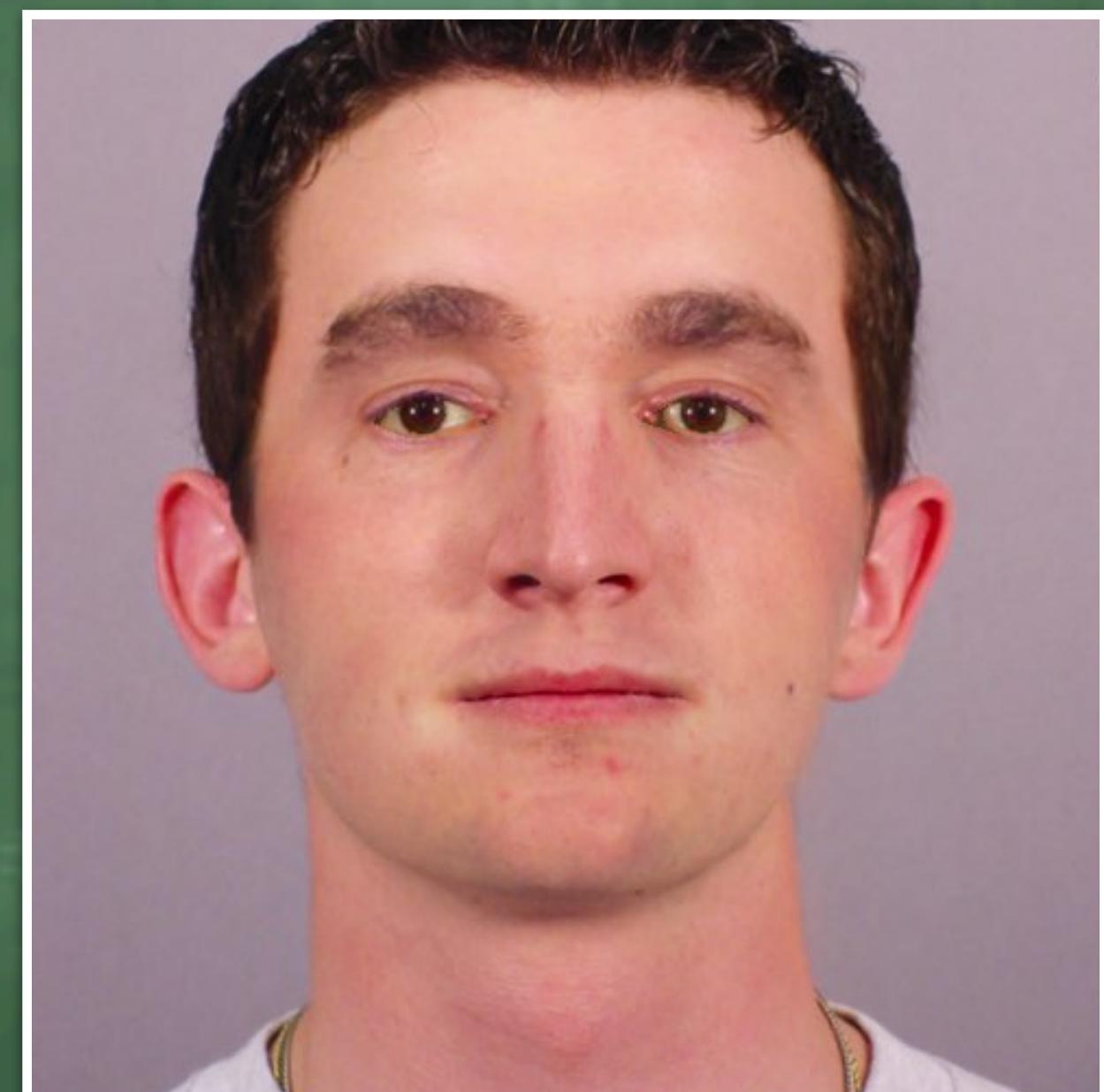


No
(eyes,
nose
and mouth
replaced)



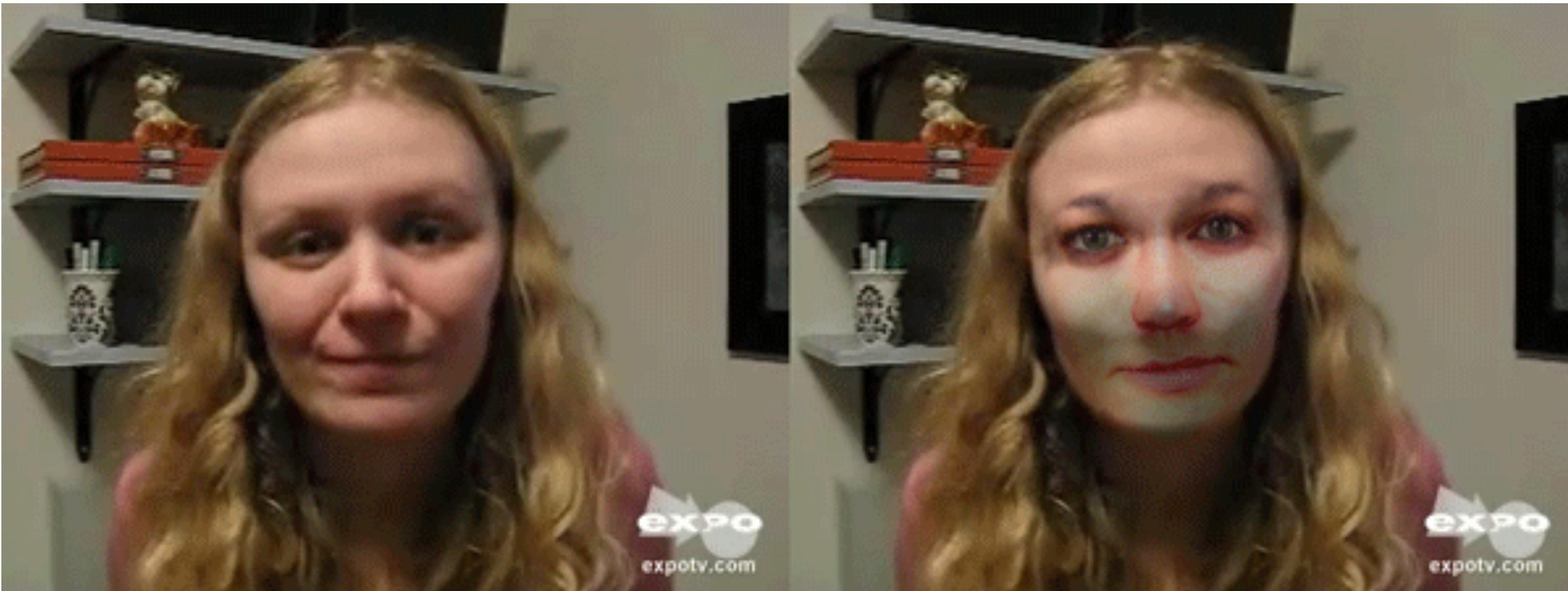
No
(eyes
replaced)





