

# Face Recognition I

CSE 40537/60537 Biometrics

**Daniel Moreira**  
Spring 2022

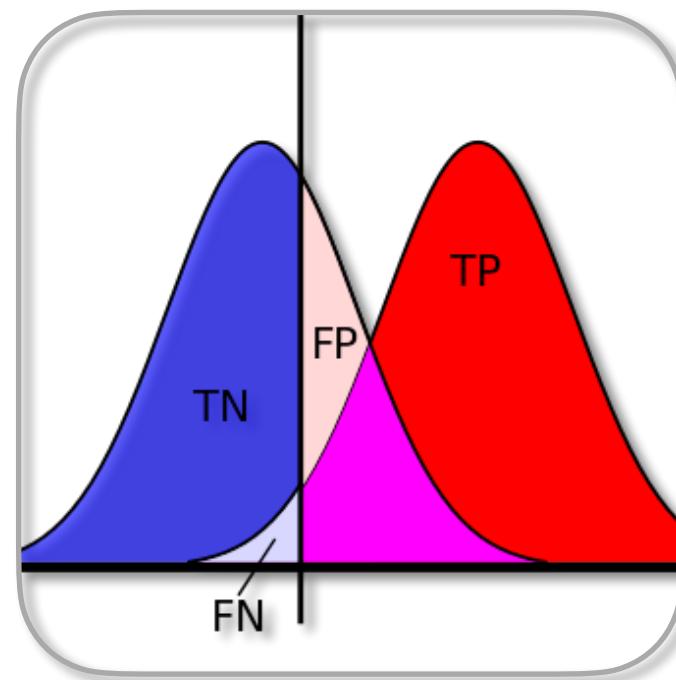


# Today you will...

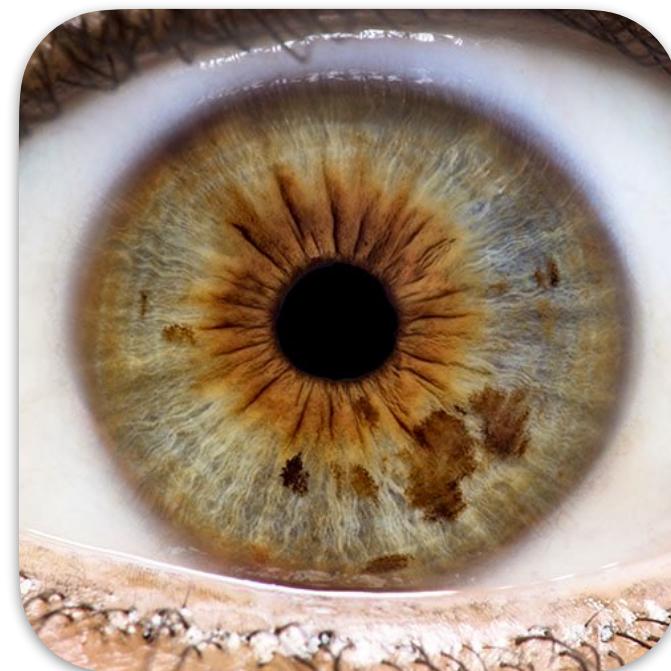
*Get to know*  
Reasons to use faces for recognition.  
How faces compare to fingerprints and irises.

# Course Overview

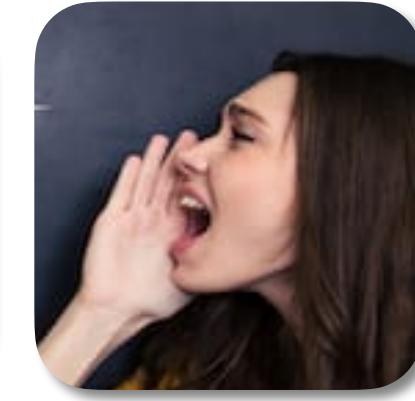
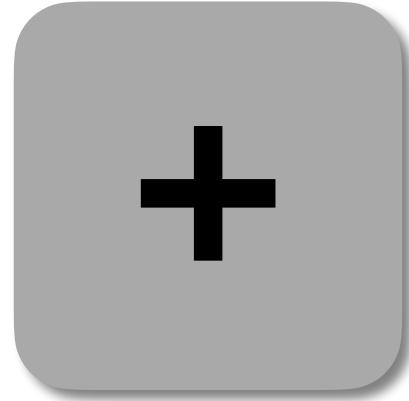
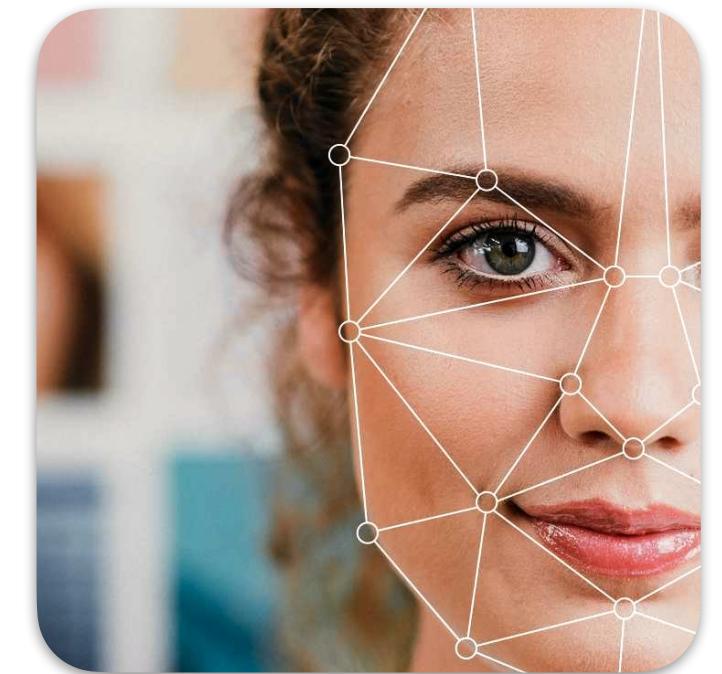
## Content



**Basics**  
Concepts  
Metrics  
Metric implementation



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



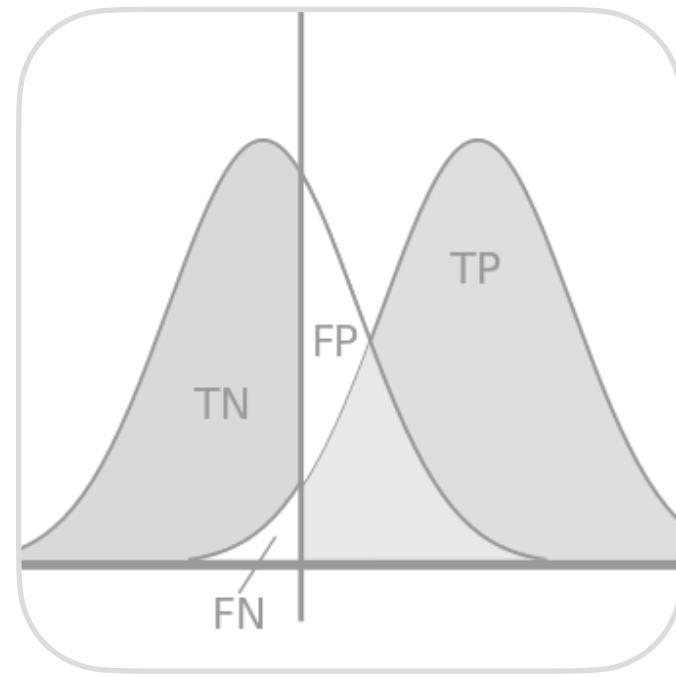
**Alternative Traits and Fusion Concepts**



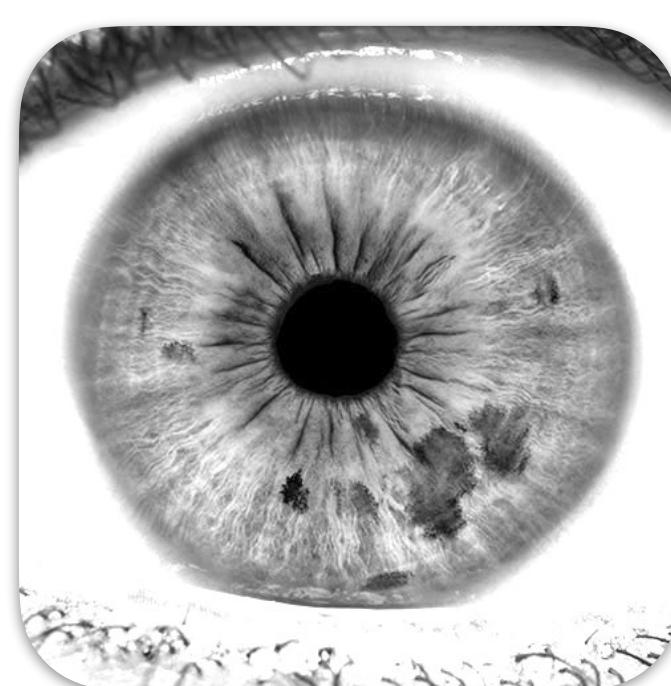
**Invited Talks (2)**  
State of the art  
Future work

# Course Overview

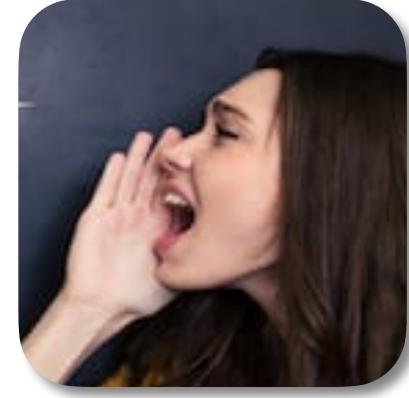
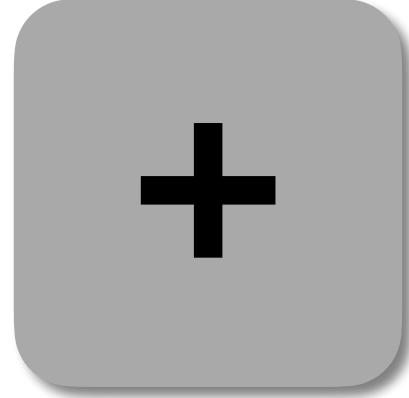
## Content



