

# Face Recognition I

CSE 40537/60537 Biometrics

**Daniel Moreira**  
Spring 2022



# Today you will...

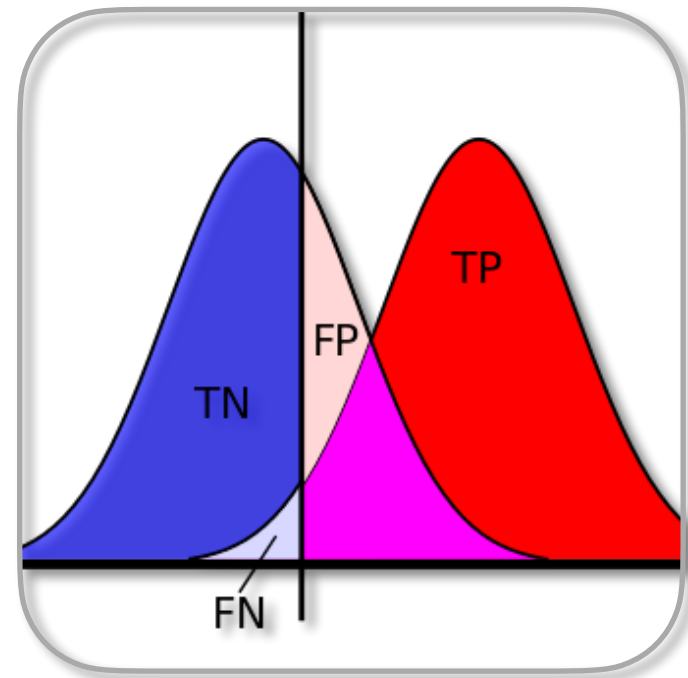
*Get to know*

Reasons to use faces for recognition.

How faces compare to fingerprints and irises.

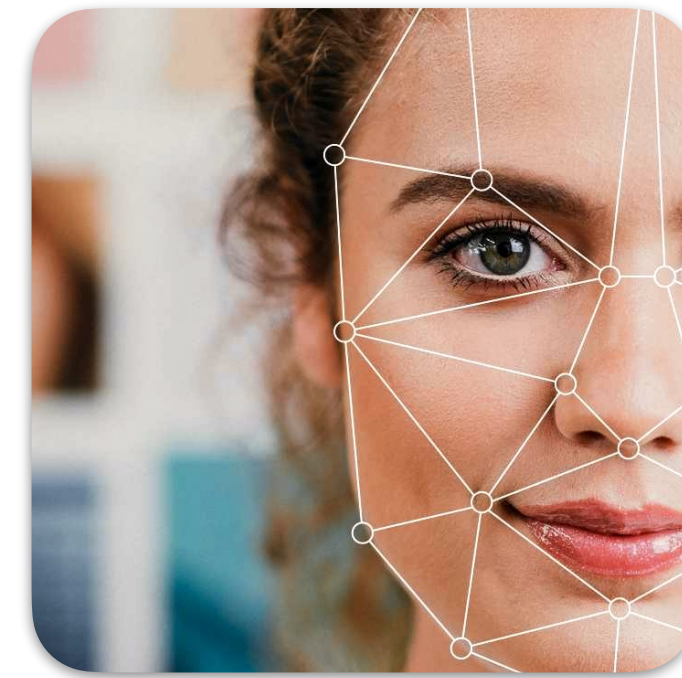
# Course Overview

## Content



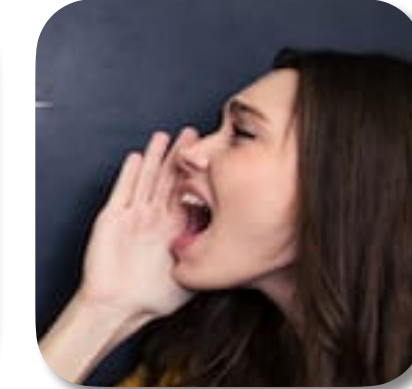
### Basics

Concepts  
Metrics  
Metric  
implementation



### Core Traits (3)

Concepts  
Baseline implementation  
Data collection  
Evaluation  
Attacks  
Assignments