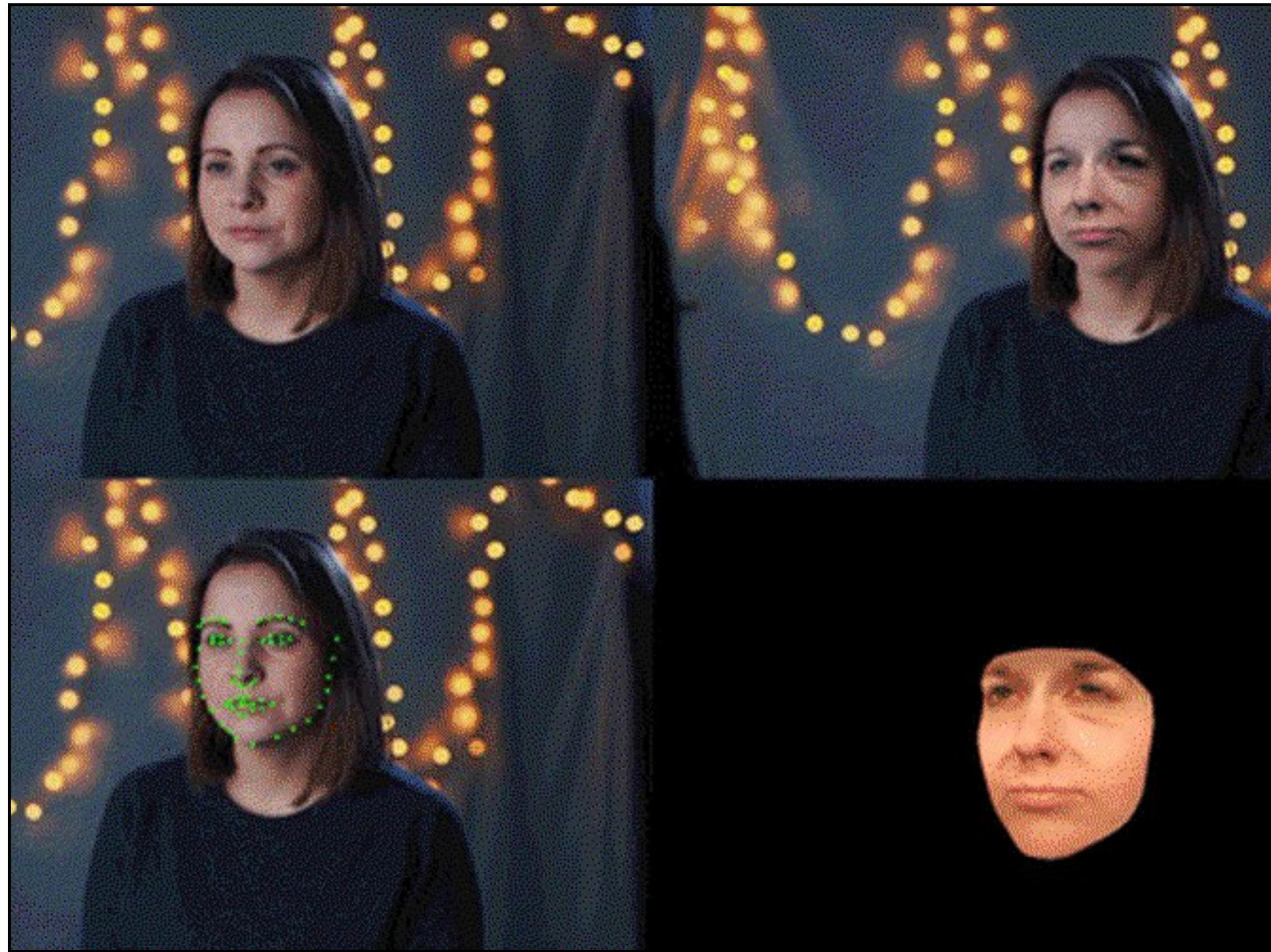
First Steps

Video Replacement



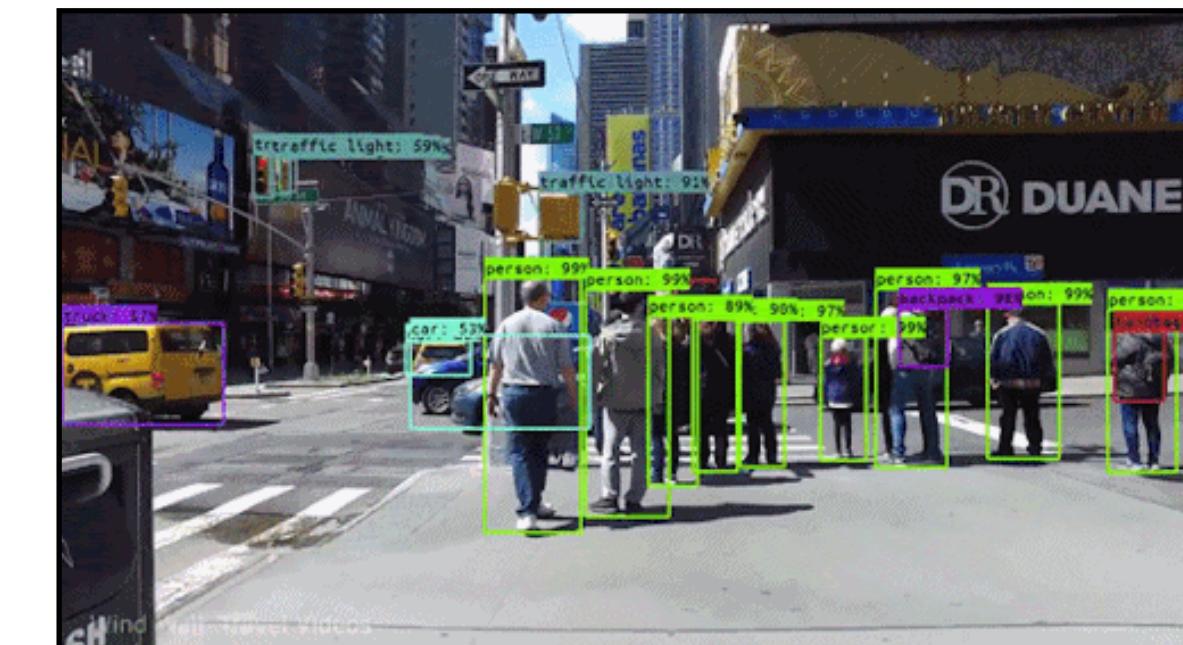
What's Next?

Synthetic Controlled Diversity



Controlled replacements of gender, age, and ethnicity, with synthetic identities (to ensure privacy).

Challenge: keep everything (e.g., emotions, sentiments, reactions) but identity.



Load irises

Load examination

Save examination

Save report

Quit program



Tool Supporting the Human Examination of Post-Mortem Iris Images

<https://danielmoreira.github.io/project/tshepii/>

The Problem

Interpretable Iris Recognition



How to convince people
who do not possess image
processing expertise?

Load irises

Load examination

Save examination

Save report

Quit program



Tool Supporting the Human Examination of Post-Mortem Iris Images

<https://danielmoreira.github.io/project/tshepii/>

The screenshot displays several functional panels:

- Human-Interpretable Features:** A section with three rows of checkboxes and counters for 'TSHEPII', 'SURF', and 'Crypts'. Each row includes a 'Show Matched' checkbox and a 'Show Unmatched' checkbox, followed by a counter table and a status message like 'out of 0'.
- Non-Human-Interpretable Features:** A section for 'Gabor Filters' with a threshold of 0.4461 and 'BSIF Filters' with a threshold of 0.4216.
- Manual Annotation:** A panel for 'Annotate...' with color-coded buttons for 'Matching Regions' (green) and 'Non-Matching Regions' (red). It also includes checkboxes for 'Show Matching Regions' and 'Show Non-Matching Regions'.
- Global match score:** A simple text field showing the value 0.4216.

How about you?

Background

What I know: computer scientists,
data scientists, software engineers.
8 graduate and 2 undergraduate students.

Can you code?

What is your preferred programming language?



How about you?

Expectations

Given your (future) career, what are your course expectations?



bit.ly/47SNMAC



How about you?

Accommodation Needs

Please reach out to me in private ASAP.
We'll make things work.



About the topic

Biometrics

What comes to your mind?



bit.ly/45sHVQA

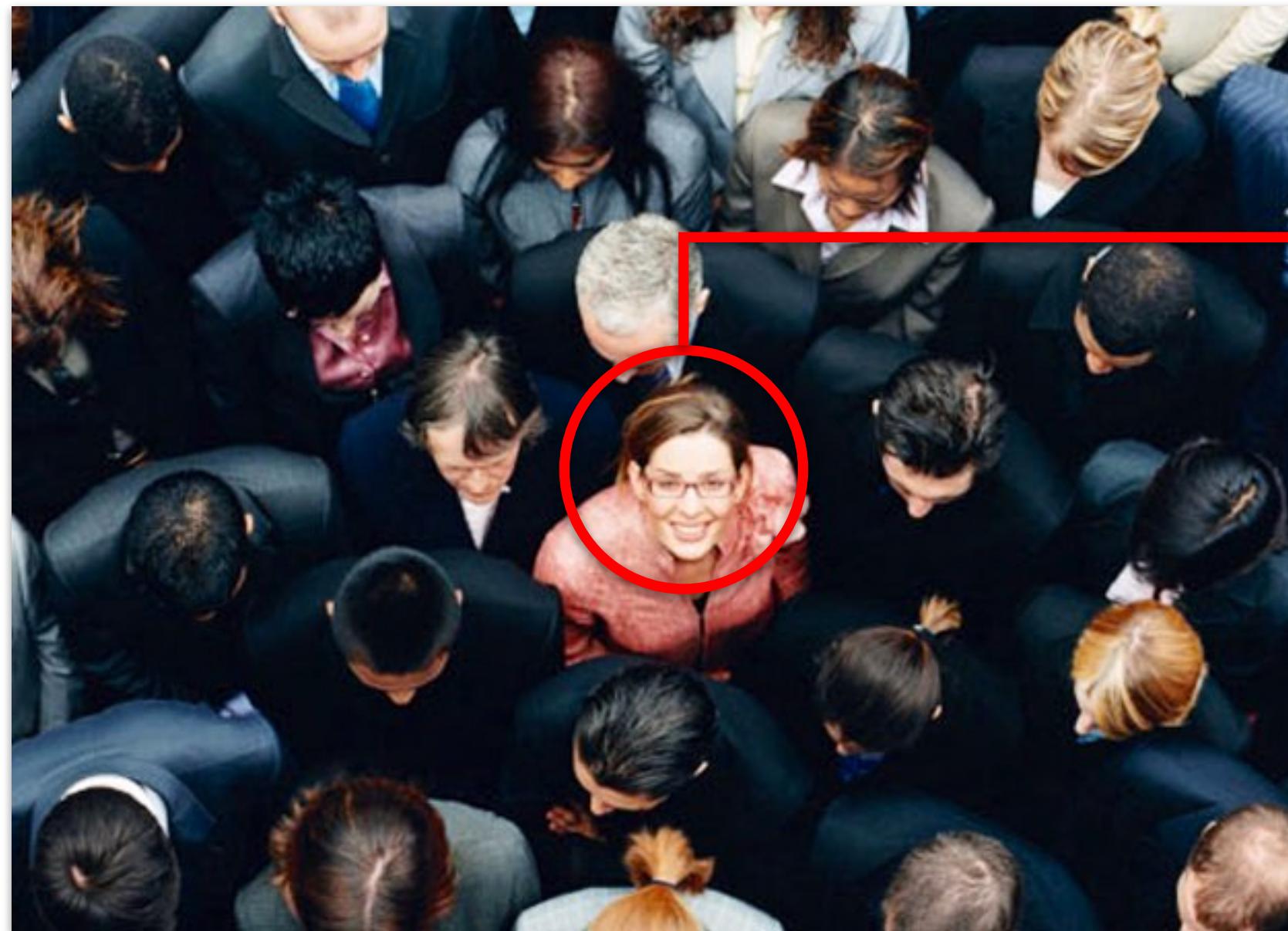


What is Biometrics?



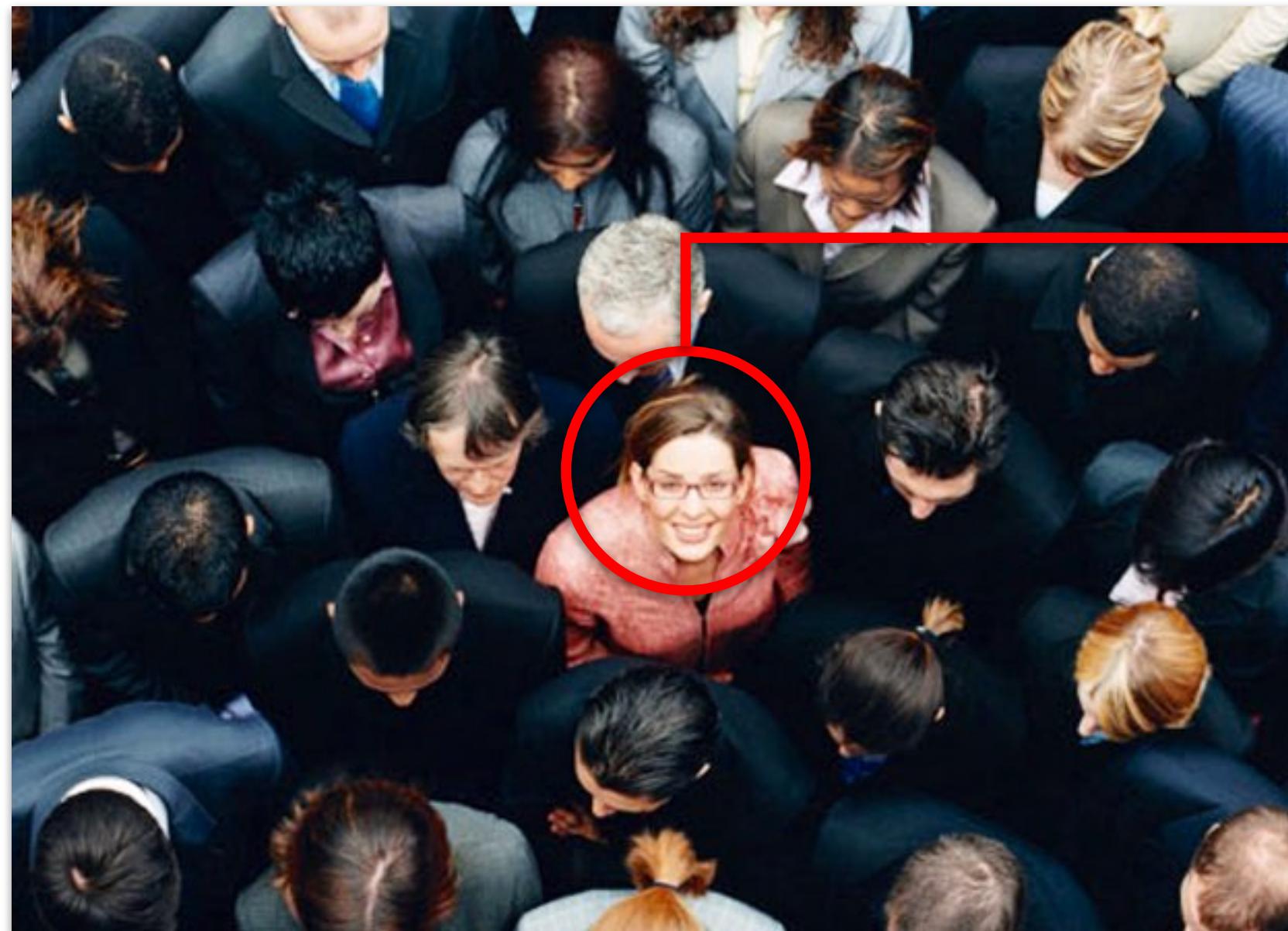
7 billion people
Who is this person?
Is this person Jane Doe?