Basics  
Concepts  
Metrics  
Metric implementation



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



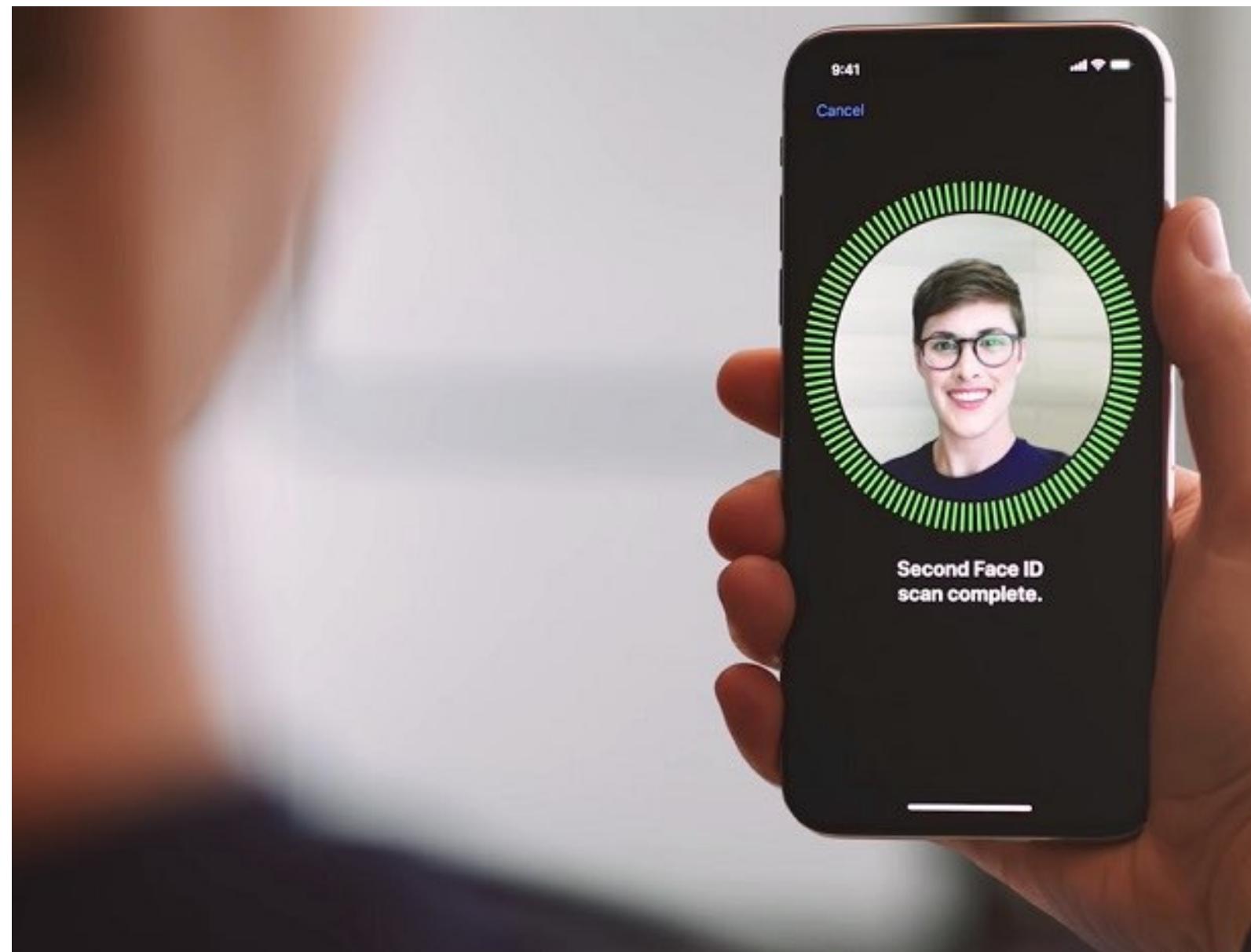
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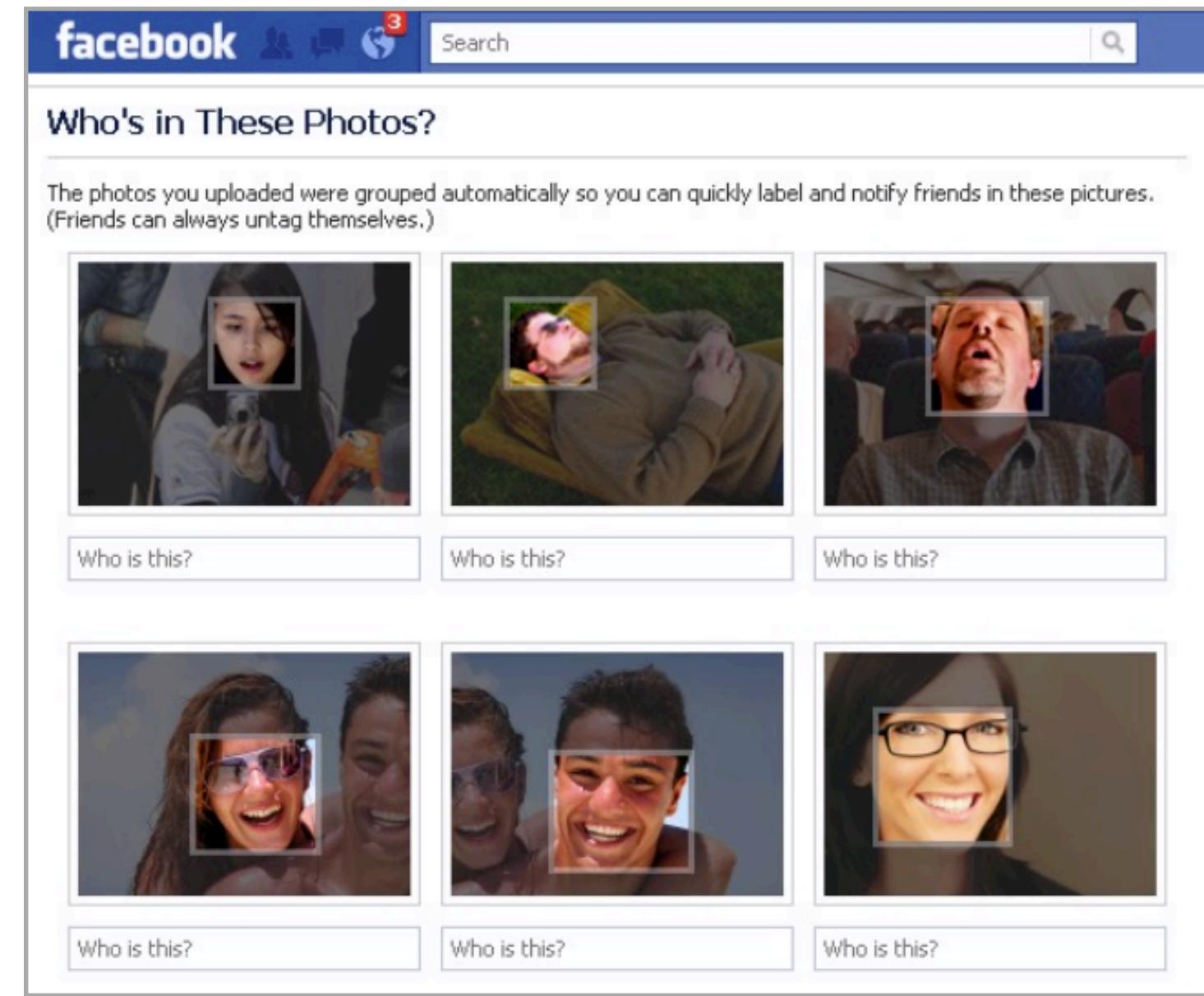
**Invited Talks (2)**  
State of the art  
Future work

# Why Faces?

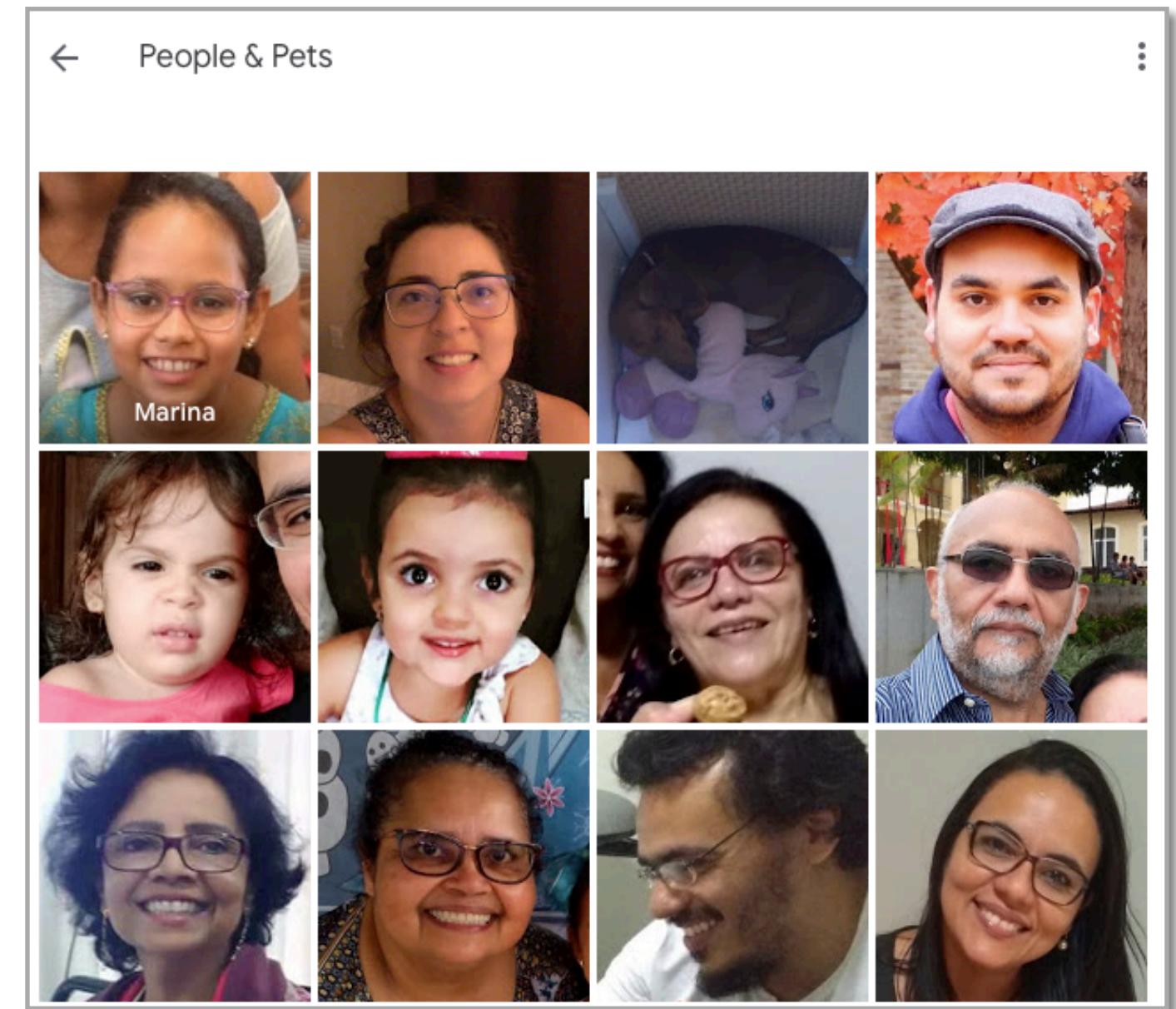
Face recognition is a reality



Personal devices



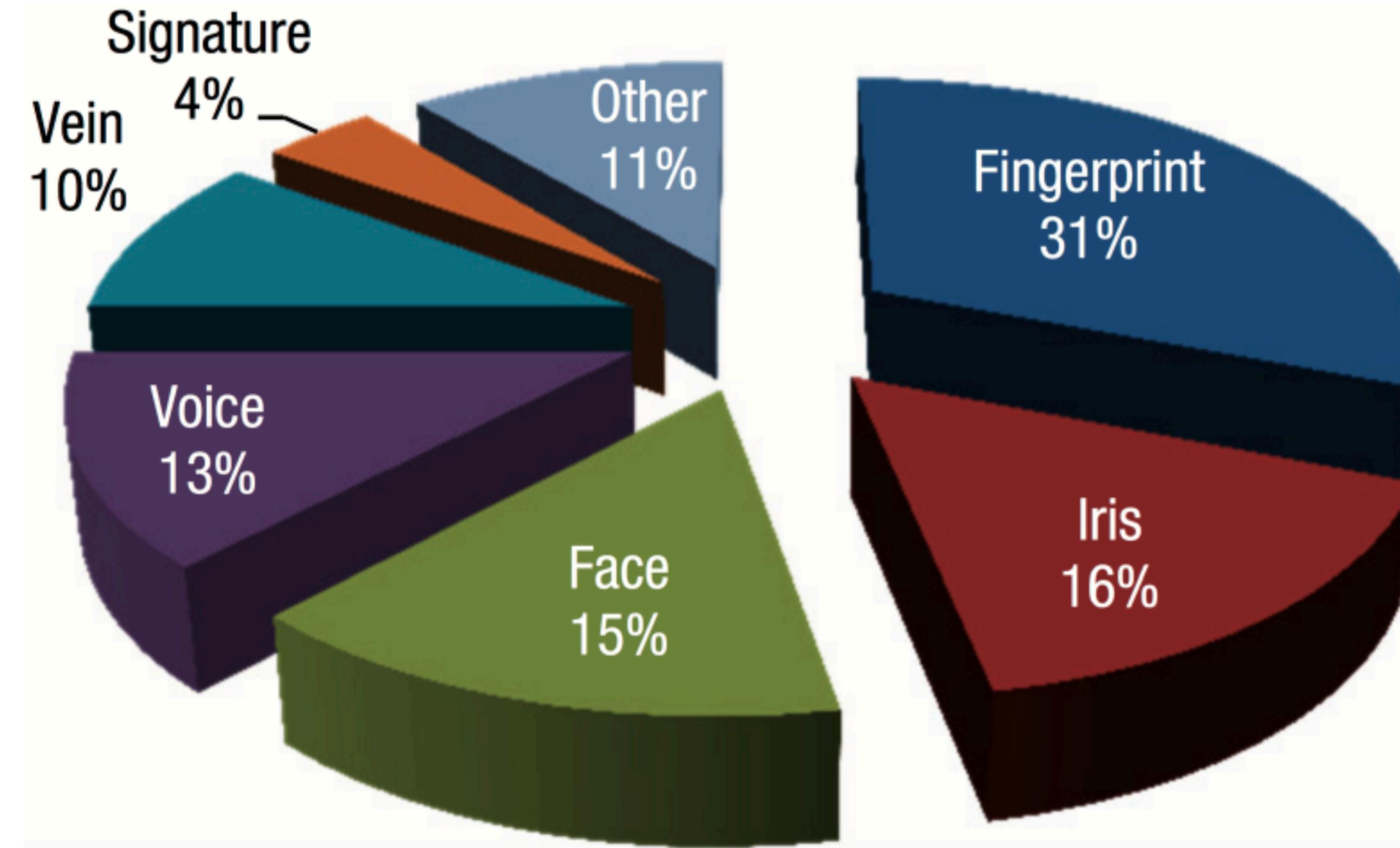
Facebook



Google Photos

# Why Faces?

**Market**



Source: Mani and Nadeski, *Processing solutions for biometric systems*, Texas Instruments, 2015

# Why Faces?

**Face recognition is an innate ability**

**Temporal cortex**

Active in monkey's brains  
when they are presented with faces.

**Prosopagnosia**

Lost ability to recognize faces  
when the temporal cortex is damaged.  
Affected folks can still recognize objects.



# Why Faces?



Who is she?



How different from  
the other one?

# Why Faces?



Who is she?



How different from  
the other one?