**Alternative Traits and  
Fusion  
Concepts**

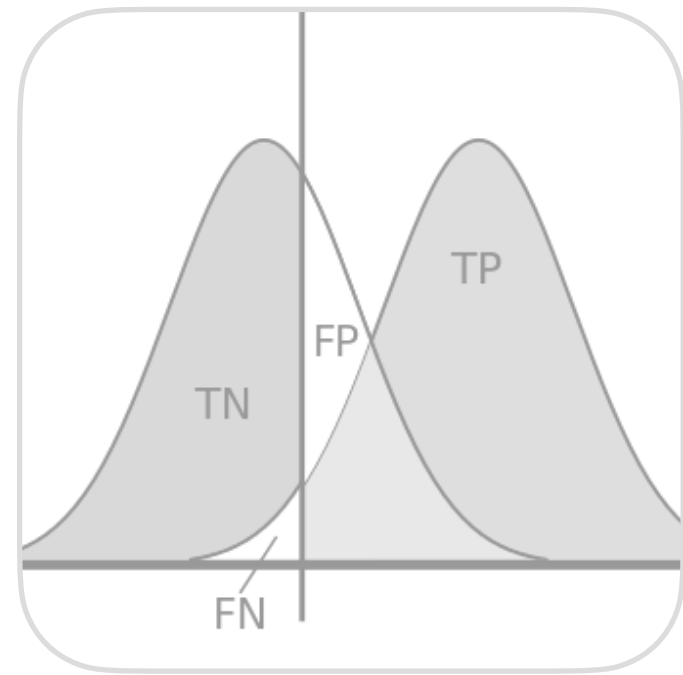


**Invited Talks (2)**  
State of the art  
Future work



# Course Overview

## Content



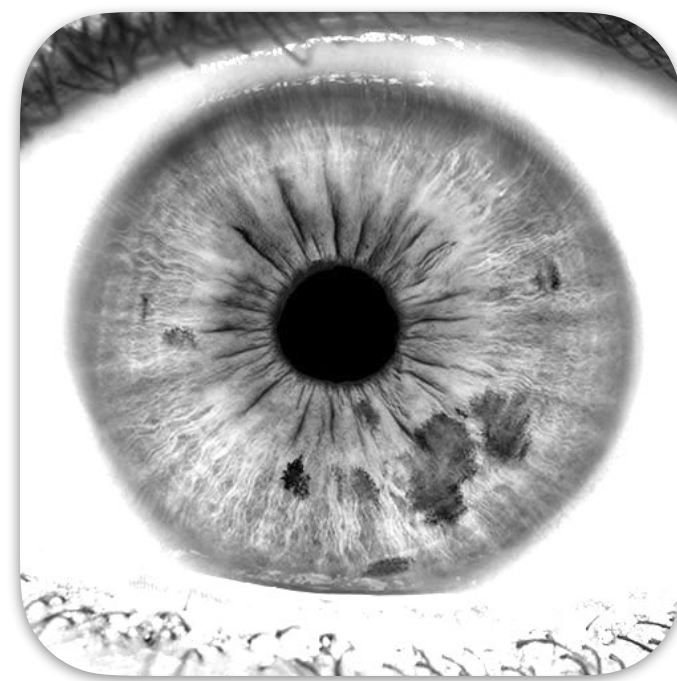
### Basics

Concepts

Metrics

Metric

implementation



### Core Traits (3)

Concepts

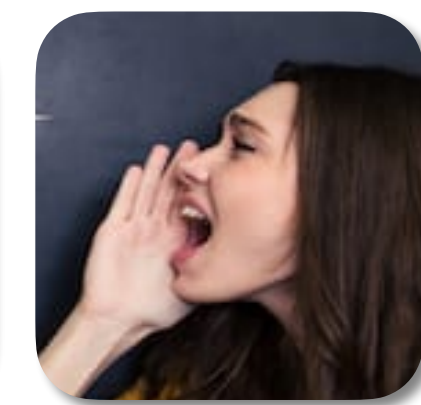
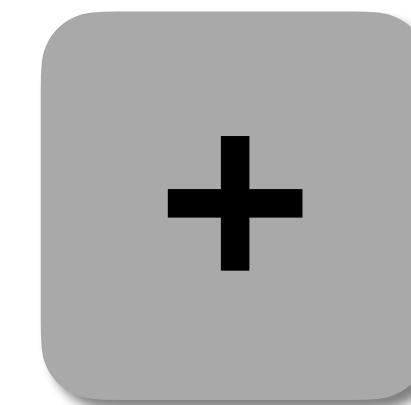
Baseline implementation