What is Biometrics?



- **7 billion people**
Who is this person? (*Identification*)
Is this person Jane Doe? (*Verification*)

What is Biometrics?



- 7 billion people
 - Who is this person? (*Identification*)
 - Is this person Jane Doe? (*Verification*)

Biometrics aims at *identifying* or *verifying* the claimed identity of an individual based on their *physical*, *chemical* or *behavioral* traits.

What is Biometrics?



In this course, we aim at
computer-aided Biometrics.

We'll focus on **software solutions**
rather than hardware.

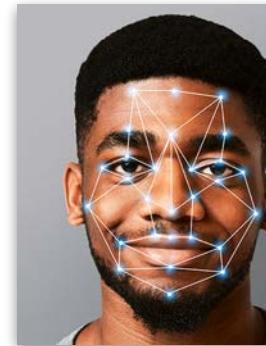
But we'll get to use some
devices, I promise.

What is Biometrics?

Identity verification through:



A unique trait
of yours.



physical



chemical



behavioral



Not something
you have.



Not something
you know.



Why use Biometrics?

Consumers prefer biometric authentication to traditional passwords, Visa says

⌚ Jan 6, 2020 | [Chris Burt](#)

CATEGORIES [Biometrics News](#) | [Financial Services](#)

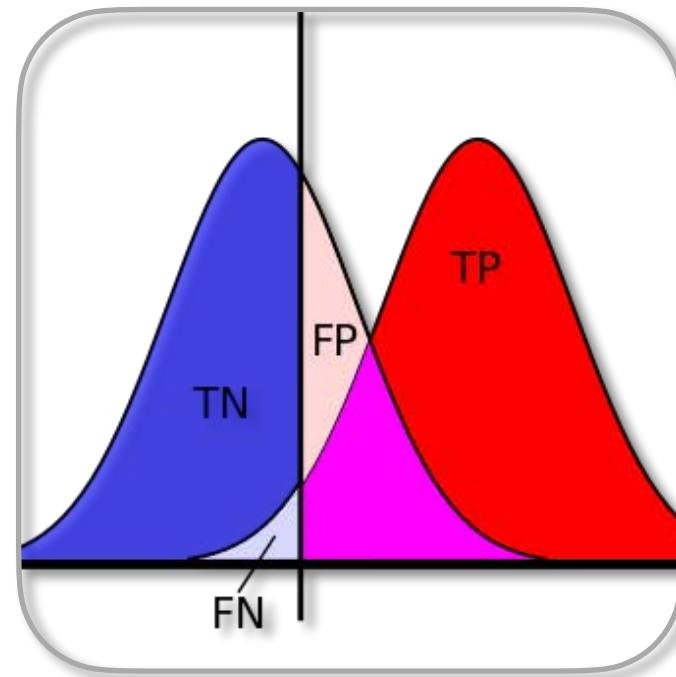


Almost 70 percent of U.S. shoppers did not go through with an online purchase because they either forgot the password, couldn't log in or couldn't receive a one-time passcode, according to research conducted by [Visa](#), while another report from Verizon found that as many as 80 percent of data breaches are caused by compromised and weak passwords.

<https://www.biometricupdate.com/202001/consumers-prefer-biometric-authentication-to-traditional-passwords-visa-says>

Course Overview

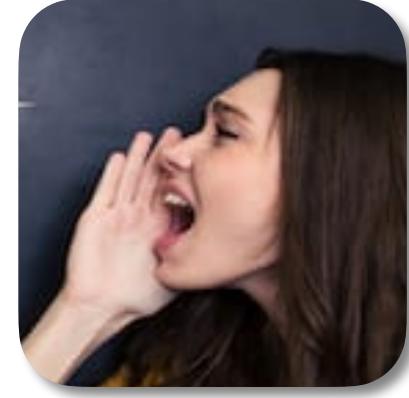
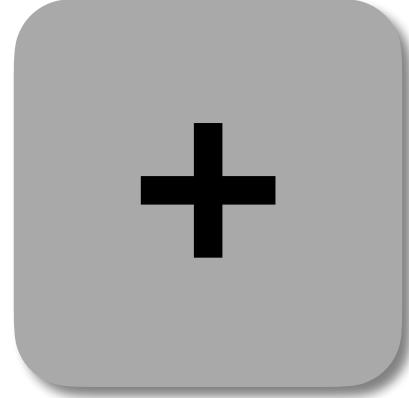
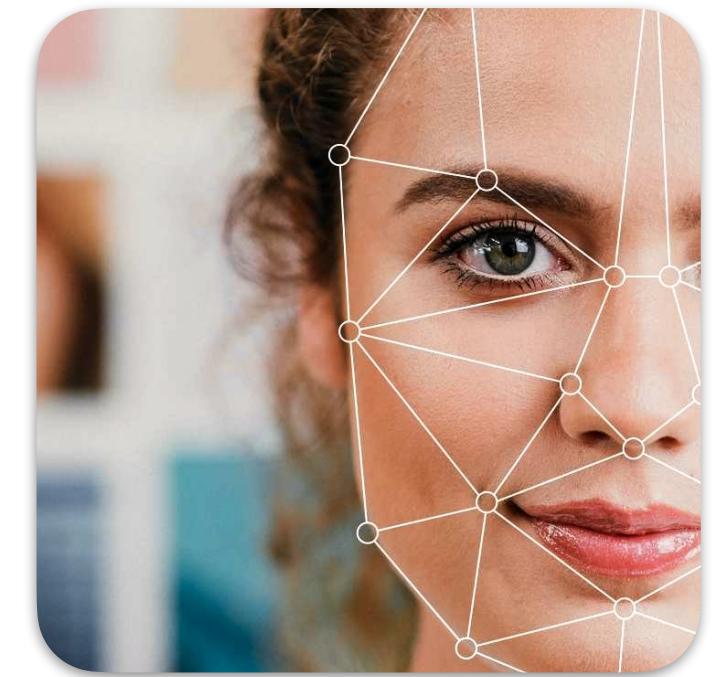
Content



Basics
Concepts
Metrics
Metric implementation



Core Traits (3)
Concepts
Baseline implementation
Data collection
Evaluation
Attacks
Assignments



Alternative Traits and Fusion Concepts



Invited Talks (2)
State of the art
Future work



LOYOLA
UNIVERSITY CHICAGO

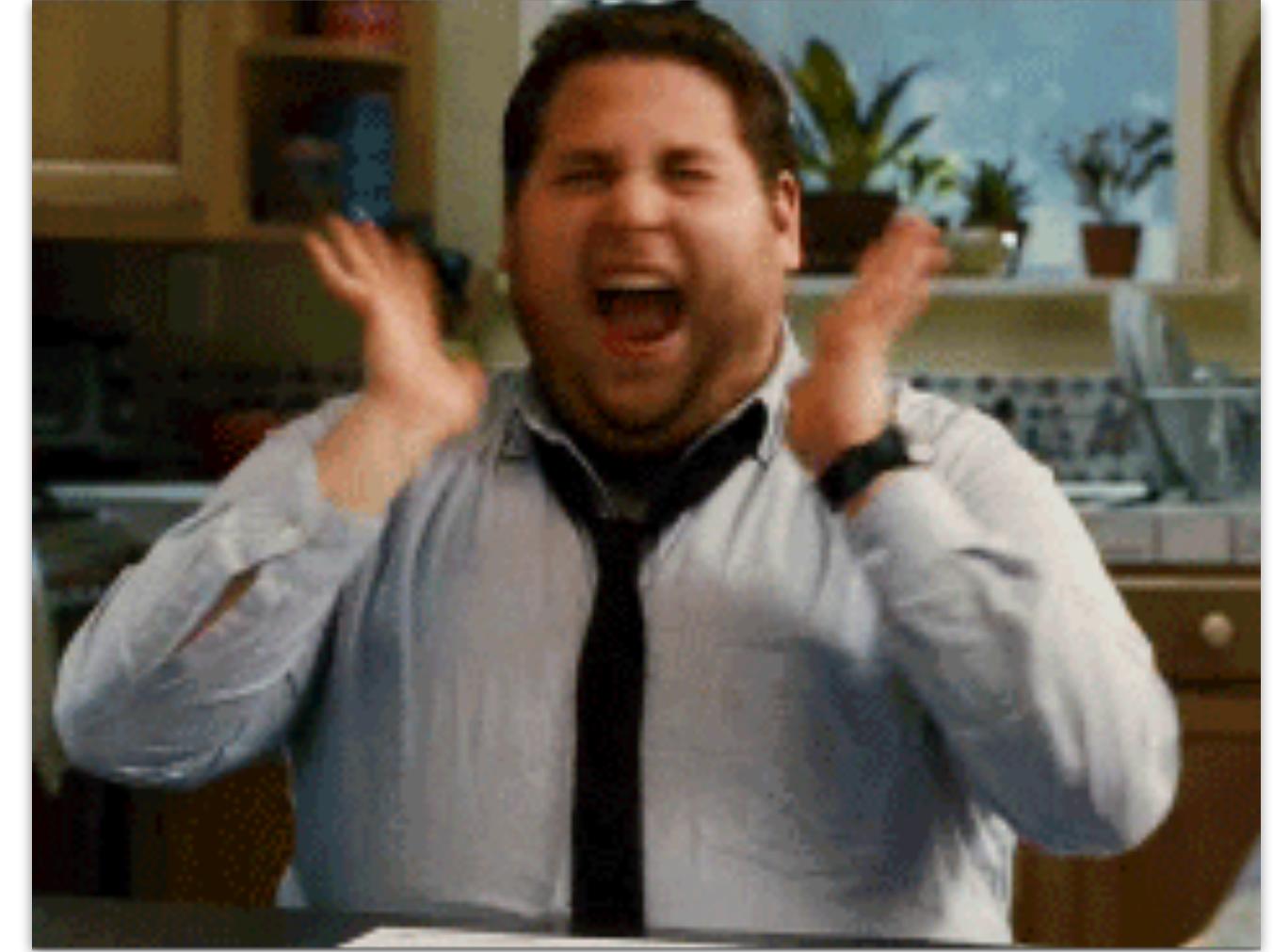
Course Overview

Structure

26 lectures

4 in-class coding days with data collection

2 invited talks



Workload

4 assignments

2 exams (midterm and final)