# Why Faces?

*Margaret Thatcher Illusion*  
Peter Thompson



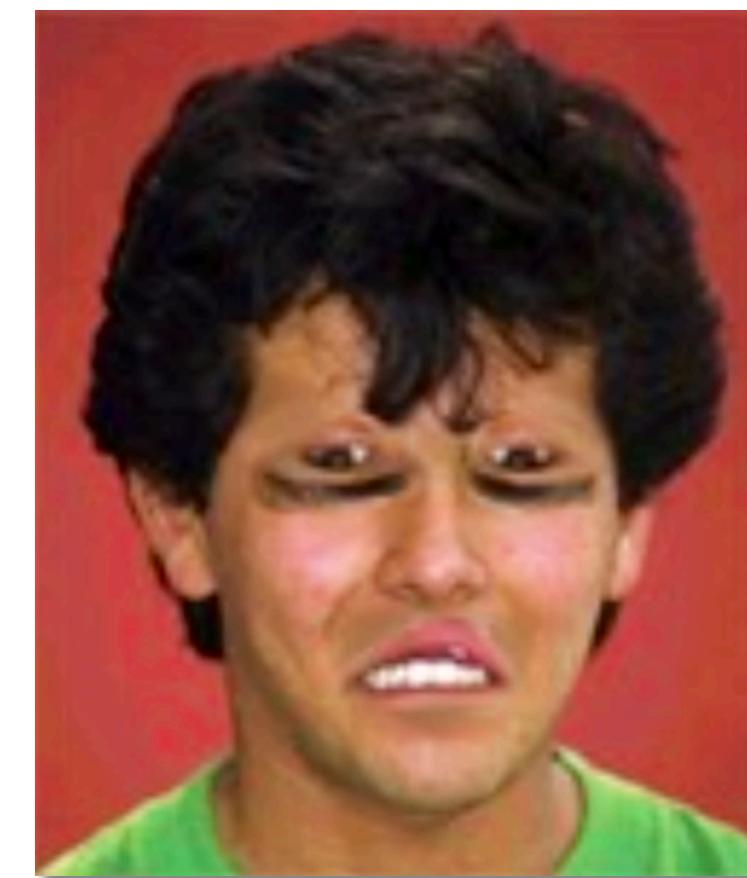
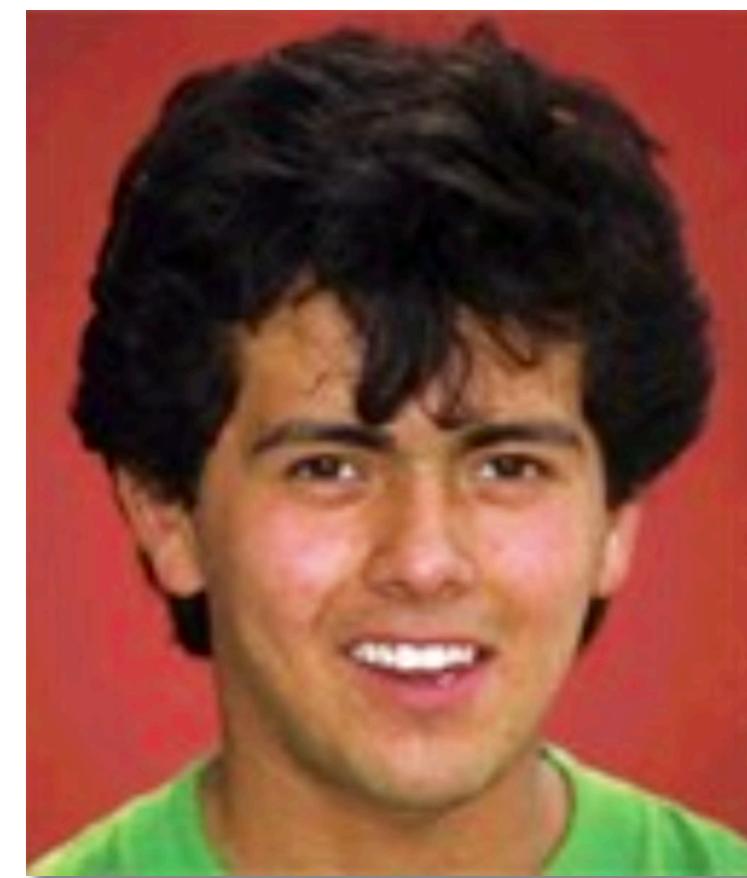
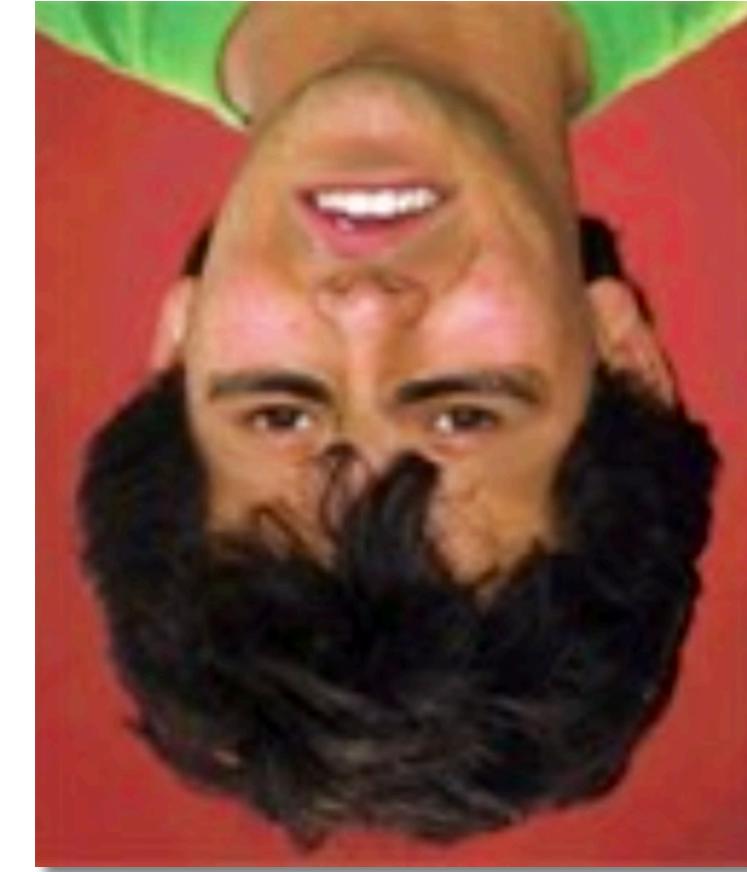
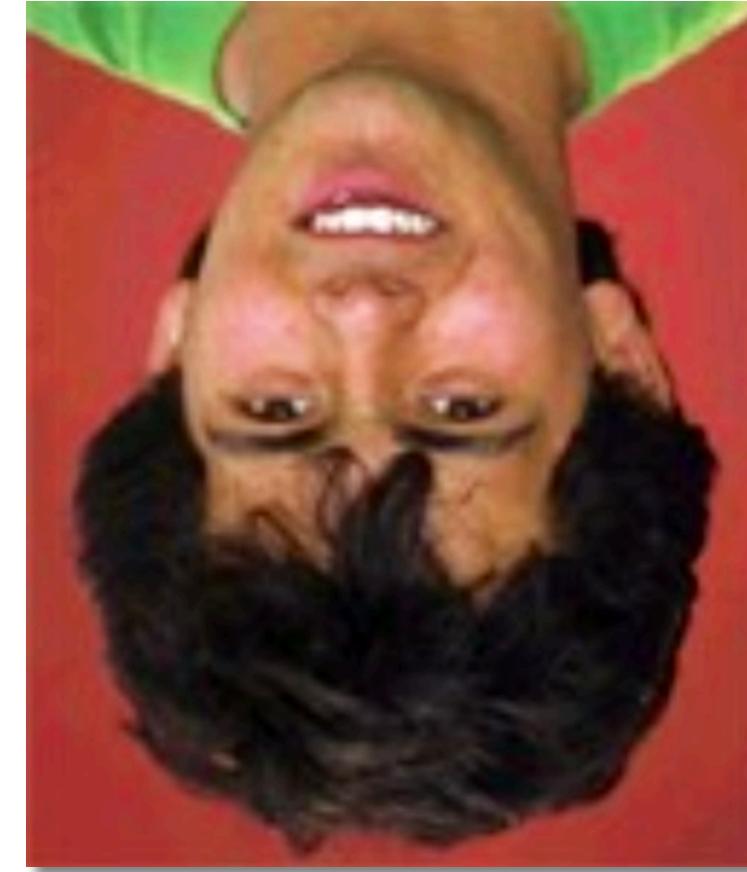
Who is she?



How different from  
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# Why Faces?

[https://faculty.washington.edu/  
chudler/java/faces.html](https://faculty.washington.edu/chudler/java/faces.html)



# Why Faces?

**Face recognition is an innate ability**

**Facial Pareidolia**

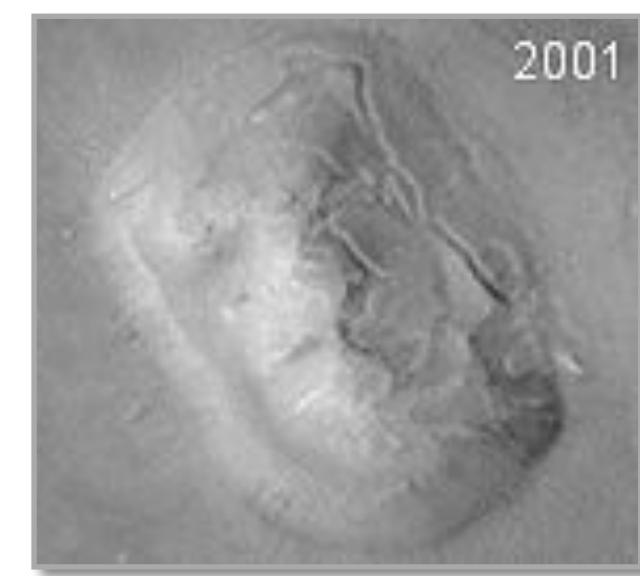
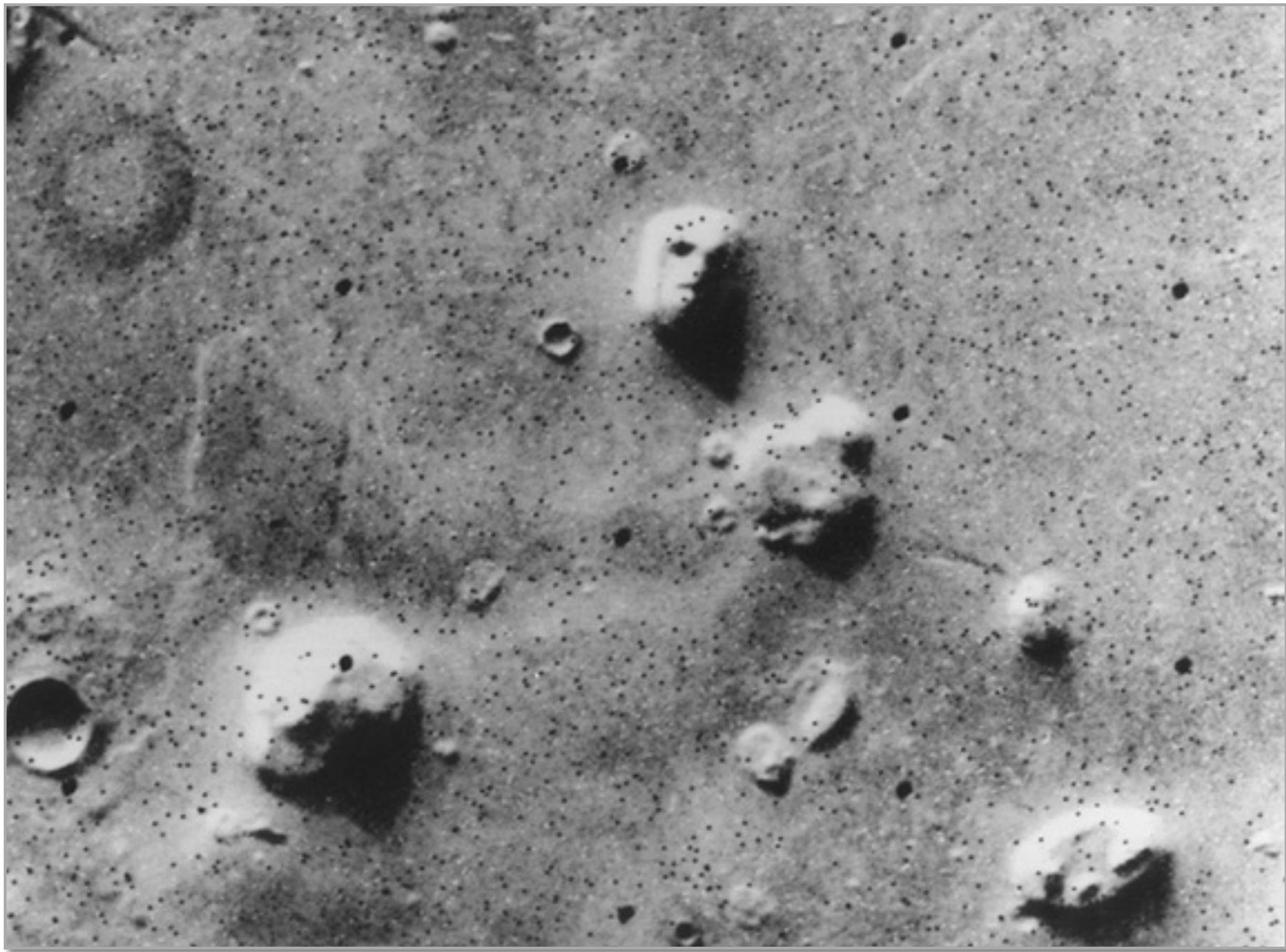
It is natural for us to perceive faces on random places.



+Dunken K Bliths

# Why Faces?

Source: <http://www.space.com/17191-face-on-mars.html>



1976

1998

2001

# Why Faces?

*Slave's Market*  
Salvador Dali



# Why Faces?

*Slave's Market*  
Salvador Dali



**Perceptual  
Rivalry**



*Voltaire's Bust*  
Jean-Antoine Houdon

# Why Faces?



*The Fruit Basket*  
Giuseppe Arcimboldo



*The Gardener*  
Giuseppe Arcimboldo

**Perceptual  
Rivalry**

# Why Faces?



*The Fruit Basket*  
Giuseppe Arcimboldo



*The Gardener*  
Giuseppe Arcimboldo

**Perceptual  
Rivalry**

# Fingerprints, Irises vs. Faces

## Universality (1/8)

Does everybody have the trait?