Data collection

Evaluation

Attacks

Assignments



### Alternative Traits and Fusion

Concepts



### Invited Talks (2)

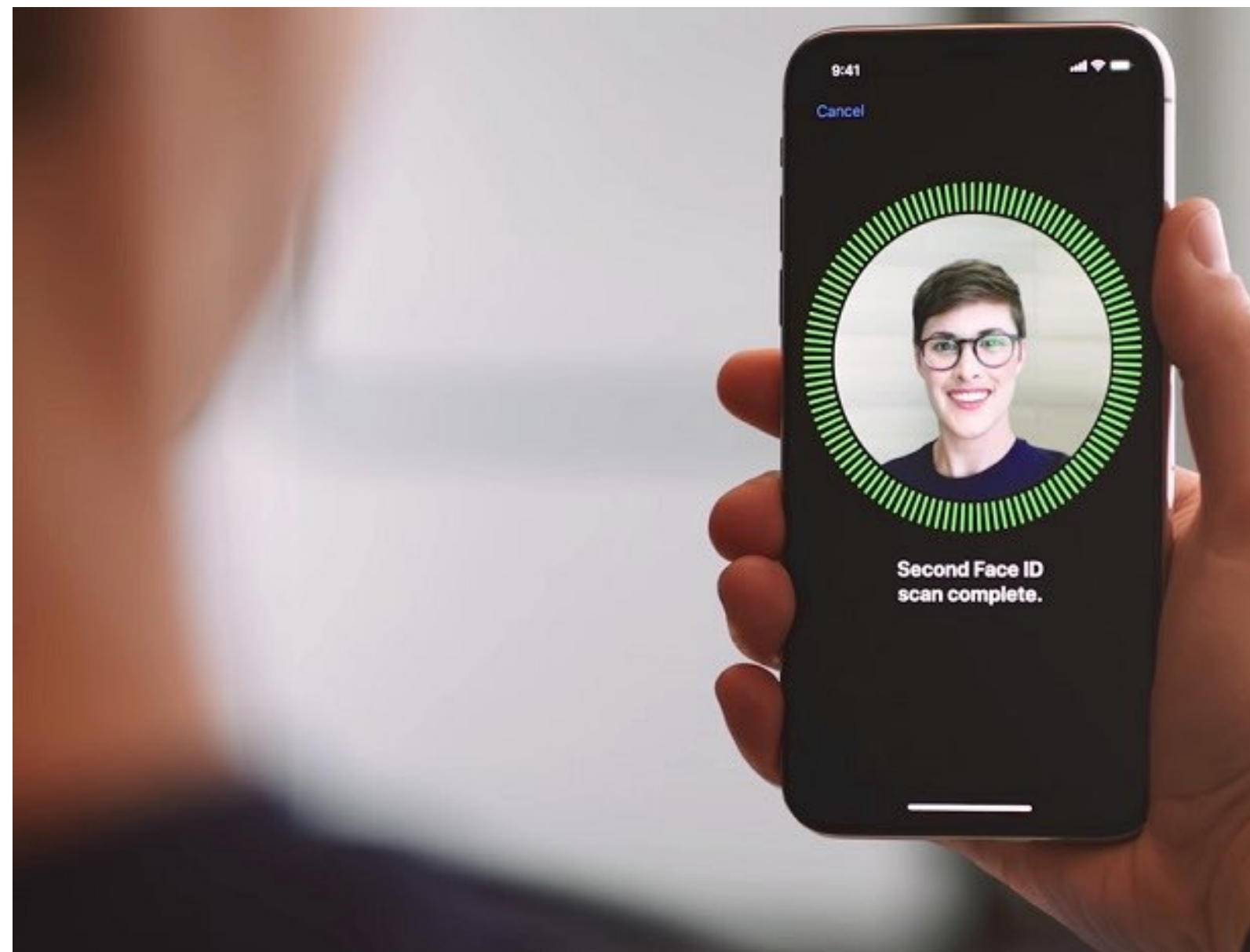