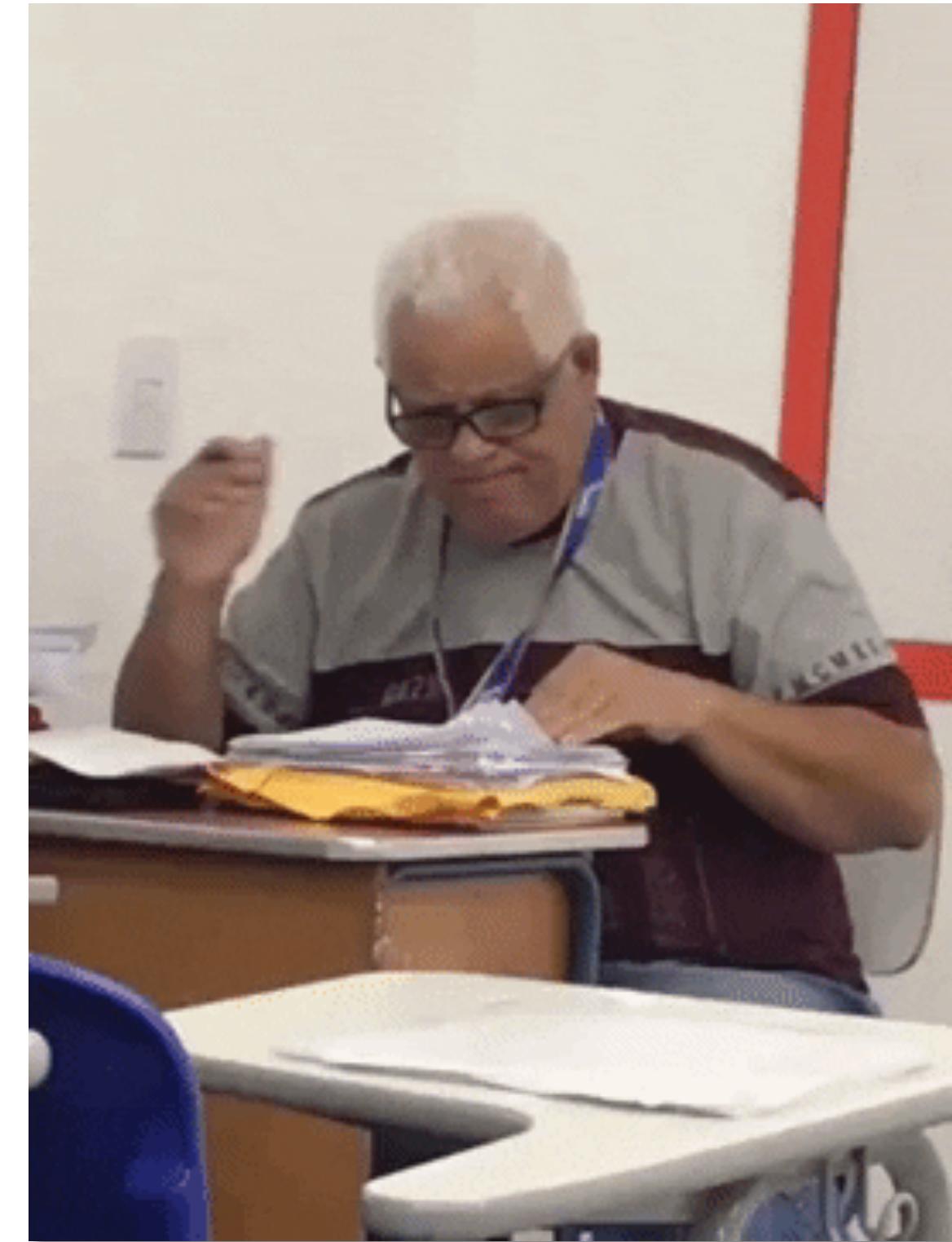
1 project with written report and presentation

Course Overview

Grading

| | Undergraduate | Graduate |
|-----------------|---------------|------------|
| Assignments (4) | 40% | 25% |
| Exams (2) | 50% | 40% |
| Project | 10% (extra) | 25% |
| Participation | 10% | 10% |
| On the News | 1% (extra) | 1% (extra) |

| | | | |
|-------------|-------------|-------------|-------------|
| A [96, 100) | B+ [88, 92) | C+ [76, 80) | D+ [64, 68) |
| A- [92, 96) | B [84, 88) | C [72, 76) | D [60, 64) |
| | B- [80, 84) | C- [68, 72) | F (0, 60) |



Code of Honor

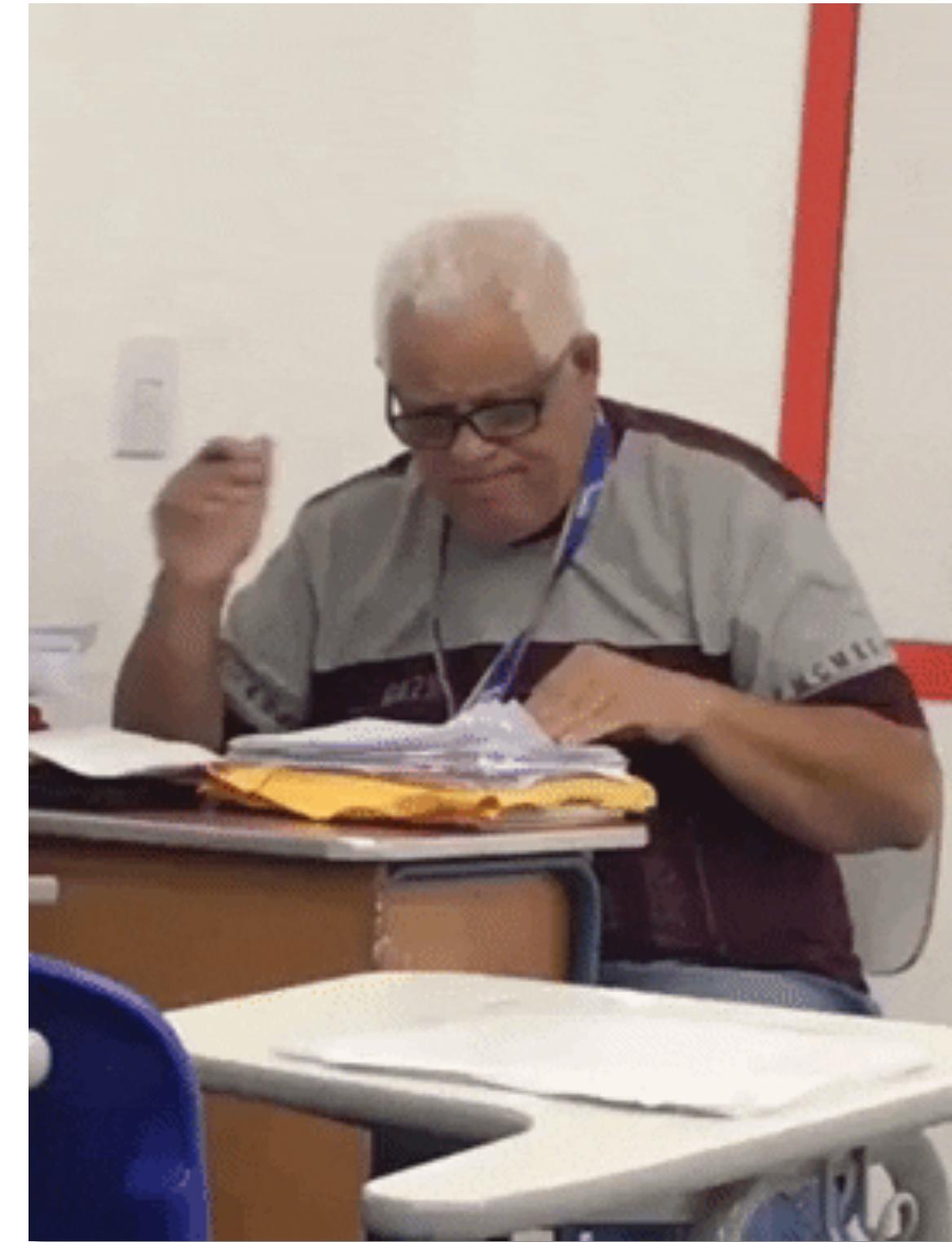
Please refer to <https://honorcode.nd.edu/>
Break it and get an F.

Course Overview

Grading

| | Undergraduate | Graduate |
|------------------------|---------------|------------|
| Assignments (4) | 40% | 25% |
| Exams (2) | 50% | 40% |
| Project | 10% (extra) | 25% |
| Participation | 10% | 10% |
| On the News | 1% (extra) | 1% (extra) |

| | | | |
|-------------|-------------|-------------|-------------|
| A [96, 100) | B+ [88, 92) | C+ [76, 80) | D+ [64, 68) |
| A- [92, 96) | B [84, 88) | C [72, 76) | D [60, 64) |
| | B- [80, 84) | C- [68, 72) | F (0, 60) |



Code of Honor

Please refer to <https://honorcode.nd.edu/>
Break it and get an F.