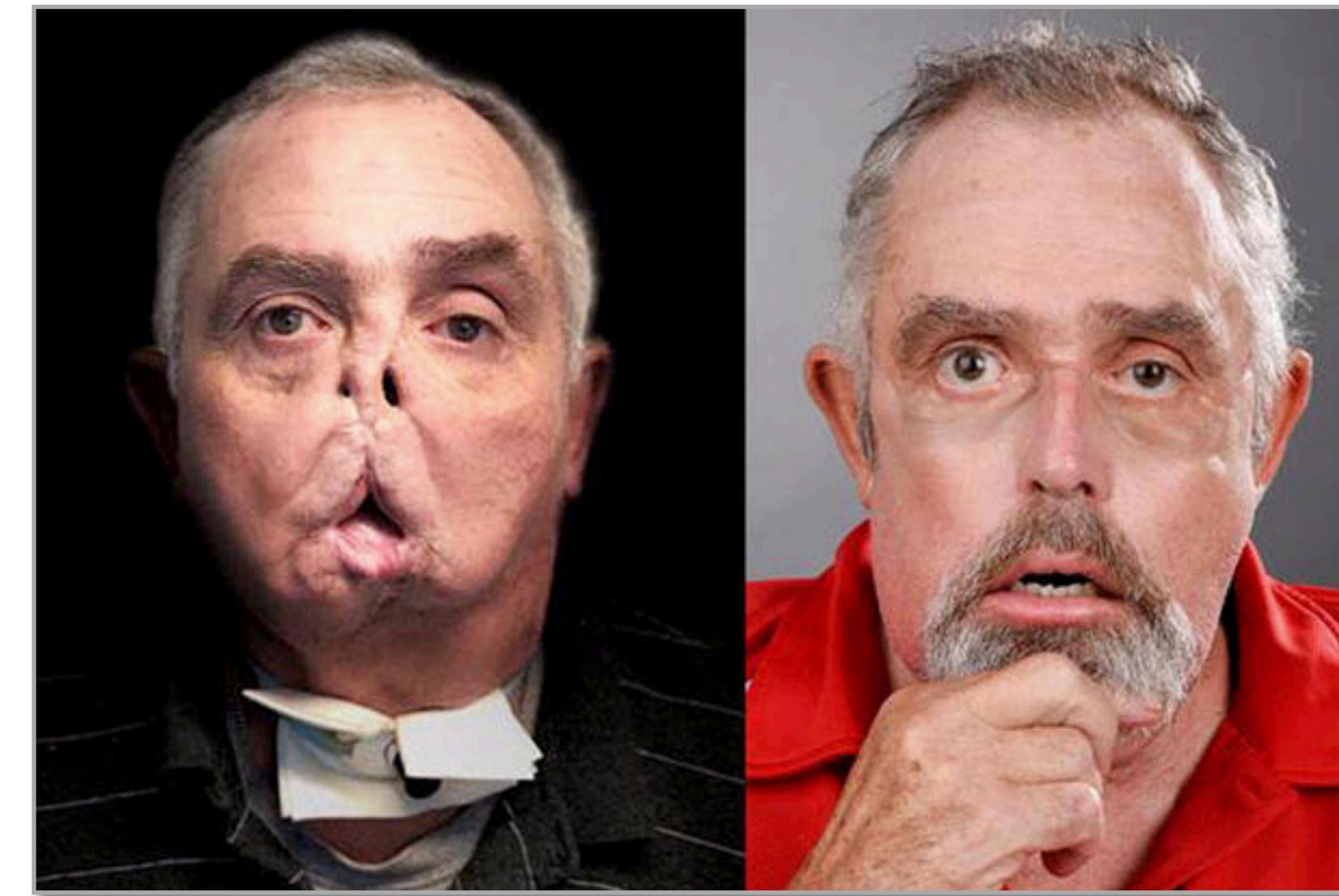
<https://www.smithsonianmag.com/science-nature/adermatoglyphia-the-genetic-disorder-people-born-without-fingerprints-180949338/>

The screenshot shows a magazine page with the header "Smithsonian MAGAZINE" and navigation links for "SUBSCRIBE", "SMARTNEWS", "HISTORY", "SCIENCE", "INGENUITY", "ARTS & CULTURE", and "TRAVEL". The main title is "Adermatoglyphia: The Genetic Disorder Of People Born Without Fingerprints". Below the title is a short text: "The extremely rare disease causes no problems—apart from occasional difficulties with the authorities". A large image shows three fingers with smooth skin against a green background. A caption below the image reads: "The finger pads of a person with adermatoglyphia are entirely smooth. (Photo by Sprecher et. al.)". The author's name, "By Joseph Stromberg", and the date, "JANUARY 14, 2014", are also visible.

Adermatoglyphia



<https://www.cbsnews.com/pictures/amazing-face-transplants-graphic-images/>



Face transplants

# Fingerprints, Irises vs. Faces

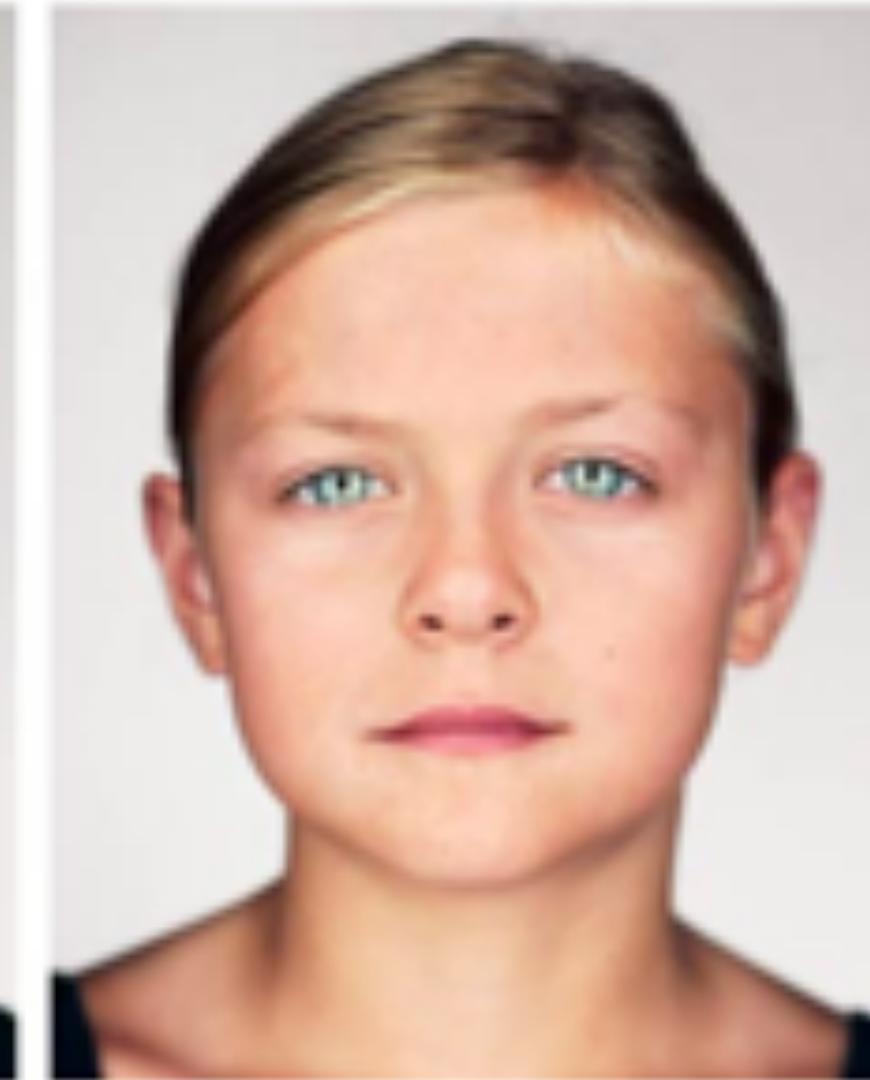
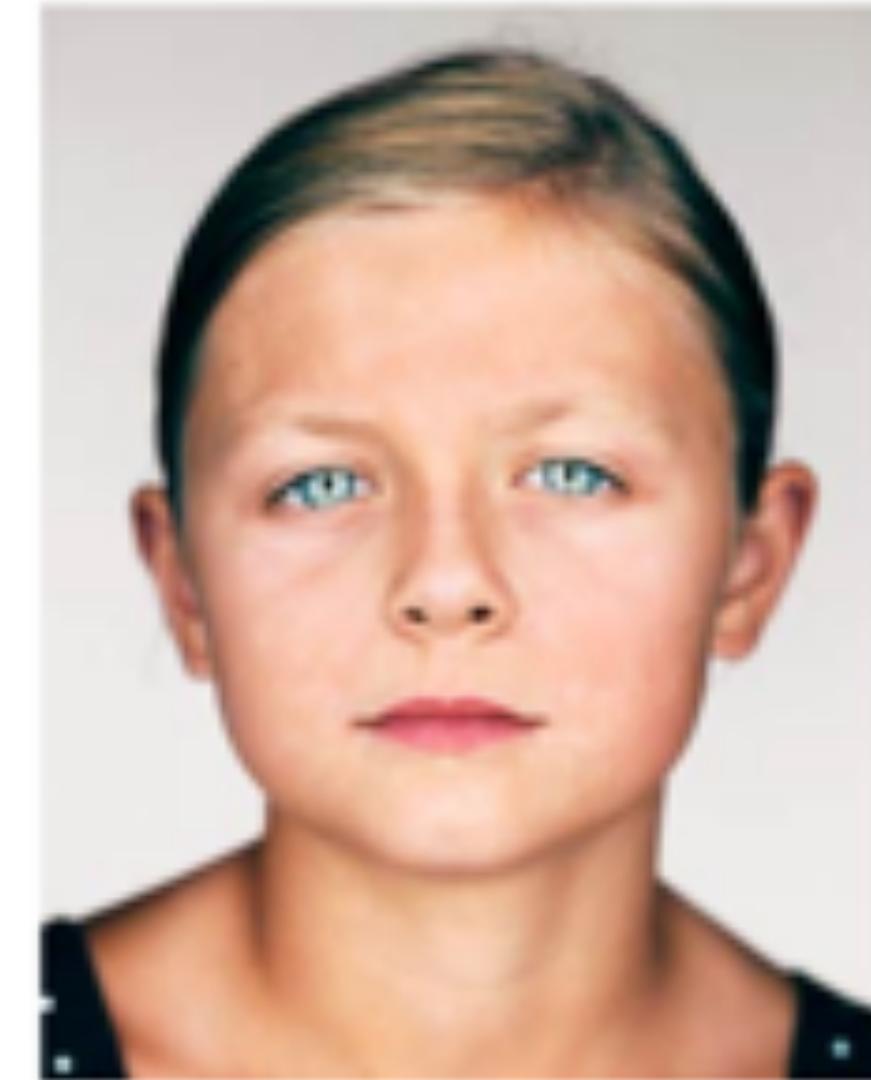
## Uniqueness (2/8)

How likely two or more individuals will present the same trait?

Source: John Daugman  
Lecture Notes, 2018



Galton's probability of 2 people presenting the same fingerprint: 1 in 64 billion.



Identical twins.

# Identical Twins?



# Identical Twins?

Source: John Daugman  
Lecture Notes, 2018



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Source: John Daugman  
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Lecture Notes, 2018

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Source: John Daugman  
Lecture Notes, 2018



Source: John Daugman  
Lecture Notes, 2018



Source: <http://lubbockonline.com/slideshows/051108/277846477/slides4.shtml>



Mother and daughter.

# Identical Twins?



Source: John Daugman  
Lecture Notes, 2018



Source: John Daugman  
Lecture Notes, 2018



Source: [http://lubbockonline.com/  
slideshows/051108/277846477/](http://lubbockonline.com/slideshows/051108/277846477/)  
slide4.shtml

Mother and daughter.



Source: John Daugman  
Lecture Notes, 2018

Unrelated.



Completely  
unrelated  
subjects.