State of the art

Future work

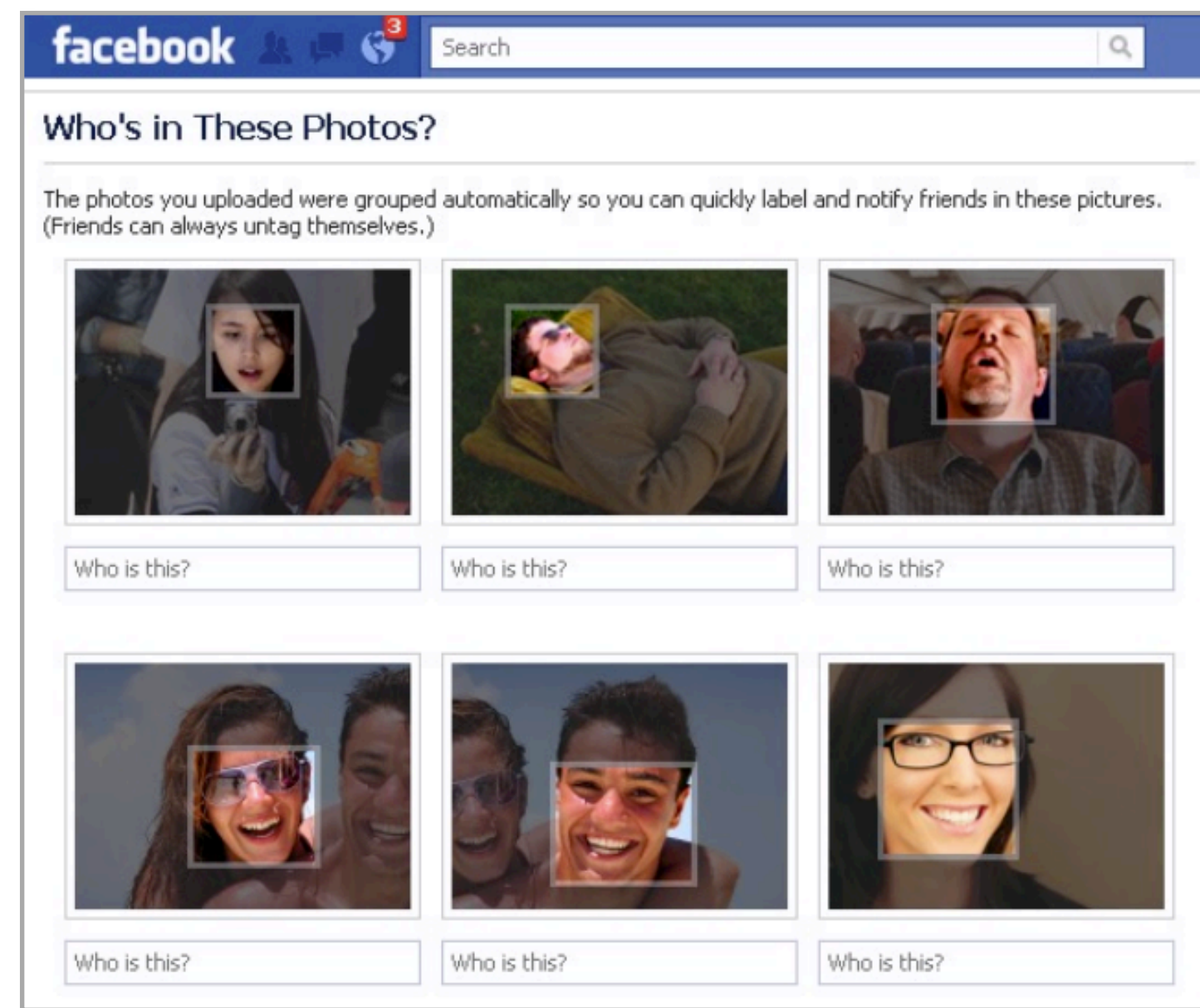


# Why Faces?

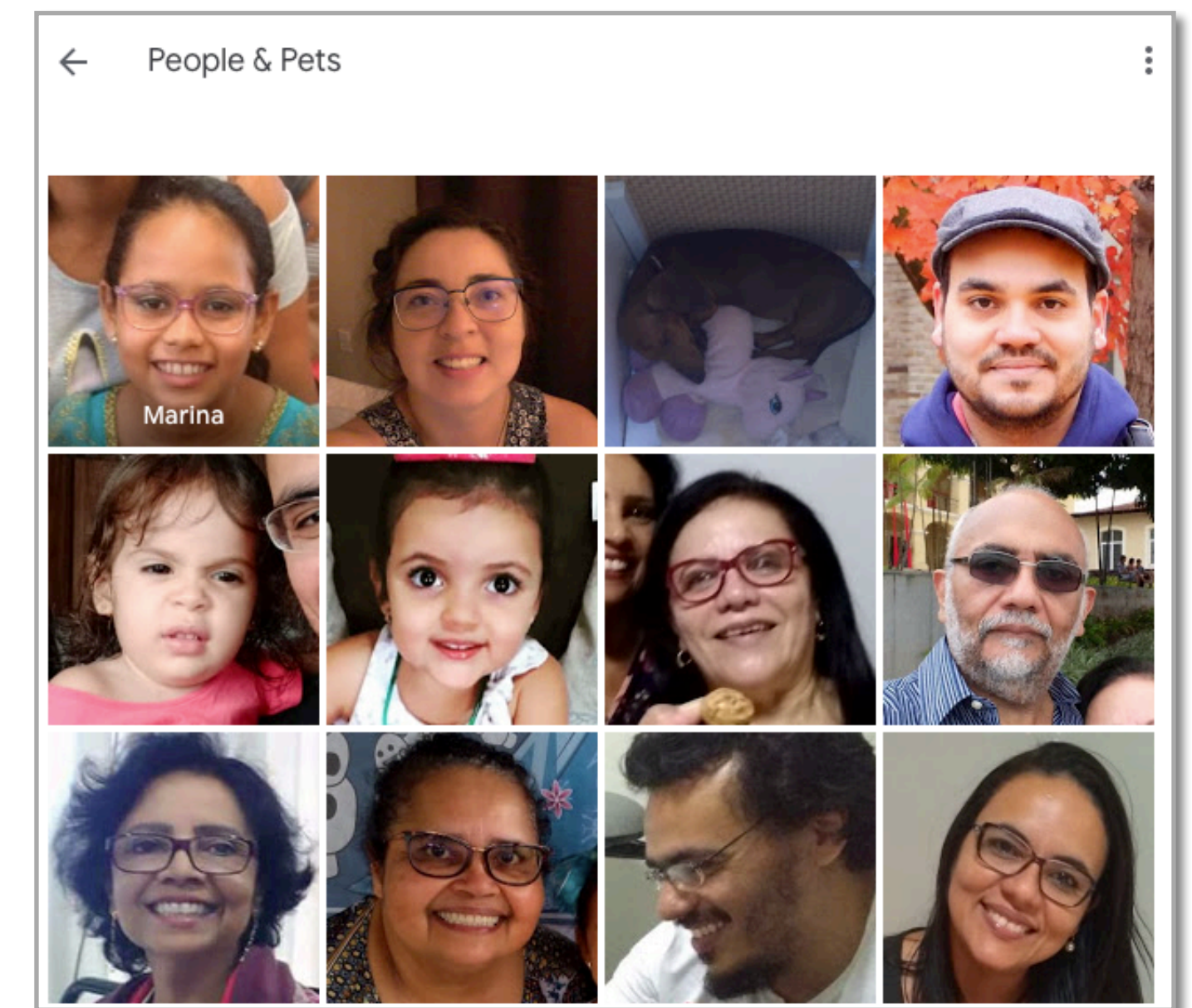
Face recognition is a reality