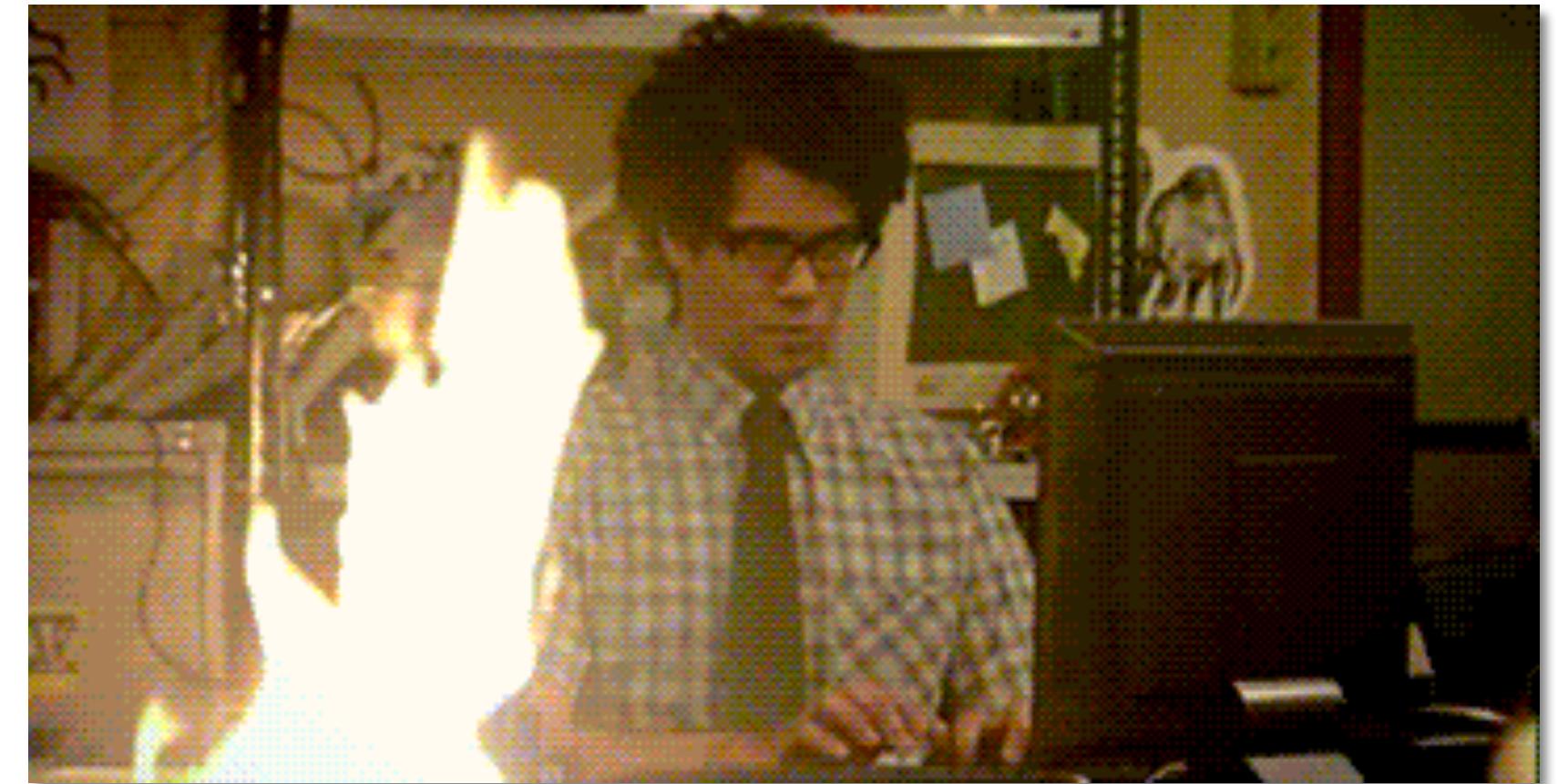
Course Overview

Assignments

Individual take-home activities

Submission through Sakai

Late policy: -10% of the maximum possible grade for each day of delay.



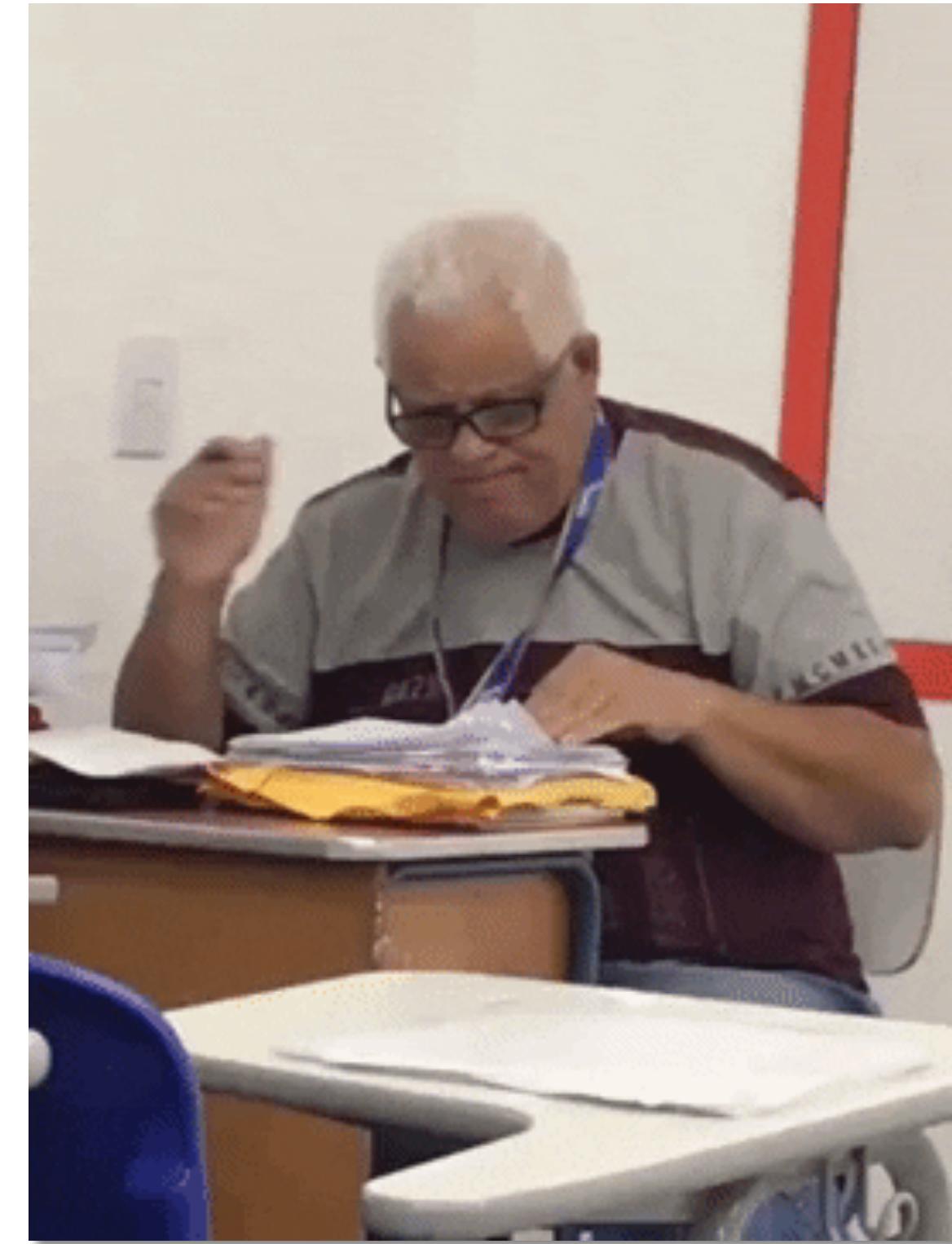
| Assignment 1 | Assignment 2 | Assignment 3 | Assignment 4 |
|-------------------|-------------------------|------------------|------------------|
| Metric Collection | Fingerprint Recognition | Face Recognition | Iris Recognition |

Course Overview

Grading

| | Undergraduate | Graduate |
|------------------|---------------|------------|
| Assignments (4) | 40% | 25% |
| Exams (2) | 50% | 40% |
| Project | 10% (extra) | 25% |
| Participation | 10% | 10% |
| On the News | 1% (extra) | 1% (extra) |

| | | | |
|-------------|-------------|-------------|-------------|
| A [96, 100) | B+ [88, 92) | C+ [76, 80) | D+ [64, 68) |
| A- [92, 96) | B [84, 88) | C [72, 76) | D [60, 64) |
| | B- [80, 84) | C- [68, 72) | F (0, 60) |



Code of Honor

Please refer to <https://honorcode.nd.edu/>
Break it and get an F.

Course Overview

Exams

10/04: in-class written midterm

12/11-16: in-class written final



Course Overview

Exams

Style example.

[Question 1] (2 points)

Suppose you were hired by a bank company to coordinate the deployment of an access management system to control the entrance of authorized people into the many vaults spread among different branches. The bank directors have heard about Biometrics but are not certain about the benefits of using it. They think using simple access cards and long passwords is as effective and much cheaper than using a biometric system. If it is your duty to change their mind, **what would you say to convince them?**

Using biometrics would be a much safer system, since it uses a physical or chemical trait, rather than something that can be stolen as easily as an access card. A password could also be given to somebody else or brute-force searched to produce attacks. Furthermore, it would be more convenient for the authorized people, as forgetting a long password or losing an access card would not be a problem. (Biometrics uses a trait you always have on you). Also, problems like typos, and card damages are more likely to happen than losing a fingerprint, iris, or face.