Source: John Daugman  
Lecture Notes, 2018



# Fingerprints, Irises vs. Faces

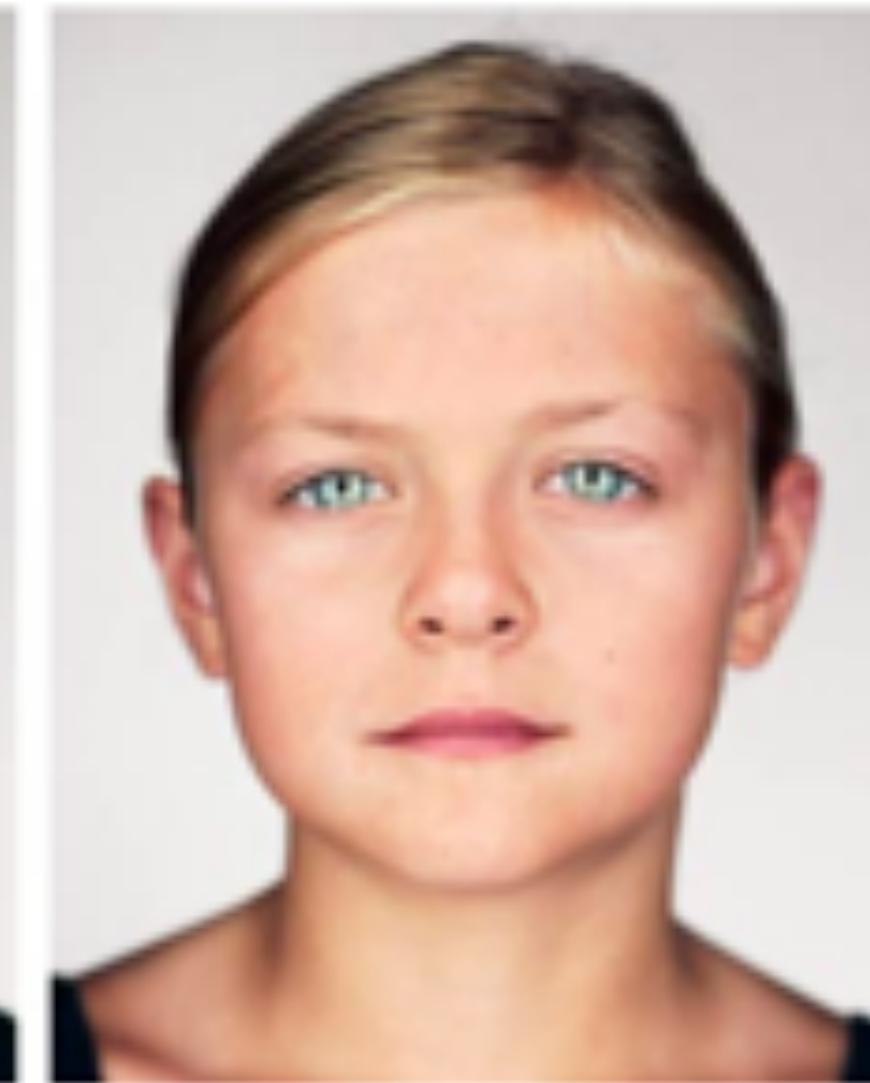
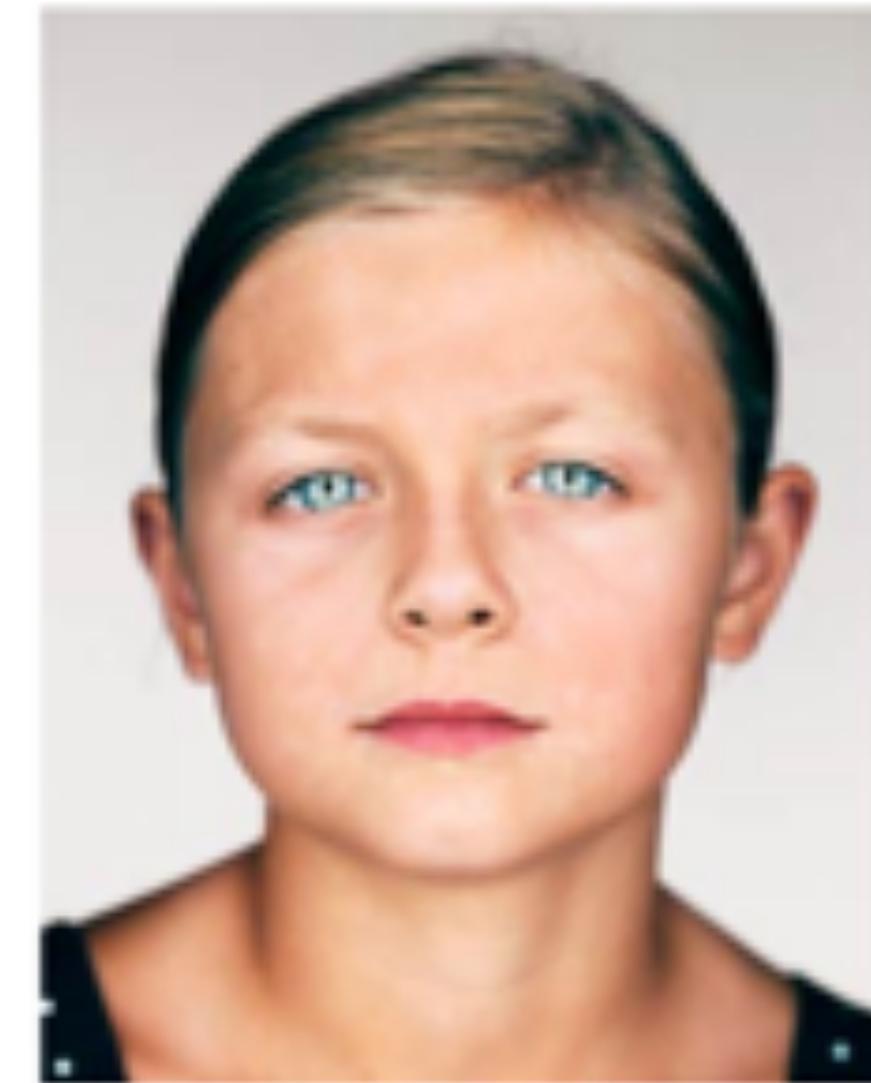
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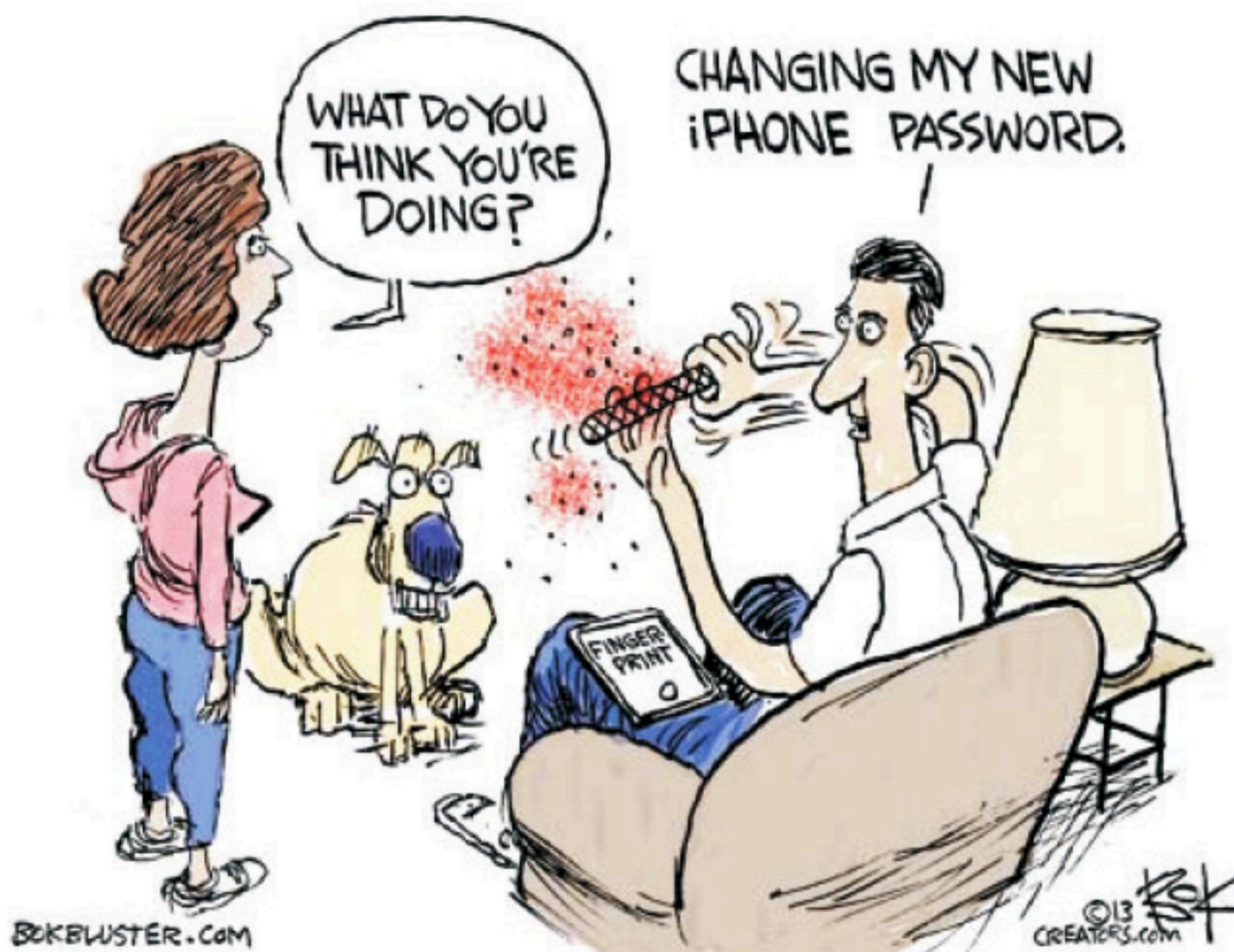


Identical twins.

# Fingerprints, Irises vs. Faces

## Permanence (3/8)

How easily does the trait change?



You cannot easily change your fingerprints.



But your face **will** change.

# Fingerprints, Irises vs. Faces

## Permanence (3/8)

How easily does the trait change?

## Aging

Source: Lantinis

*A survey of the effects of aging on biometric identity verification*  
International Journal of Biometrics 2(1), 2010



# Fingerprints, Irises vs. Faces

## Permanence (3/8)

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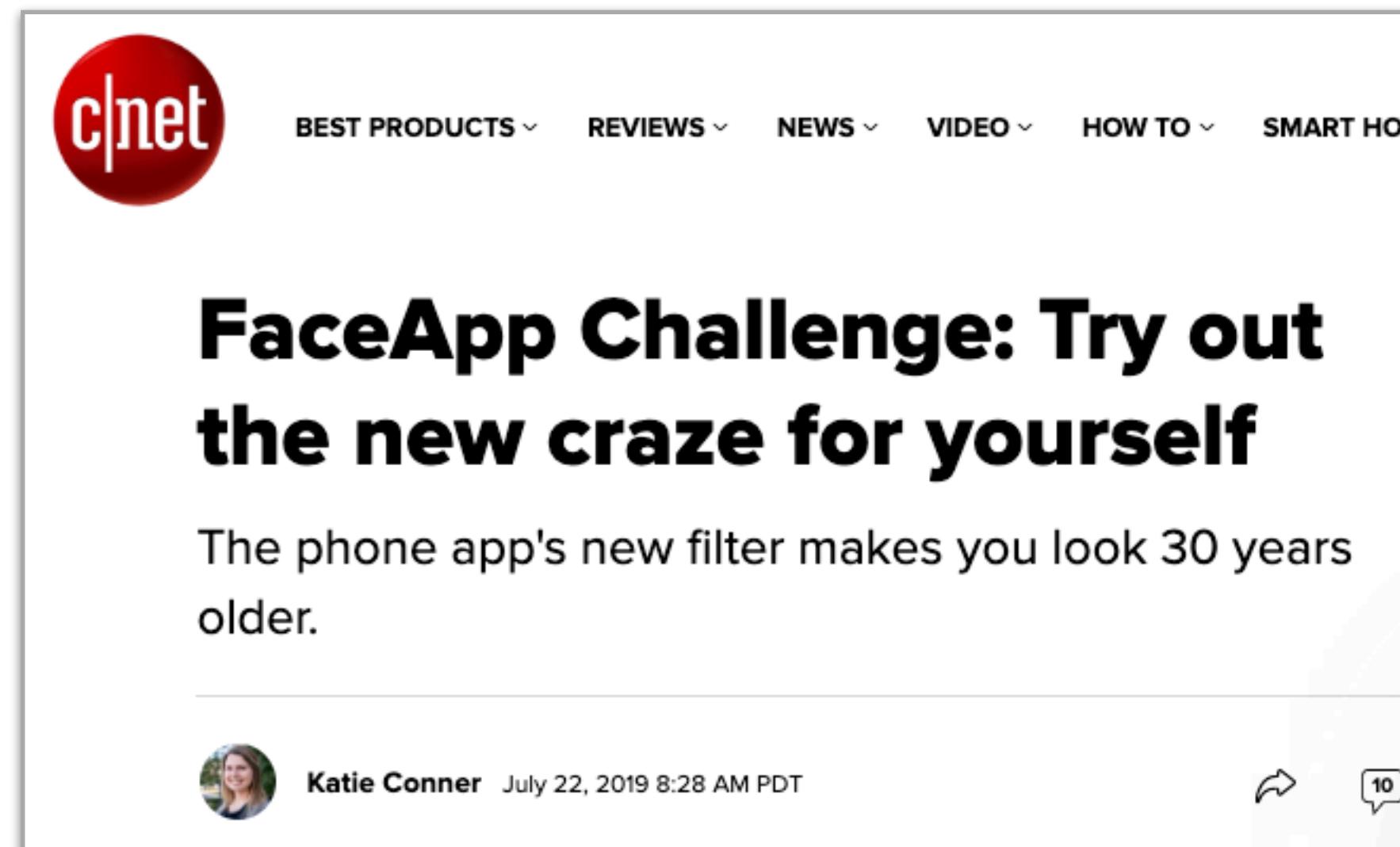
# Fingerprints, Irises vs. Faces

## Permanence (3/8)

How easily does the trait change?

## Aging

Will it always be a challenge?



The image shows a screenshot of a CNET news article. The header features the CNET logo in a red circle. Below the logo, there are navigation links: BEST PRODUCTS ▾, REVIEWS ▾, NEWS ▾, VIDEO ▾, HOW TO ▾, and SMART HOME. The main title of the article is "FaceApp Challenge: Try out the new craze for yourself". A subtitle below the title reads, "The phone app's new filter makes you look 30 years older." At the bottom of the article, there is a photo of a woman named Katie Conner, with the caption "Katie Conner July 22, 2019 8:28 AM PDT". There are also sharing icons and a comment count of "10".



<https://www.cnet.com/how-to/faceapp-challenge-try-out-the-new-craze-for-yourself/>

# Fingerprints, Irises vs. Faces

## Permanence (3/8)

How easily does the trait change?

## Aging

Will it be useful?

**Madeleine McCann**



5 years (real)

9 years (simulated)

# Fingerprints, Irises vs. Faces

## Permanence (3/8)

How easily does the trait change?