Personal devices



Facebook

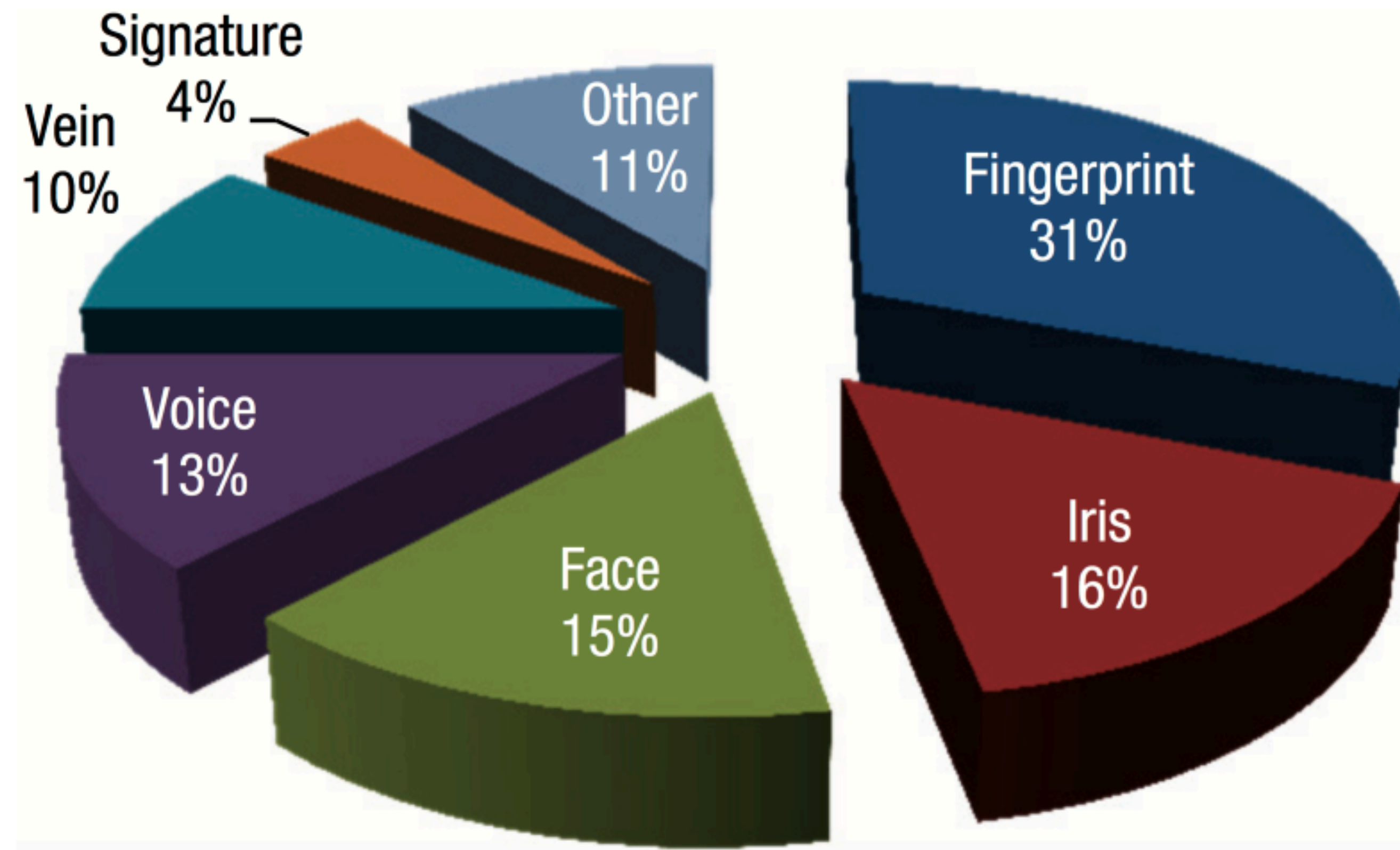


Google Photos



# 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



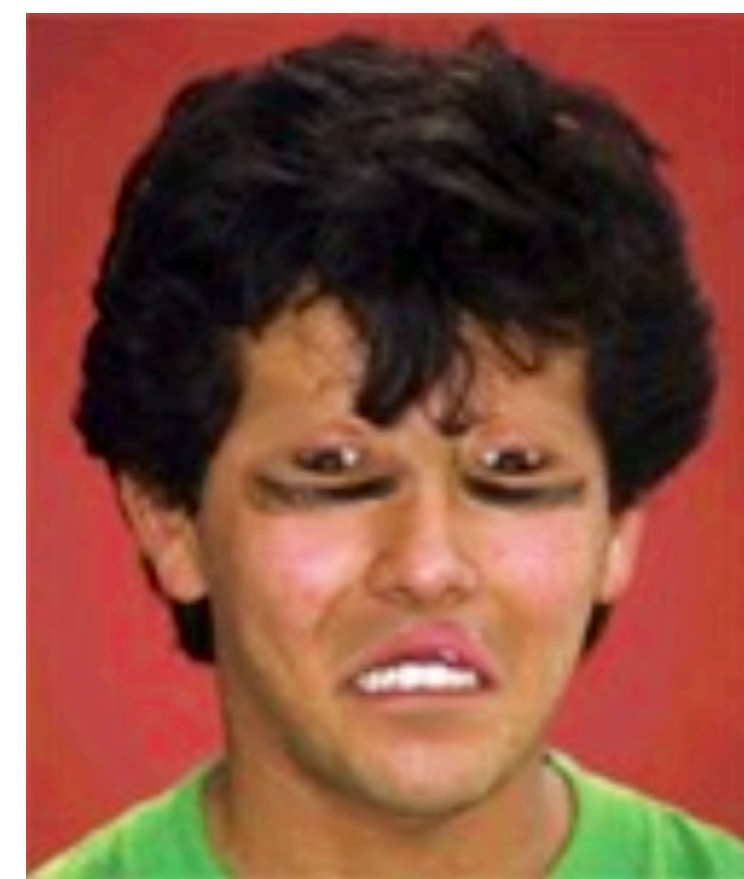