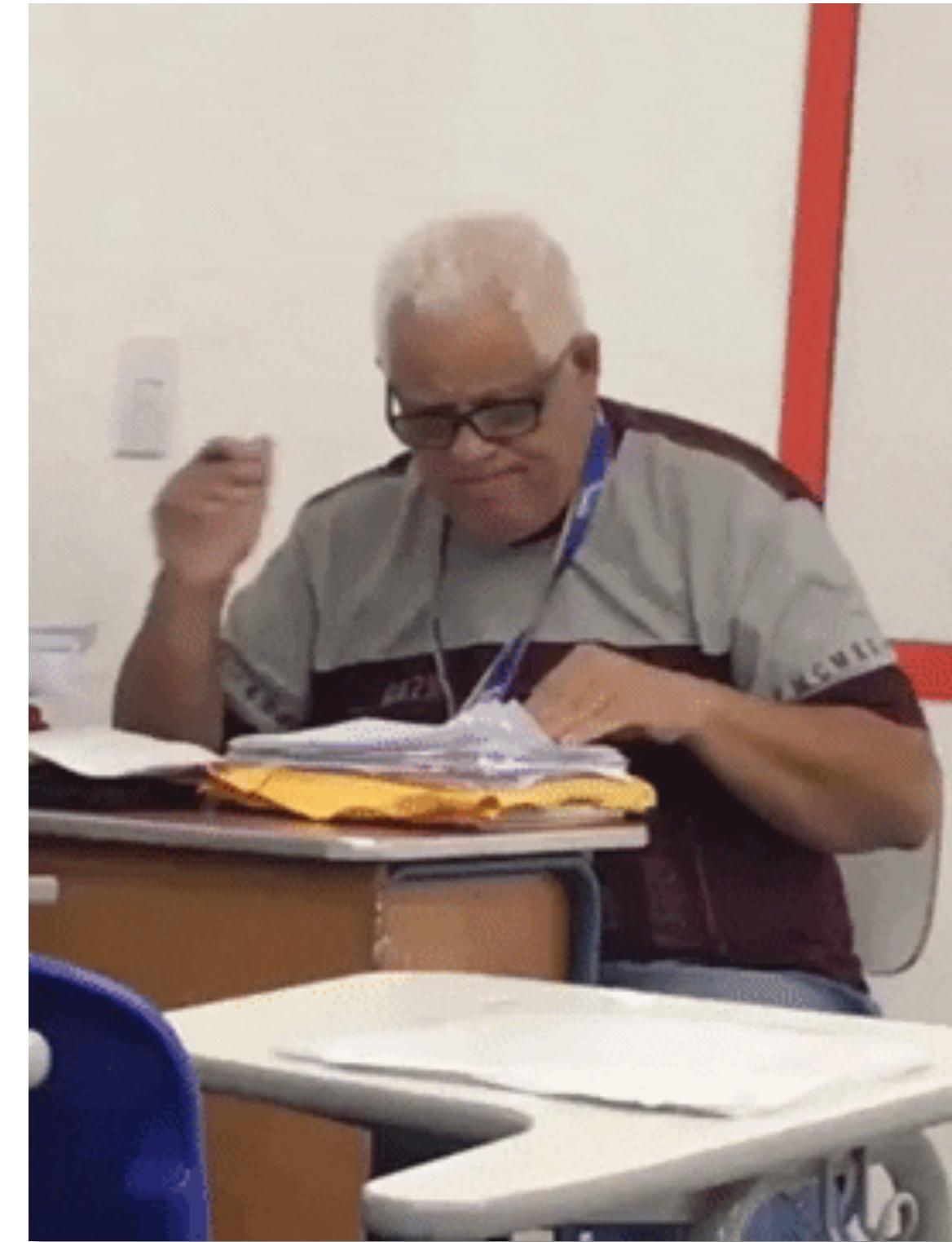
LOYOLA
UNIVERSITY CHICAGO

Course Overview

Grading

| | Undergraduate | Graduate |
|-----------------|---------------|------------|
| Assignments (4) | 40% | 25% |
| Exams (2) | 50% | 40% |
| Project | 10% (extra) | 25% |
| Participation | 10% | 10% |
| On the News | 1% (extra) | 1% (extra) |

| | | | |
|-------------|-------------|-------------|-------------|
| A [96, 100) | B+ [88, 92) | C+ [76, 80) | D+ [64, 68) |
| A- [92, 96) | B [84, 88) | C [72, 76) | D [60, 64) |
| | B- [80, 84) | C- [68, 72) | F (0, 60) |



Code of Honor

Please refer to <https://honorcode.nd.edu/>
Break it and get an F.

Course Overview

Project

Work alone or in pairs.
Provide a written report and
perform a presentation.

Optional to undergraduate students
(it will grant extra points).



Course Overview

Project

Possible Topics

Presentation attack
(performance, detection, and mitigation)
of fingerprint, face, or iris recognition.

Implementation of recognition of traits
other than fingerprints, face, and iris.

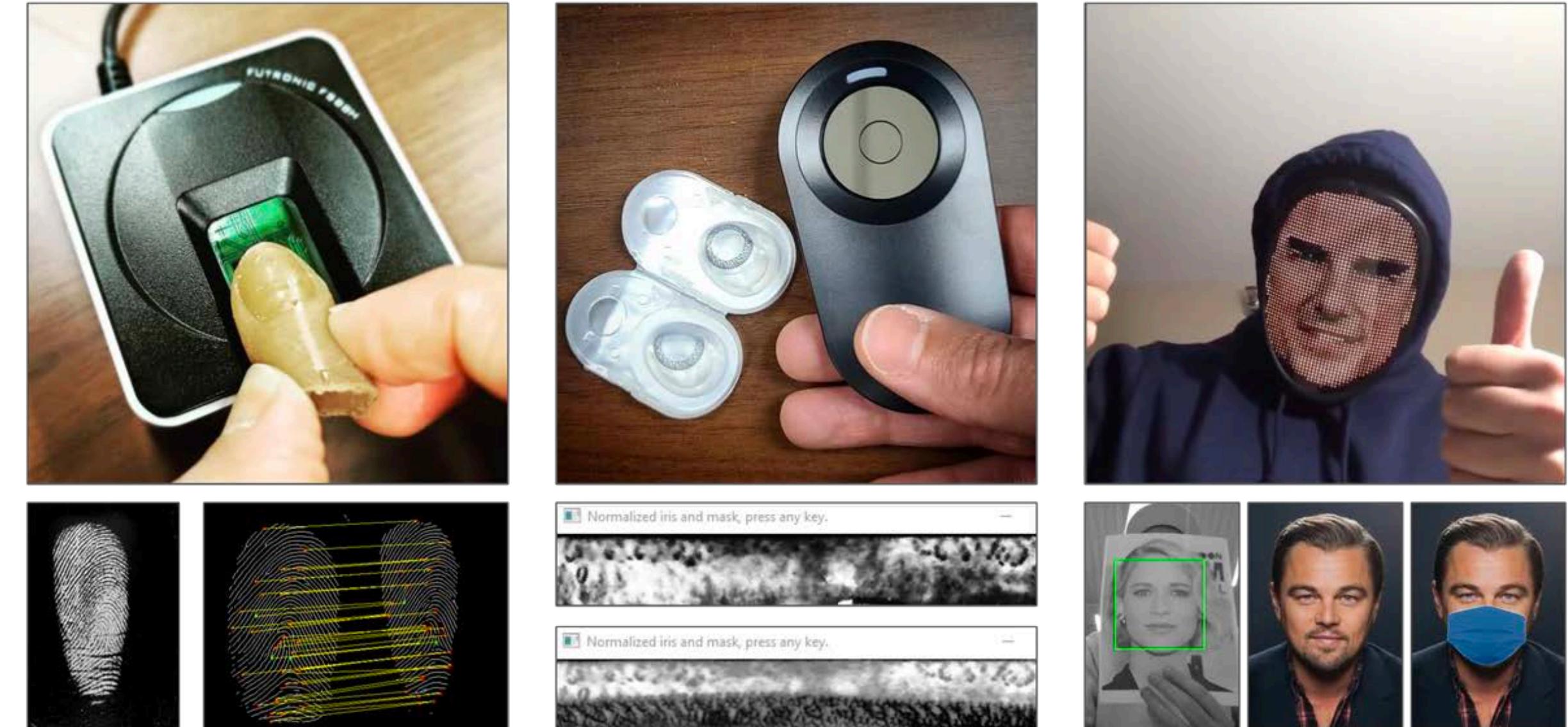


Course Overview

Project

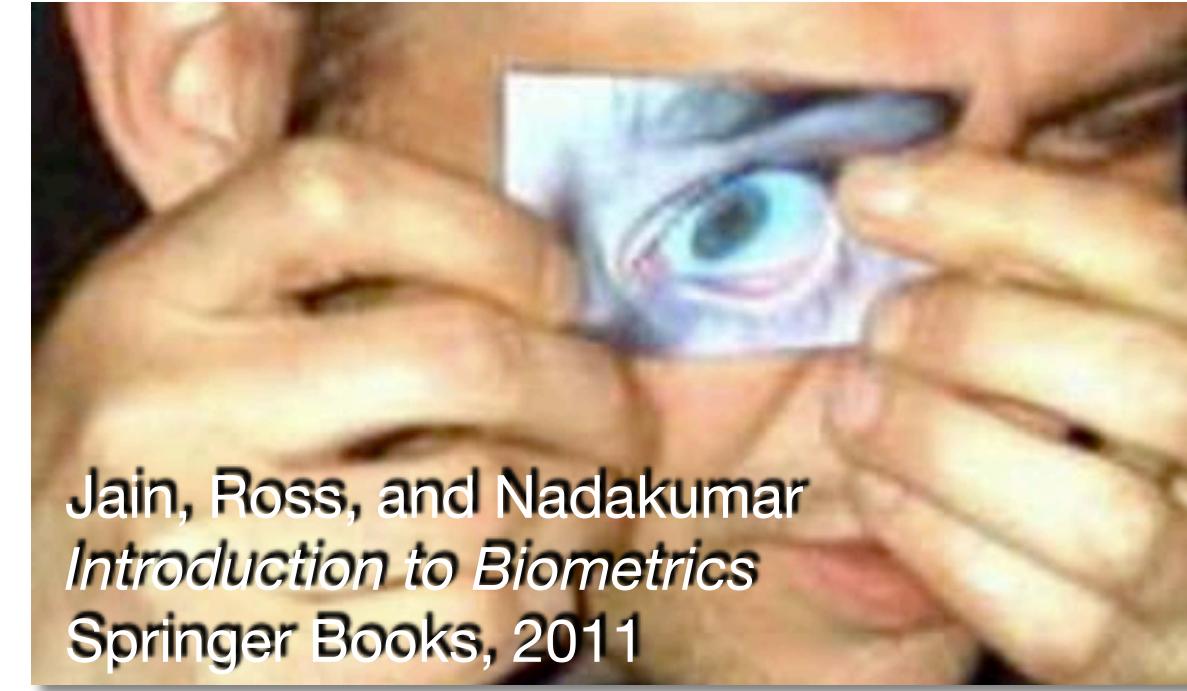
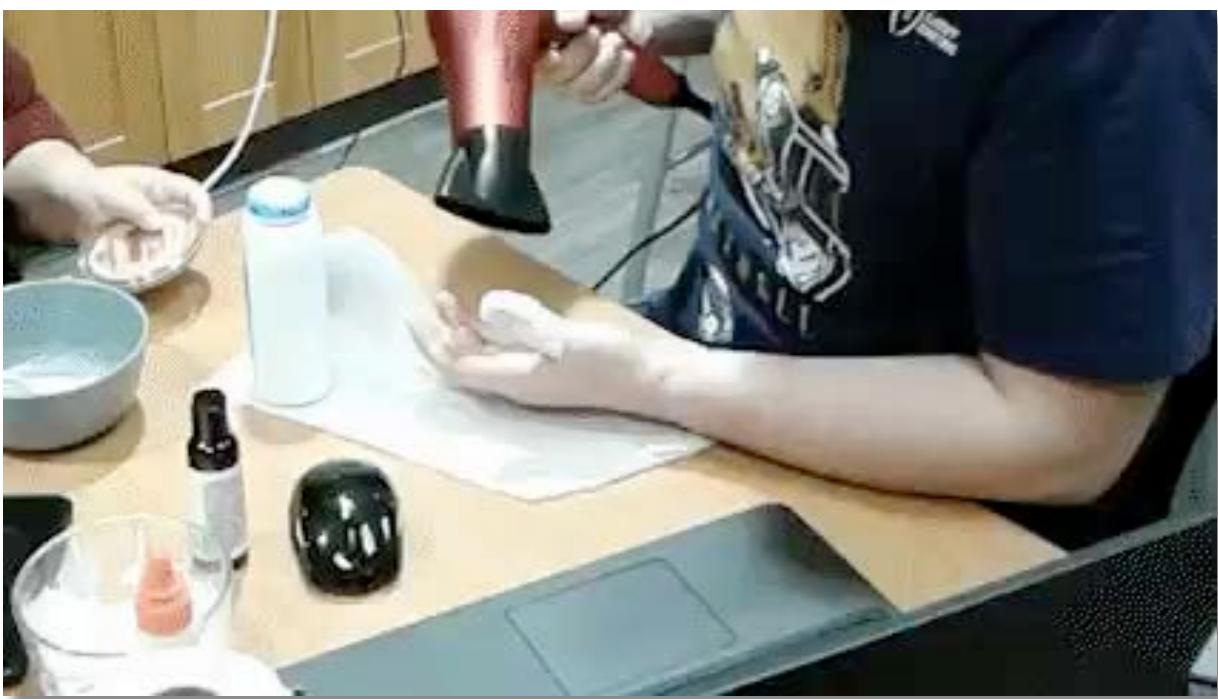
Possible Topics (*continued*)