## Deliberate Changes



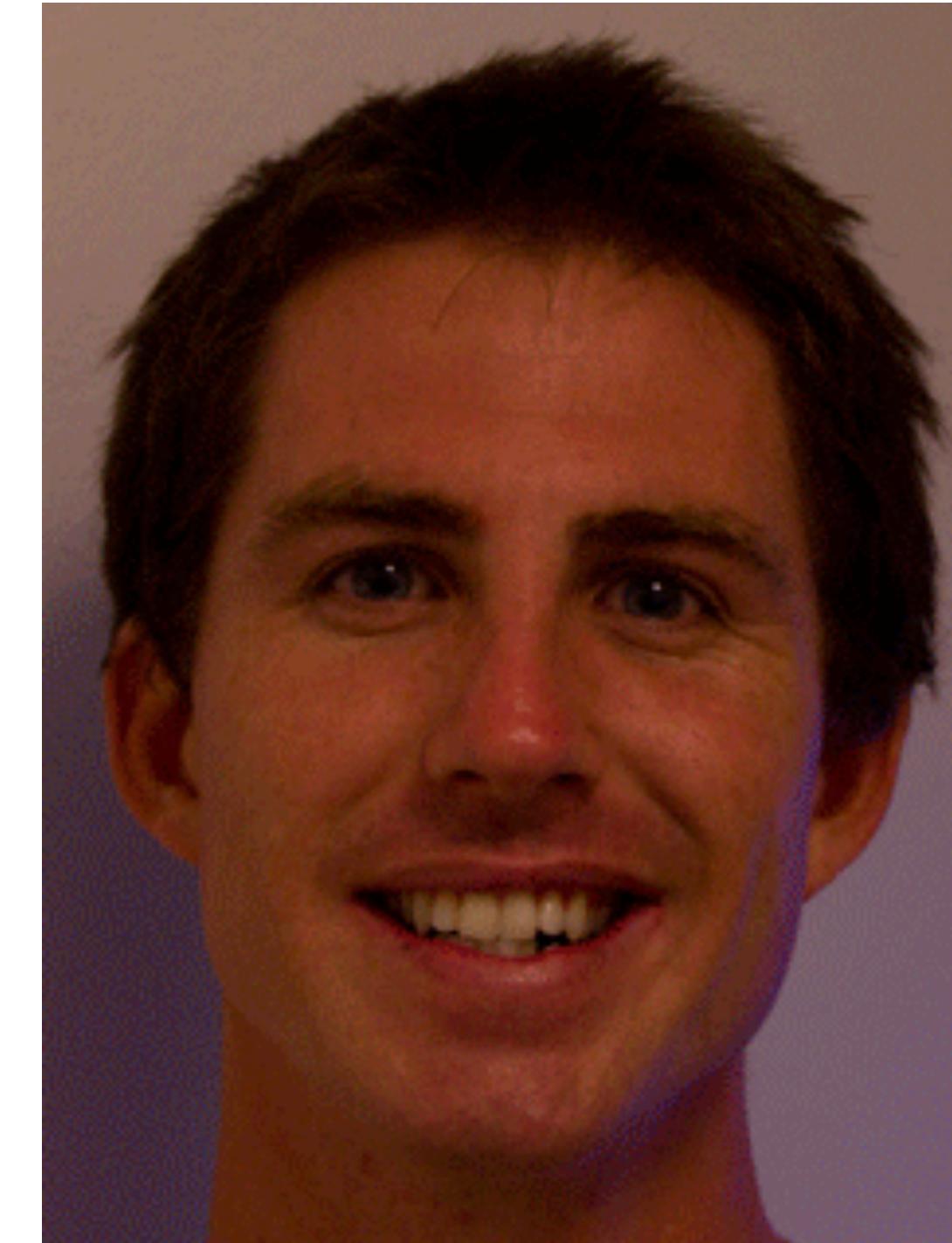
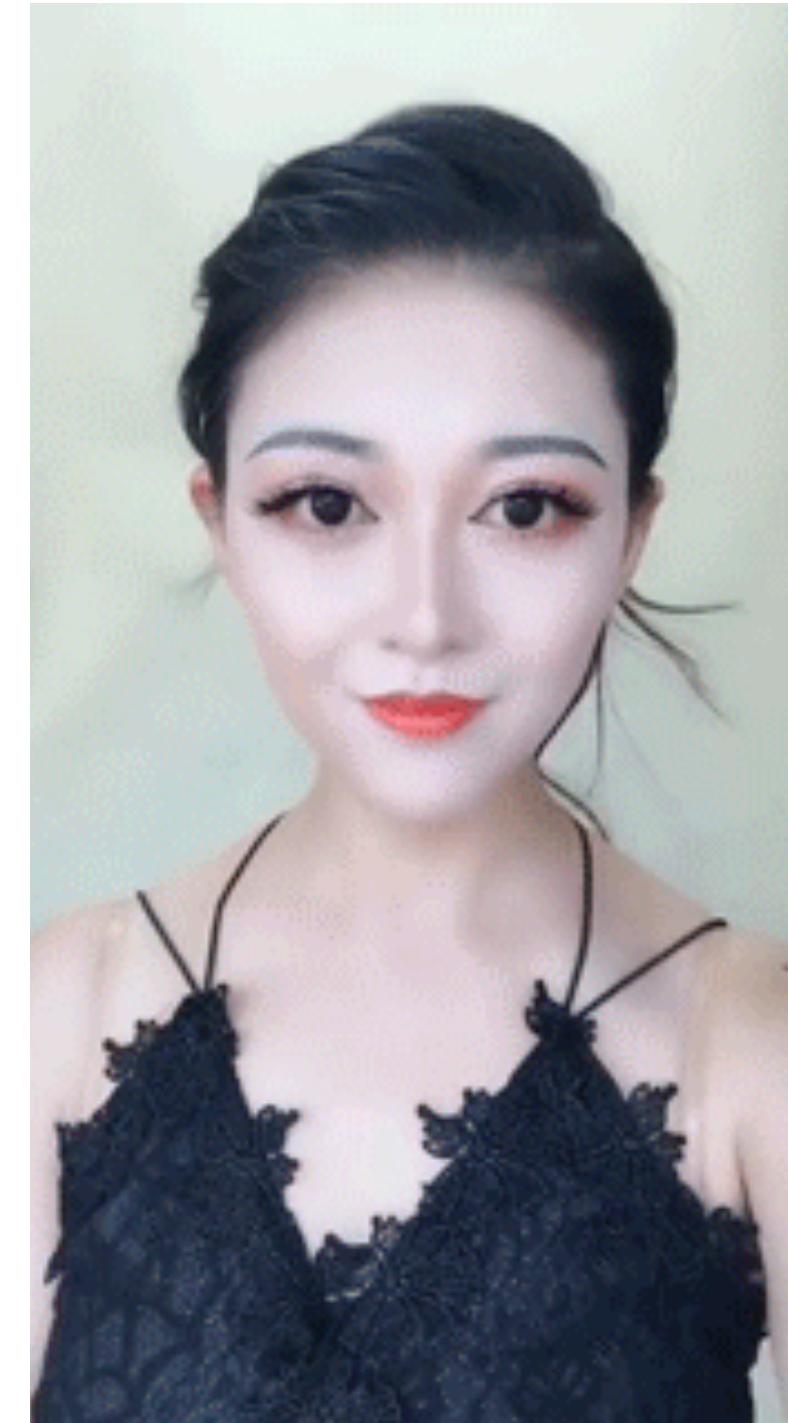
# Fingerprints, Irises vs. Faces

## Permanence (3/8)

How easily does the trait change?

## Deliberate Changes

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

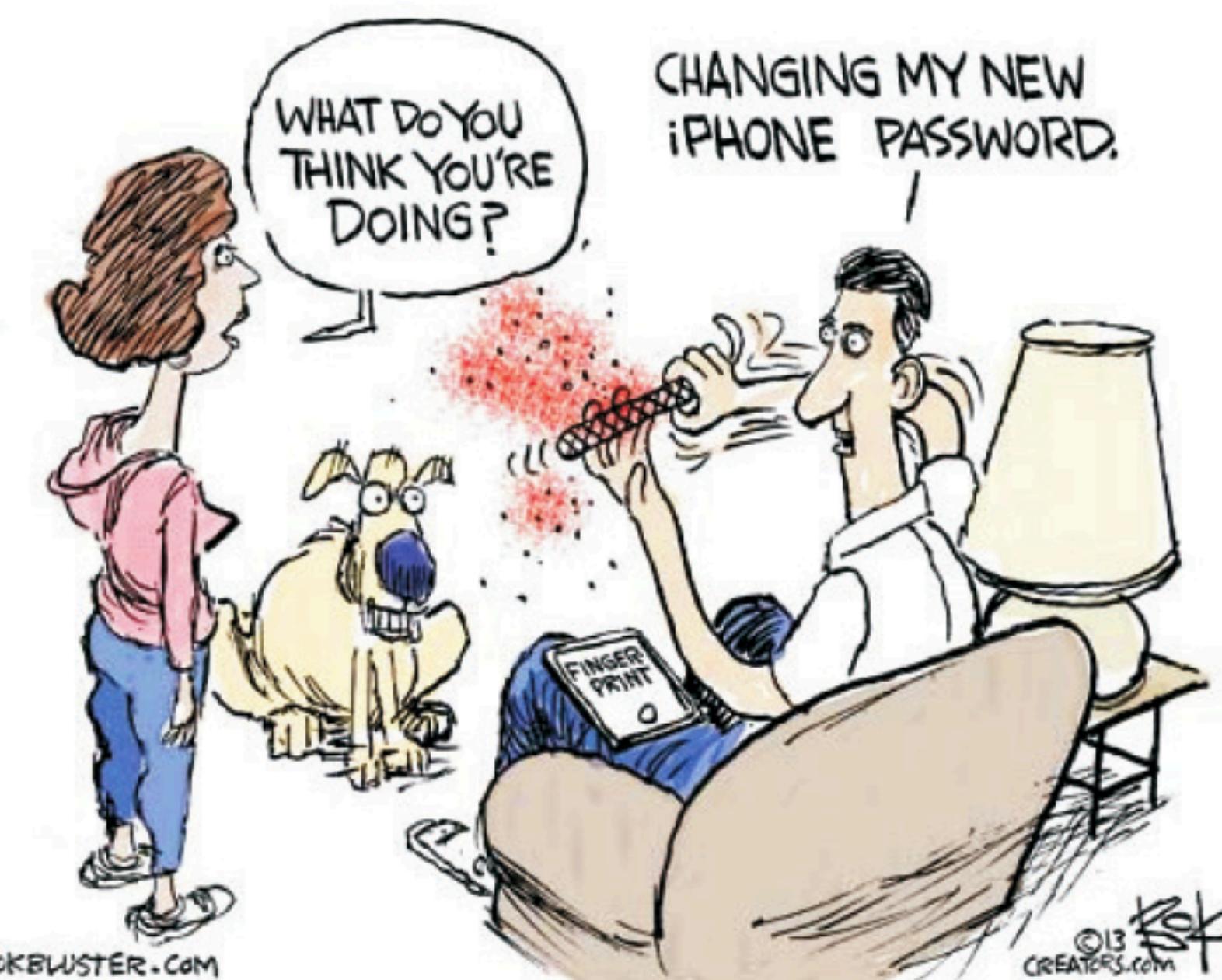




# Fingerprints, Irises vs. Faces

## Permanence (3/8)

How easily does the trait change?



You cannot easily change your fingerprints.

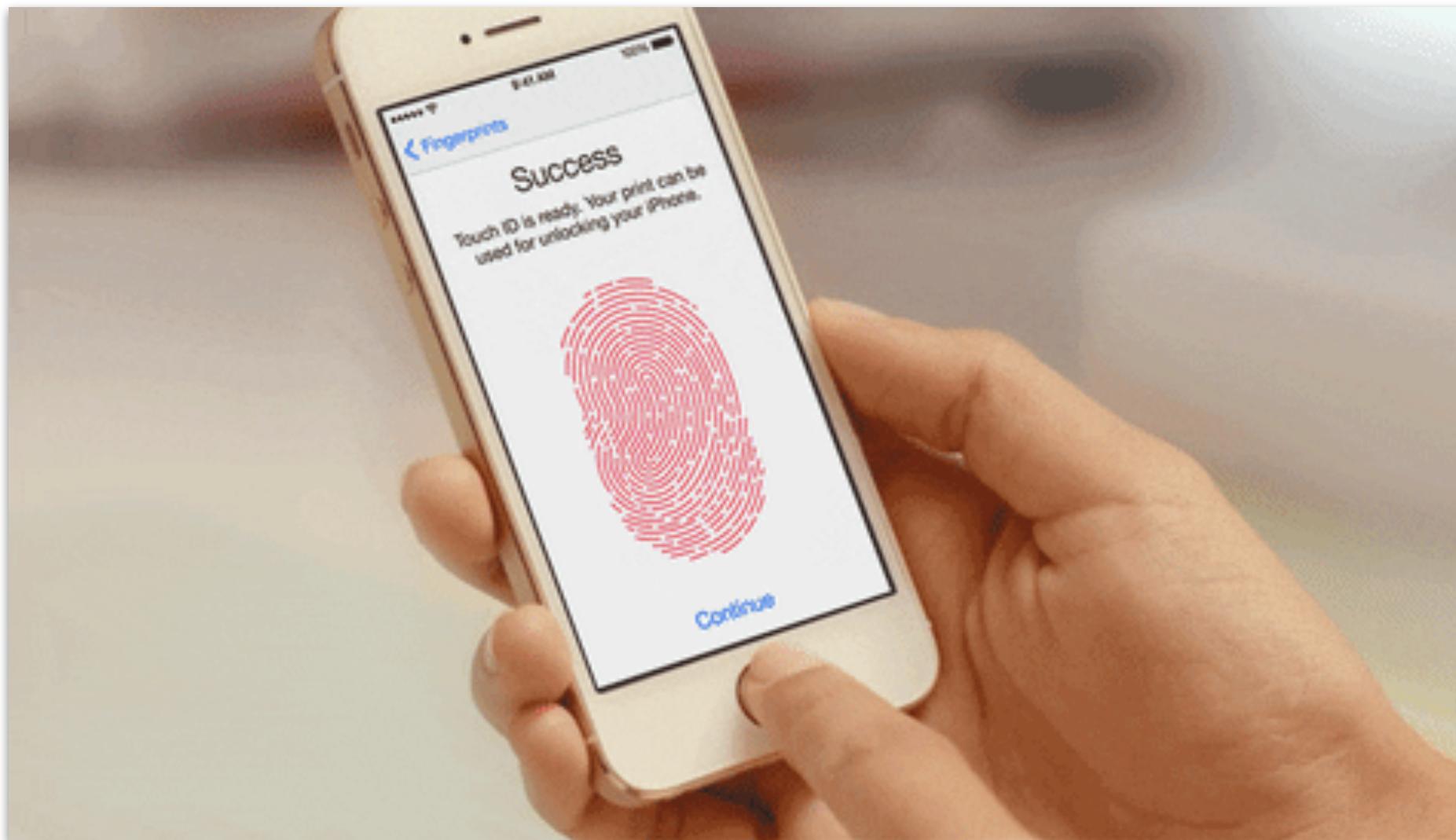


But your face **will** change.