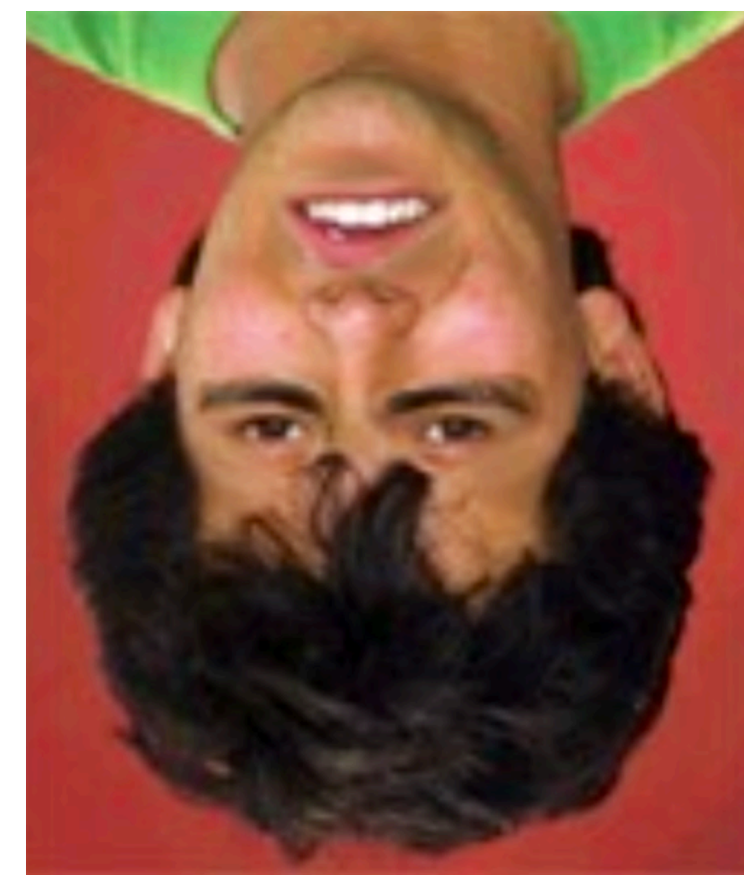
Who is she?



How different from  
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# Why Faces?