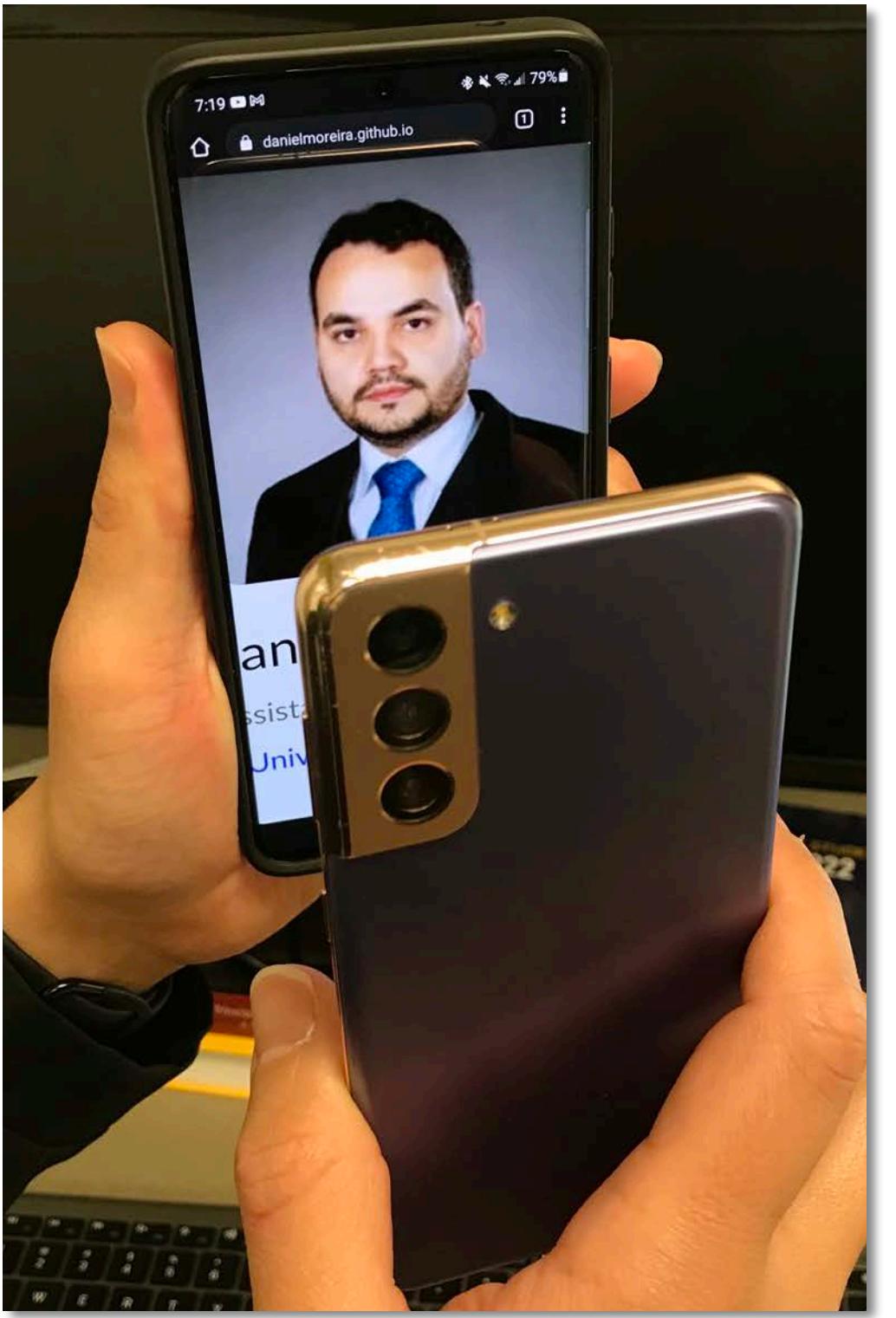
Implementation of a complete class attendance system.



Presentation and implementation of state-of-the-art scientific publications.

Discussion about the ethical aspects of Biometrics and surveillance.





[https://www.youtube.com/
watch?v=Z4nc6OYY3no](https://www.youtube.com/watch?v=Z4nc6OYY3no)



[https://www.youtube.com/
watch?v=fFe1D6p3RQg](https://www.youtube.com/watch?v=fFe1D6p3RQg)



LOYOLA
UNIVERSITY CHICAGO

Course Overview

Grading

| | Undergraduate | Graduate |
|----------------------|---------------|------------|
| Assignments (4) | 40% | 25% |
| Exams (2) | 50% | 40% |
| Project | 10% (extra) | 25% |
| Participation | 10% | 10% |
| On the News | 1% (extra) | 1% (extra) |

| | | | |
|-------------|-------------|-------------|-------------|
| A [96, 100) | B+ [88, 92) | C+ [76, 80) | D+ [64, 68) |
| A- [92, 96) | B [84, 88) | C [72, 76) | D [60, 64) |
| | B- [80, 84) | C- [68, 72) | F (0, 60) |



Code of Honor

Please refer to <https://honorcode.nd.edu/>
Break it and get an F.

Course Overview

Participation

Class Attendance

Every presence counts.

It is possible to get extra points based on interest and proactivity.



Today's attendance

Please fill out the form

bit.ly/3QWTV8P



Course Overview

Participation

***Today-I-missed* Statements**

Submit **on Sakai** after every class.

Answer one of

What is your biggest question after class?

or

What was the most interesting point you learned today?

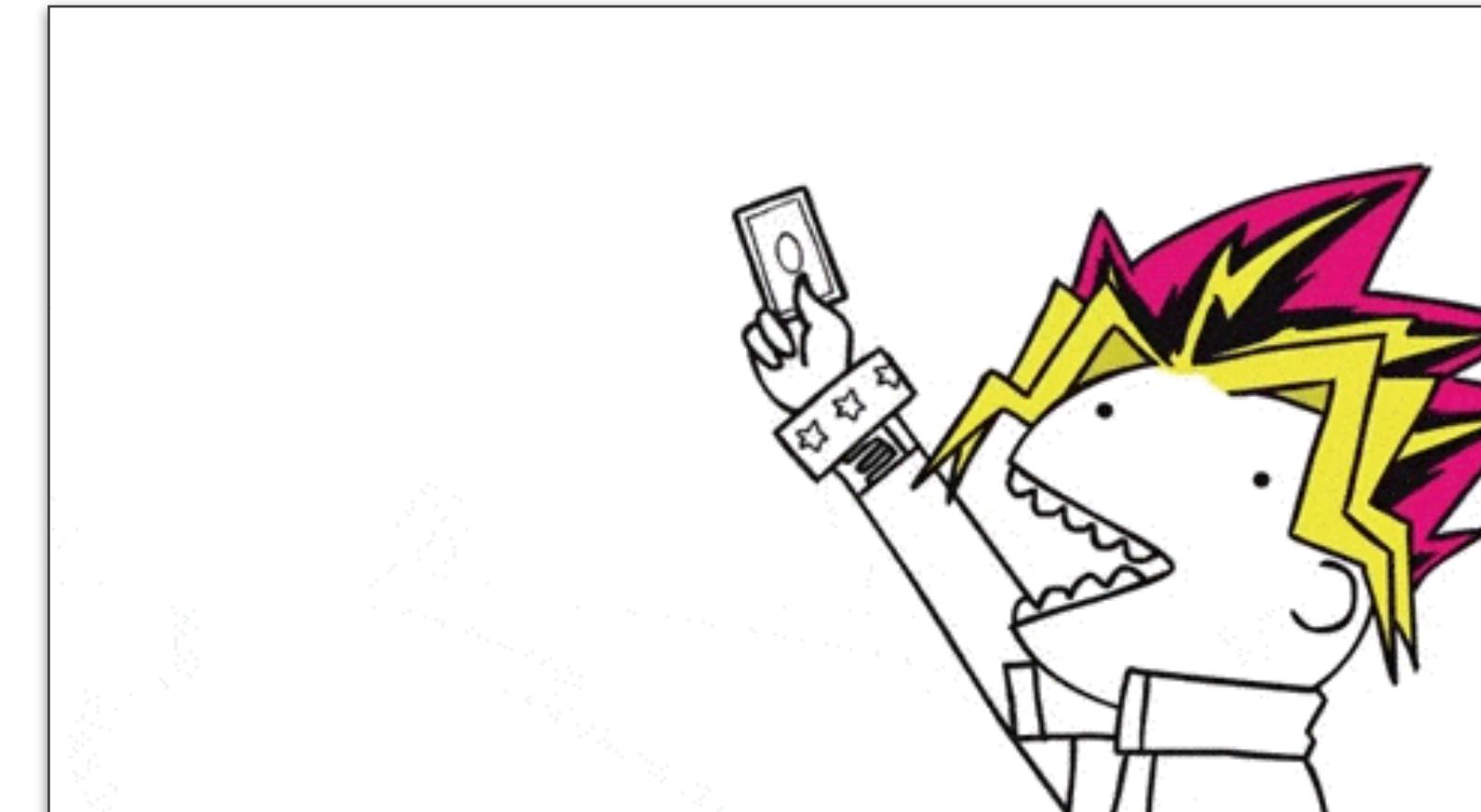


Course Overview

Participation

Oopsie Cards

Life happens, each student has 3 OCs.



Avoid losing points because of class absence and lack of *Today-I-missed* Statement submissions.

OCs may also excuse late-delivered assignments.