# Fingerprints, Irises vs. Faces

## Measurability (4/8)

How easy is it to acquire and digitize the trait?



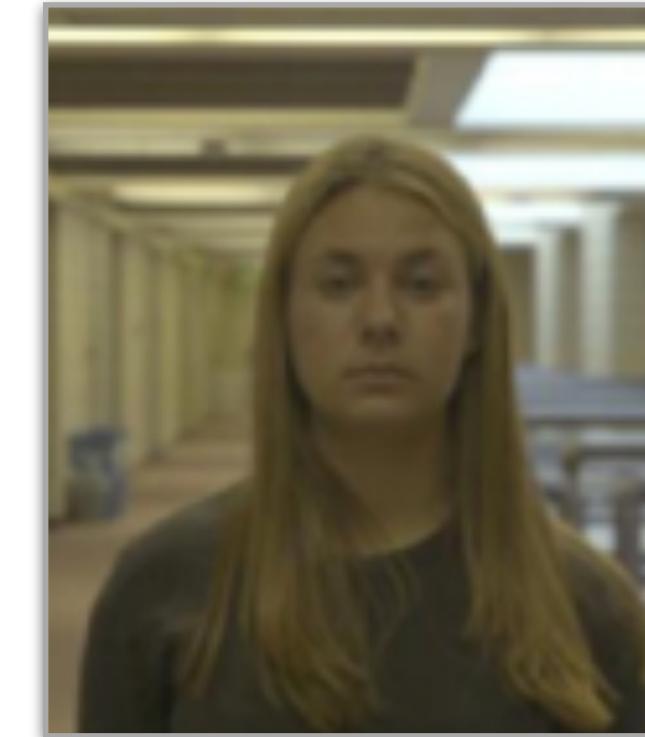
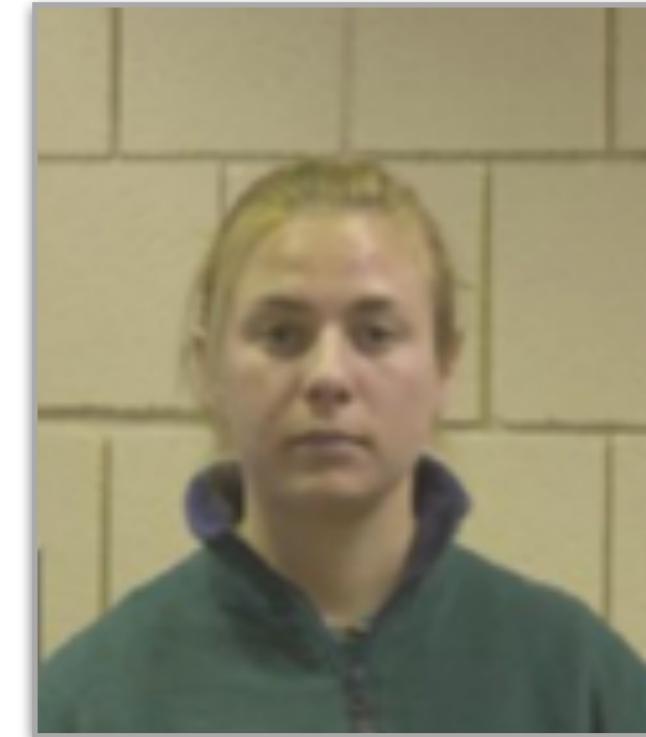
<https://www.youtube.com/watch?v=uQHqZNyXoBQ>

# Fingerprints, Irises vs. Faces

## Measurability (4/8)

How easy is it to acquire and digitize the trait?

### Unconstrained Acquisition



<https://www.nist.gov/system/files/documents/itl/iad/ig/05771424.pdf>

# Fingerprints, Irises vs. Faces

## Measurability (4/8)

How easy is it to acquire and digitize the trait?

## Large Intra-Class Variation

Different pose, illumination, expression, accessories (e.g.. glasses), resolution.



Hsu  
*Face detection and  
modeling for recognition*  
PhD Thesis, MSU, 2002.

# Fingerprints, Irises vs. Faces



## Acceptability (5/8)

Will individuals collaborate during data collection?



<https://www.youtube.com/watch?v=Qt79QAwgi80>



[https://www.youtube.com/watch?v=BYN4oF\\_bi4c](https://www.youtube.com/watch?v=BYN4oF_bi4c)

# Fingerprints, Irises vs. Faces



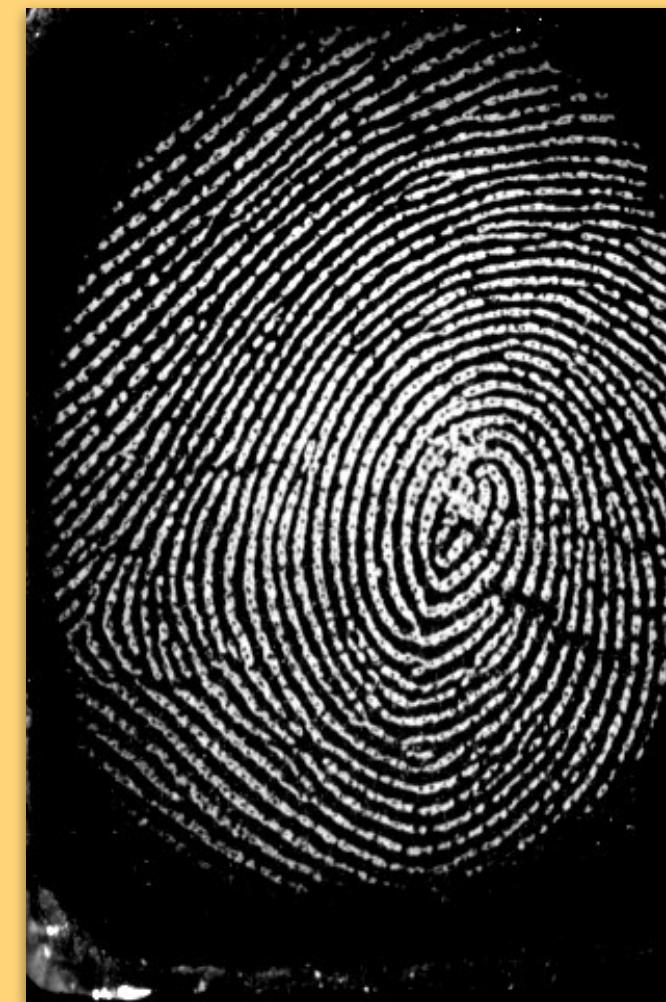
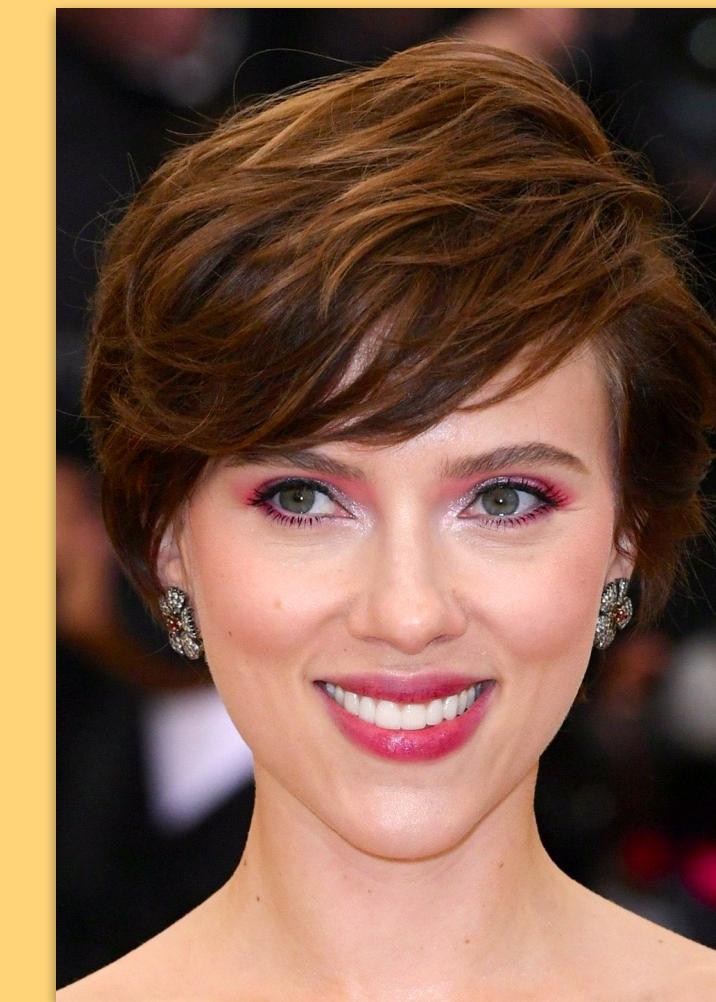
## Acceptability (5/8)

Will individuals collaborate during data collection?

## Privacy Concerns



Robert  
Downey Jr.



Scarlet  
Johansson

# Fingerprints, Irises vs. Faces



## Acceptability (5/8)

Will individuals collaborate during data collection?

## Privacy Concerns



**Whose latent fingerprint is this?  
Robert's or Scarlet's?**

Is it the fingerprint of a man or woman?  
Is it the fingerprint of a younger or older person?

**Latent Fingerprint**

# Fingerprints, Irises vs. Faces



## Acceptability (5/8)

Will individuals collaborate during data collection?

## Privacy Concerns



**Whose face is this?  
Robert's or Scarlet's?**

No way it is Scarlet's. This is a man.  
No way it is Robert. This is an older man.

**“Latent Face”**

# Fingerprints, Irises vs. Faces



## Acceptability (5/8)

Will individuals collaborate during data collection?

## Privacy Concerns

Which trait helps to recognize Scarlet quicker?



**Latent Fingerprint**



**“Latent Face”**

# Fingerprints, Irises vs. Faces

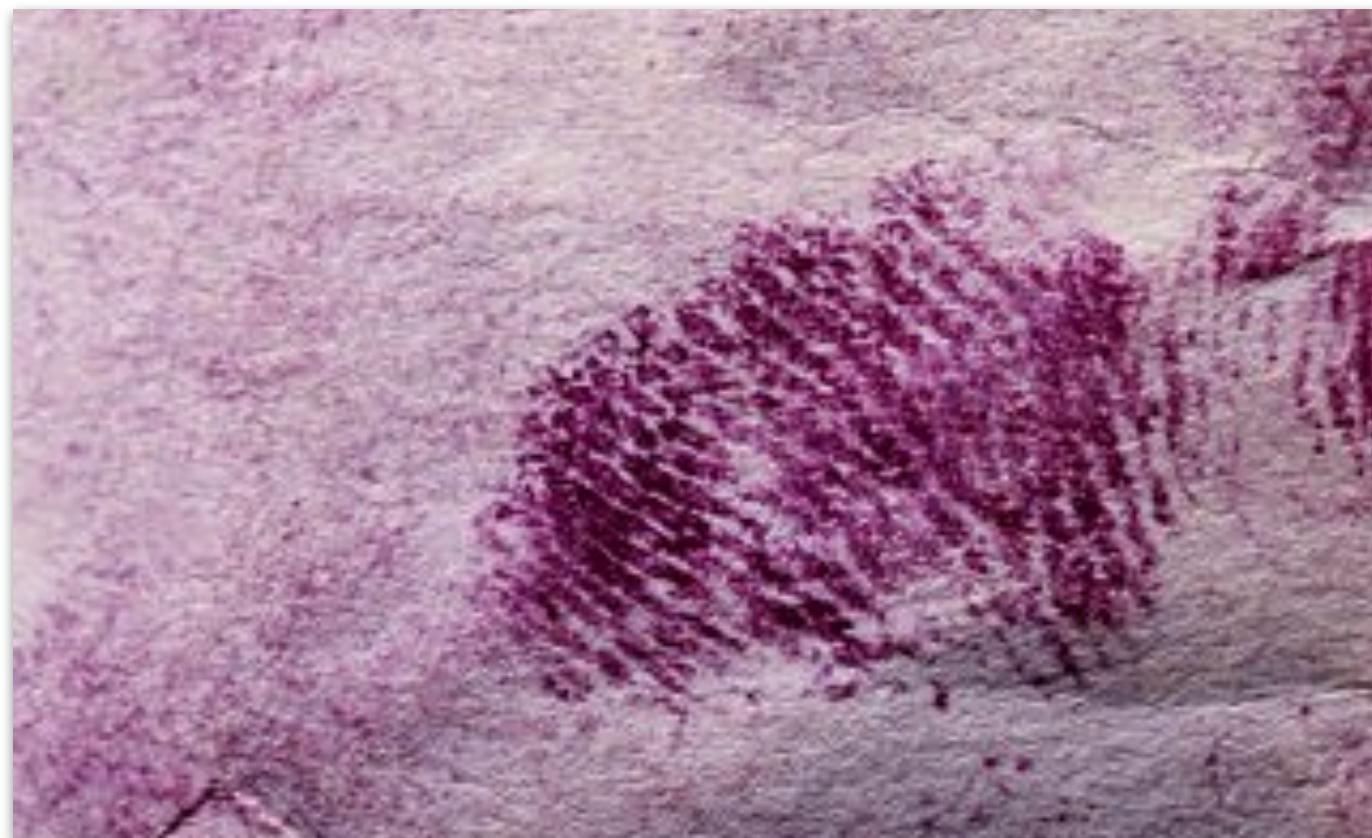


## Acceptability (5/8)

Will individuals collaborate during data collection?