<https://faculty.washington.edu/chudler/java/faces.html>



# Why Faces?

**Face recognition is an innate ability**

## **Facial Pareidolia**

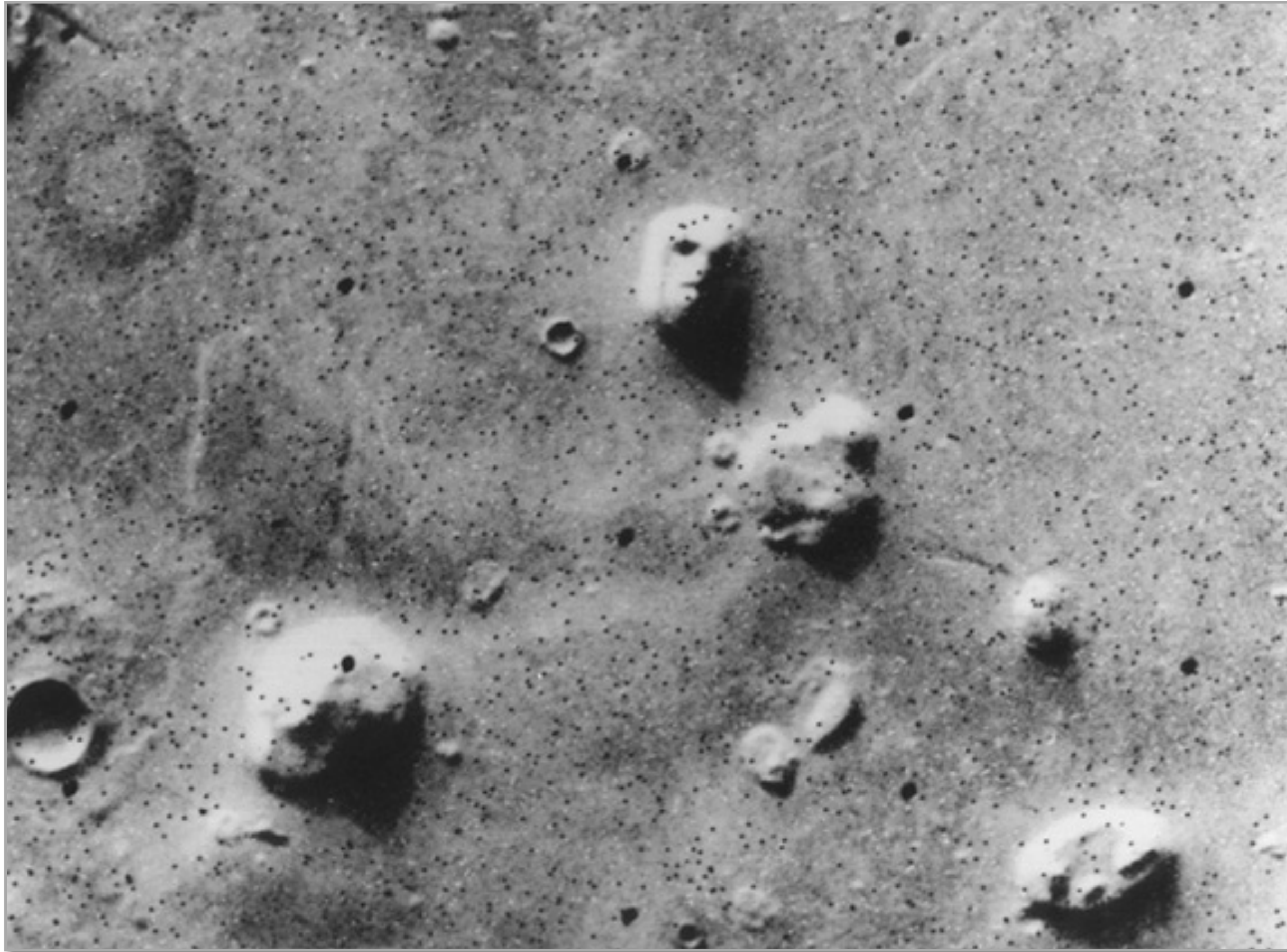
It is natural for us to perceive faces on random places.





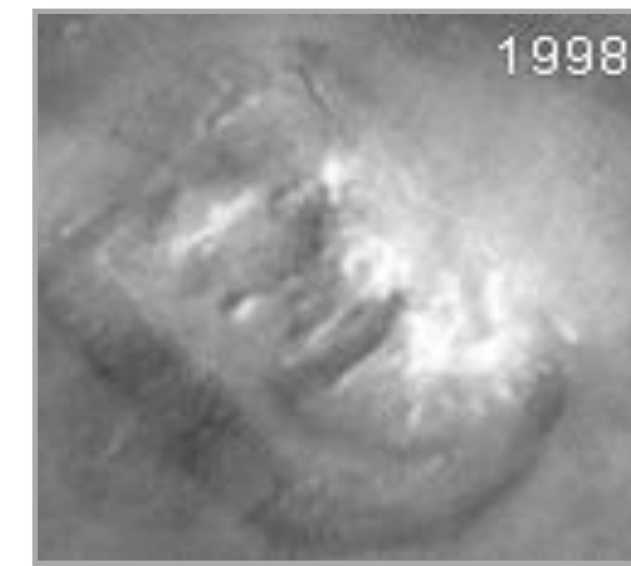
# Why Faces?