Course Overview

Grading

| | Undergraduate | Graduate |
|--------------------|---------------|------------|
| Assignments (4) | 40% | 25% |
| Exams (2) | 50% | 40% |
| Project | 10% (extra) | 25% |
| Participation | 10% | 10% |
| On the News | 1% (extra) | 1% (extra) |

| | | | |
|-------------|-------------|-------------|-------------|
| A [96, 100) | B+ [88, 92) | C+ [76, 80) | D+ [64, 68) |
| A- [92, 96) | B [84, 88) | C [72, 76) | D [60, 64) |
| | B- [80, 84) | C- [68, 72) | F (0, 60) |



Code of Honor

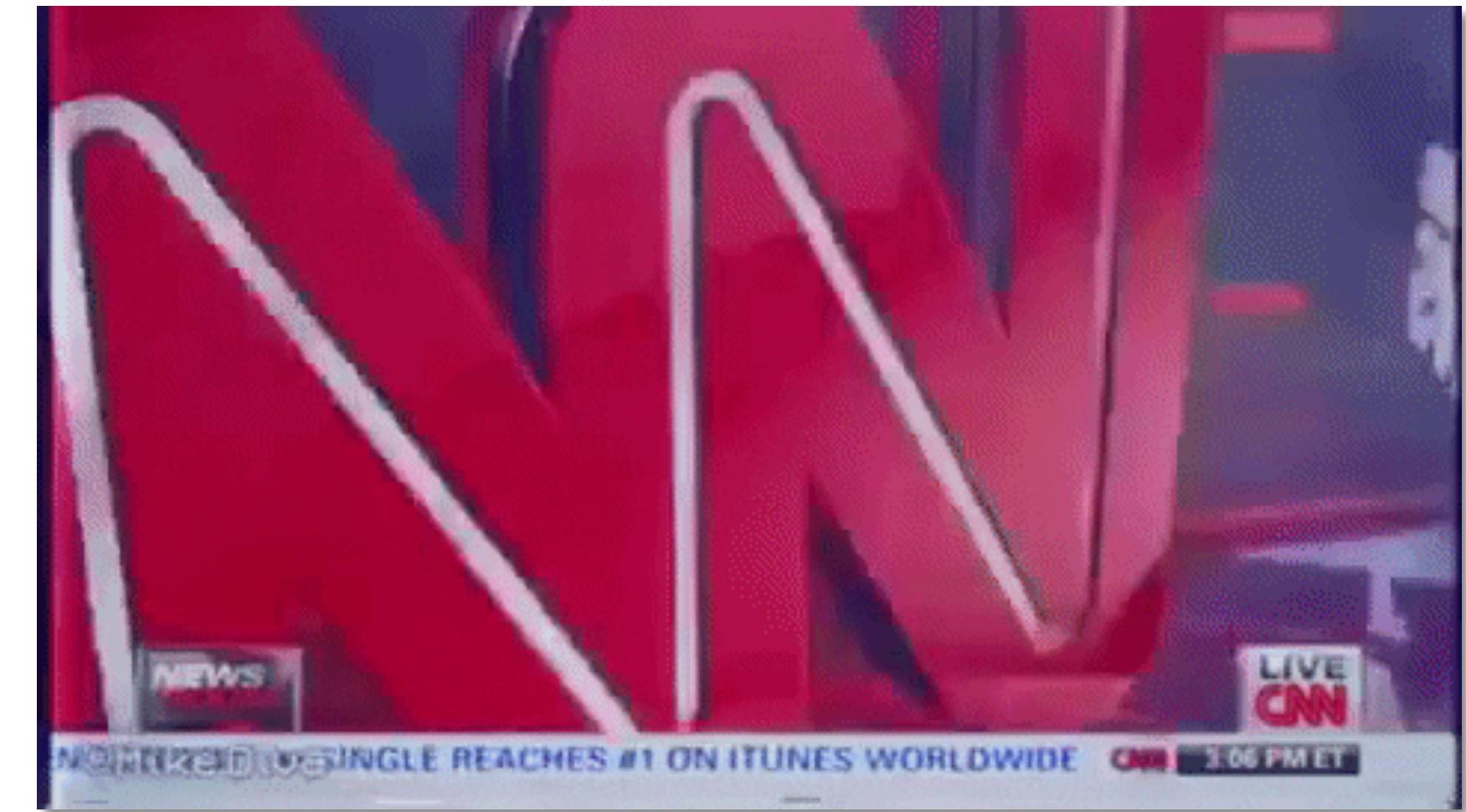
Please refer to <https://honorcode.nd.edu/>
Break it and get an F.

Course Overview

Biometrics on the News

Share with us any news you find that are related to Biometrics.

Get extra points for doing that.



Course Overview

Prerequisites

Essential

Programming, basic prob & stats,
and data structures



Desired

Python, numpy, OpenCV

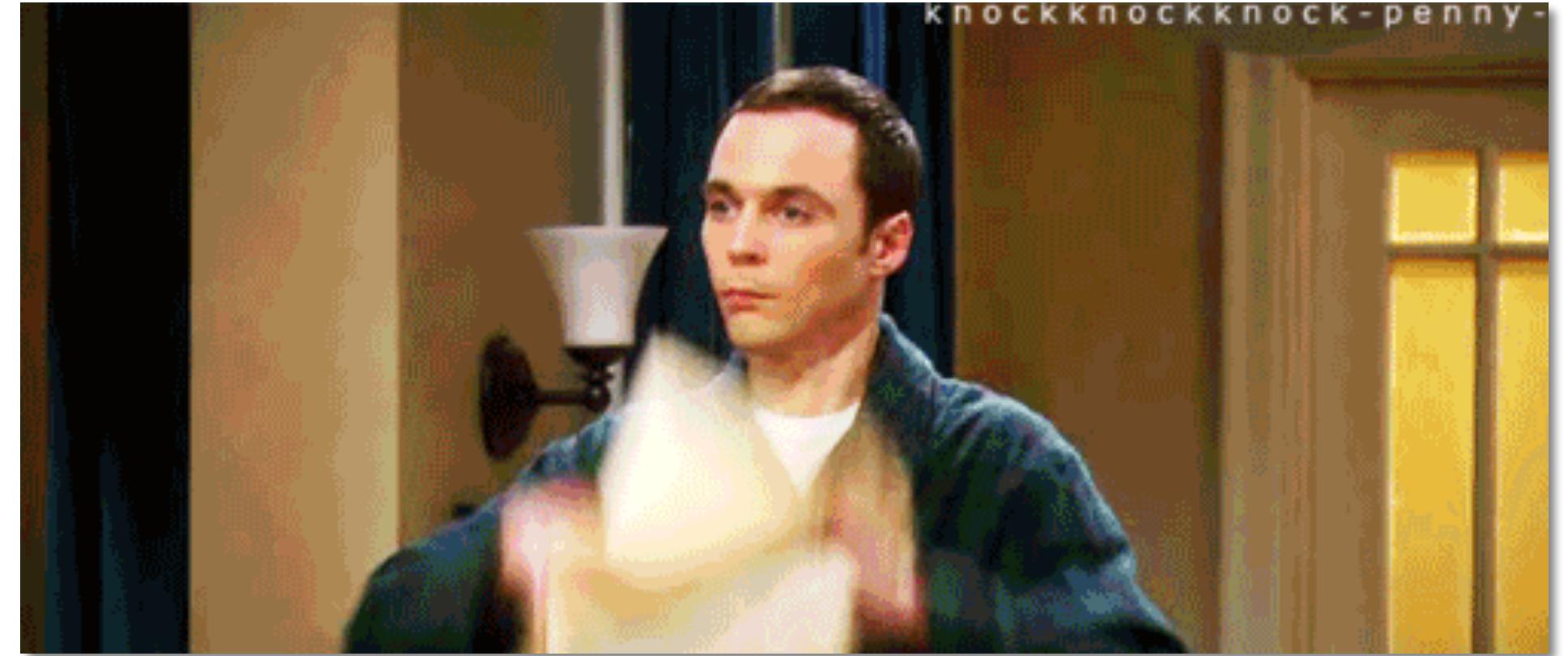
Not sure?

Please talk to me in private.

Course Overview

Bibliography

Jain, Ross, and Nandakumar
Introduction to Biometrics
Springer Books, 2011



Jain, Flynn, and Ross
Handbook of Biometrics
Springer Books, 2008

Course Overview

Data Collection

We'll collect only **our own biometric data** (instructor's and students').

Our data **will only be used** for the purpose of the course.

Our data **will not be shared** with anybody outside the course.

Our data **will be deleted** after the course.



During assignments, folks in need of other publicly available biometric databases are welcome to contact me, so we can take care of privacy and copyright issues.

Course Overview

Google Colab, Python, and Jupyter

<https://colab.research.google.com/>

You'll need a google account

Select “New Notebook” on the
bottom right of the form.

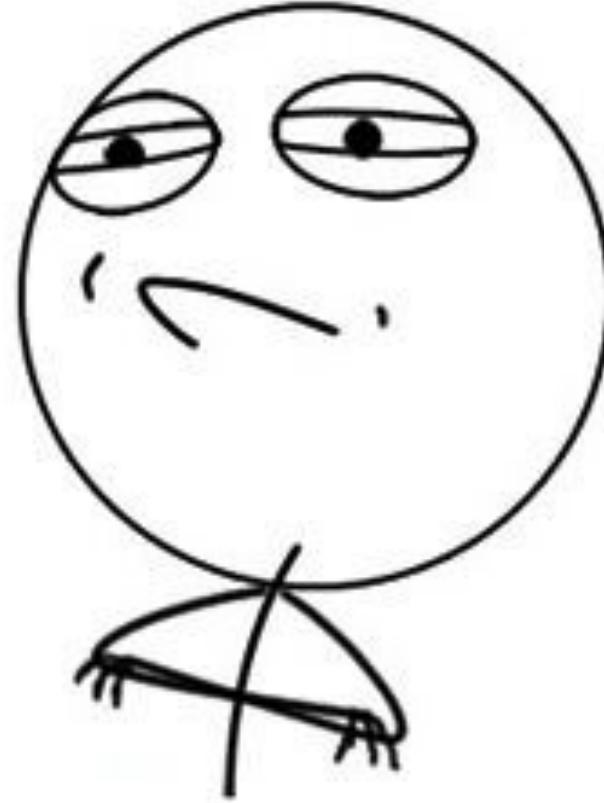
Do your first “Hello World!”



Your next tasks

Relax

Any issues? Please come and talk to me.



Sakai is up!

Please visit it as soon as possible.

Important announcements will be made there.



Start filling out your *Today-I-missed* Statement

Please visit <https://sakai.luc.edu/x/PnQvIG>.



LOYOLA
UNIVERSITY CHICAGO