## Privacy Concerns

Which trait favors **covert deployment**?



**Latent Fingerprint**



**“Latent Face”**

# Fingerprints, Irises vs. Faces



## Circumvention (6/8)

How easy can the trait be forged or imitated?



<https://www.youtube.com/watch?v=KdycMYILT0>

We are not there yet!

# Fingerprints, Irises vs. Faces



## Circumvention (6/8)

How easy can the trait be forged or imitated?

### Limitations

= WIRED

SUBSCRIBE

CapitalOne

Experience that new-car feeling.

ANDY GREENBERG SECURITY 11.14.2017 07:00 AM

## Watch a 10-Year-Old's Face Unlock His Mom's iPhone X

Yes, twins can unlock each other's iPhones. But kids accessing their parents' devices raises different concerns.



<https://www.wired.com/story/10-year-old-face-id-unlocks-mothers-iphone-x/>

# Fingerprints, Irises vs. Faces



## Circumvention (6/8)

How easy can the trait be forged or imitated?

### Attacks

Presentation Attack.



<https://www.youtube.com/watch?v=BGgQ9woZQOg>

# Fingerprints, Irises vs. Faces



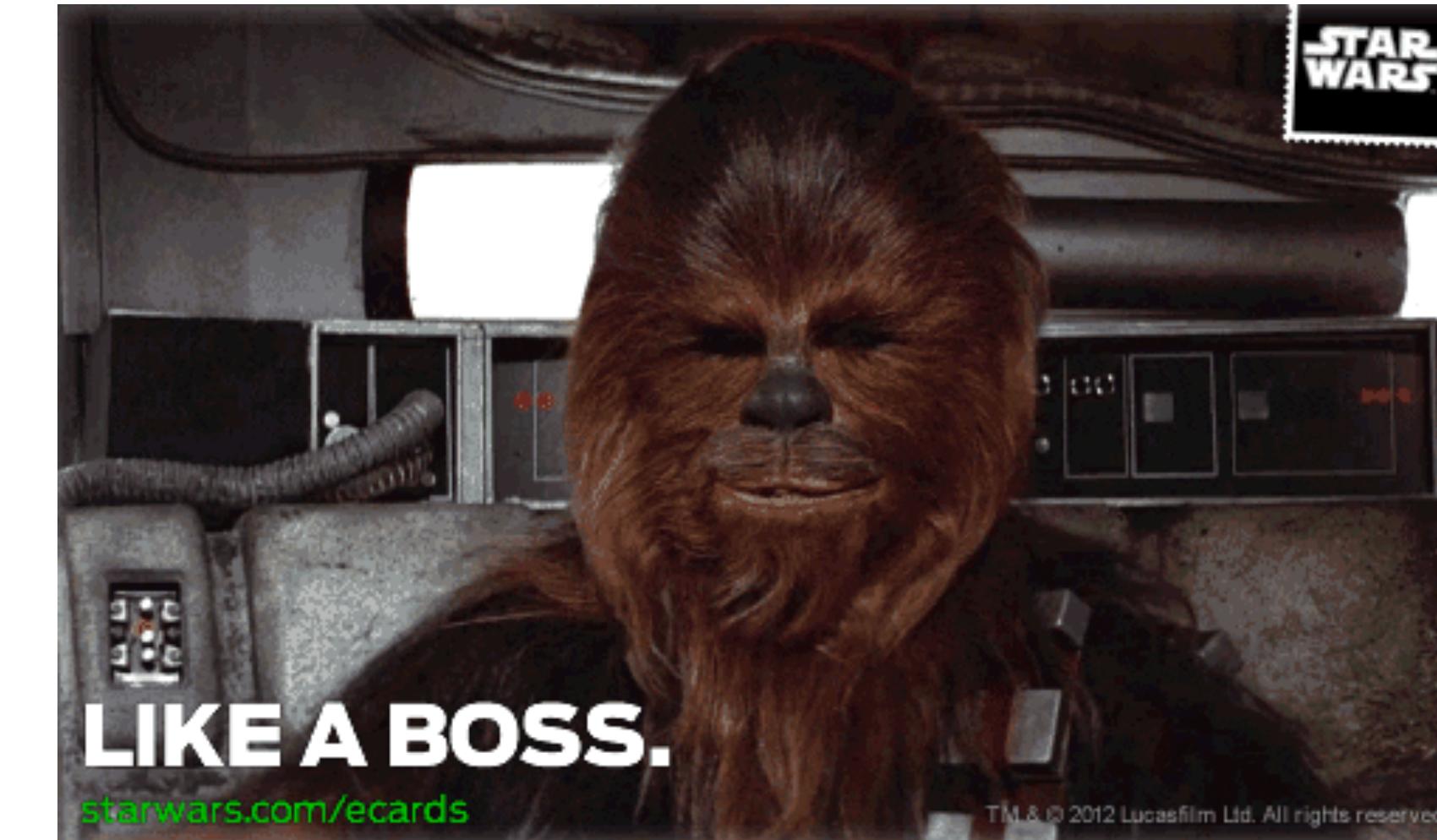
## Accountability (7/8)

How easy is it for the everyman to understand the trait comparison?



Same fingerprint?

*You need to know fingerprint features.*



Everybody is an expert  
in face recognition.

# Fingerprints, Irises vs. Faces



## Performance (8/8)

How good is the trait quantitatively according to objective metrics?

## Face Recognition Improvement

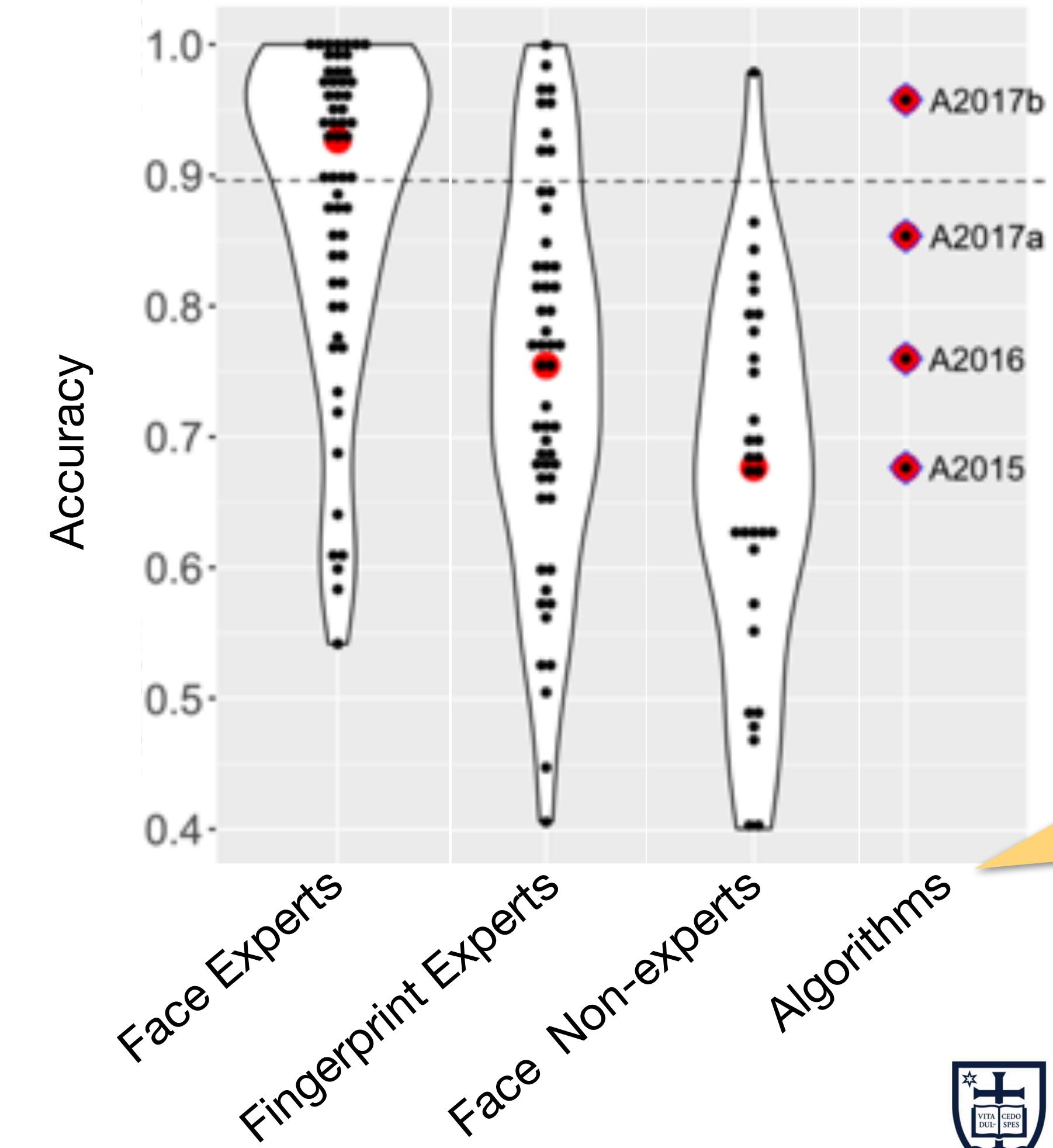
Methods are improving quickly.  
Benefits from deep learning.

## Publication

Phillips et al.

*Face recognition accuracy of forensic examiners, superrecognizers, and face recognition algorithms.*

PNAS, 2018

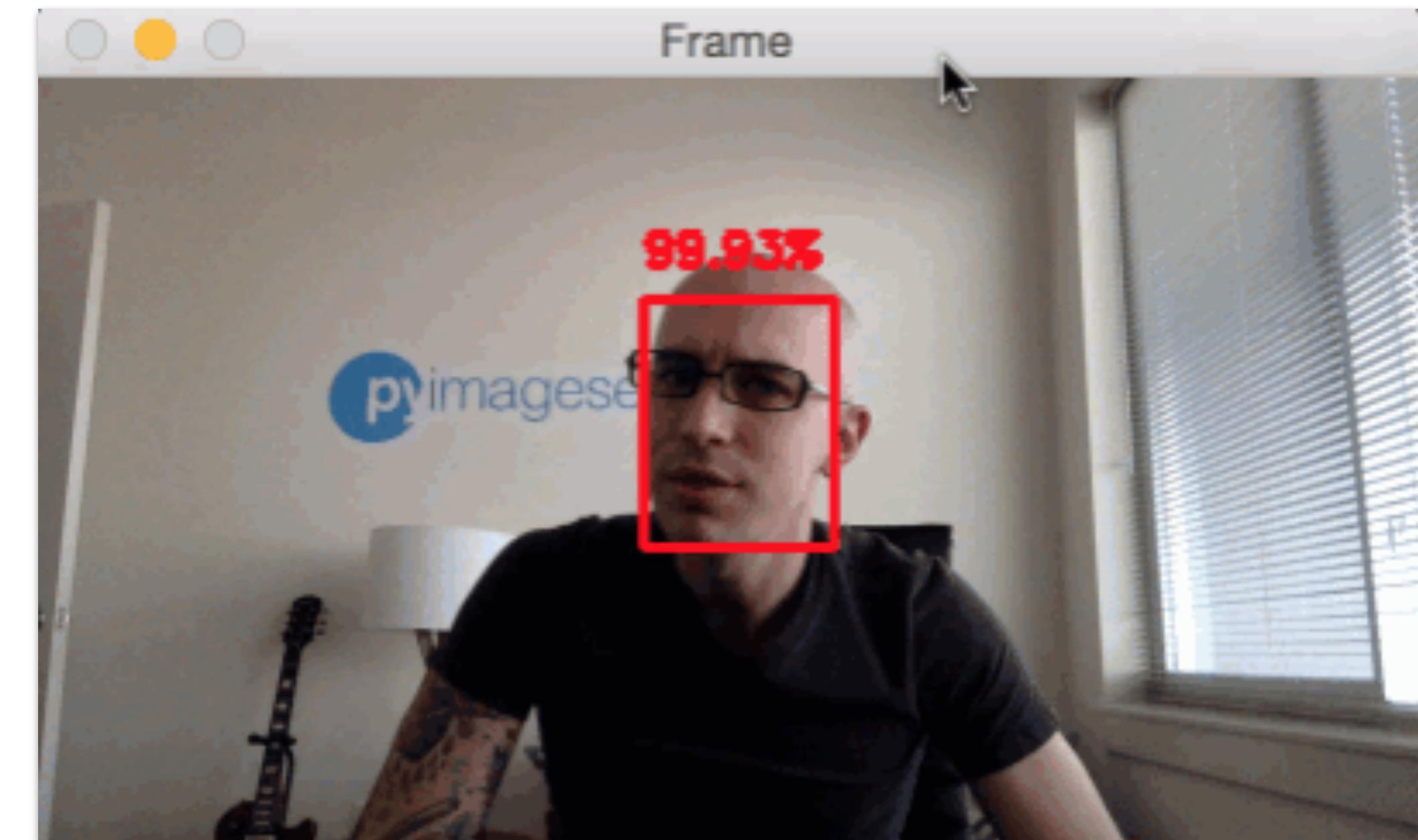


Deep  
Learning

# S'up Next?

## Face Recognition Pipeline

Face acquisition and  
face detection/localization.



<http://insidenothing.blogspot.com/2018/02/face-detection-with-opencv-and-deep.html>