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



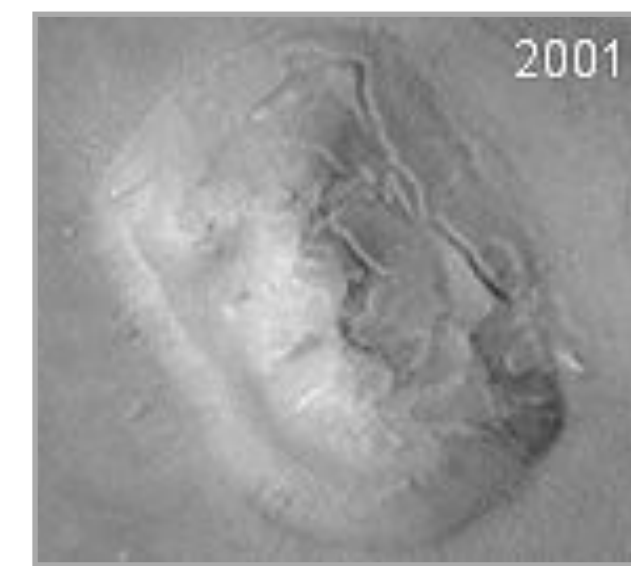
1976

1976



1998

1998



2001

2001



# Why Faces?

*Slave's Market*  
Salvador Dalí





# 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?

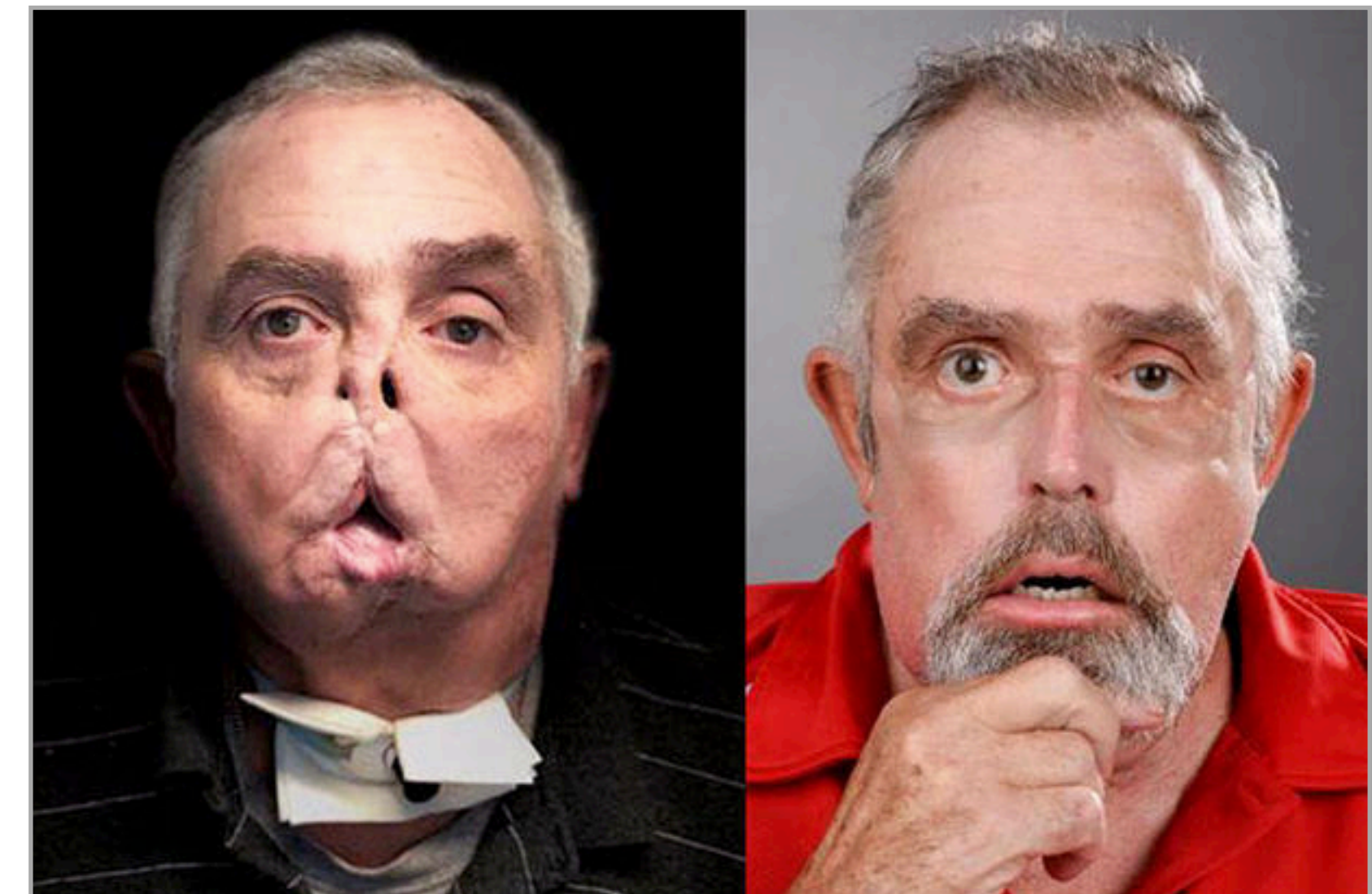
<https://www.smithsonianmag.com/science-nature/adermatoglyphia-genetic-disorder-people-born-without-fingerprints-180949338/>



Adermatoglyphia



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



Face transplants

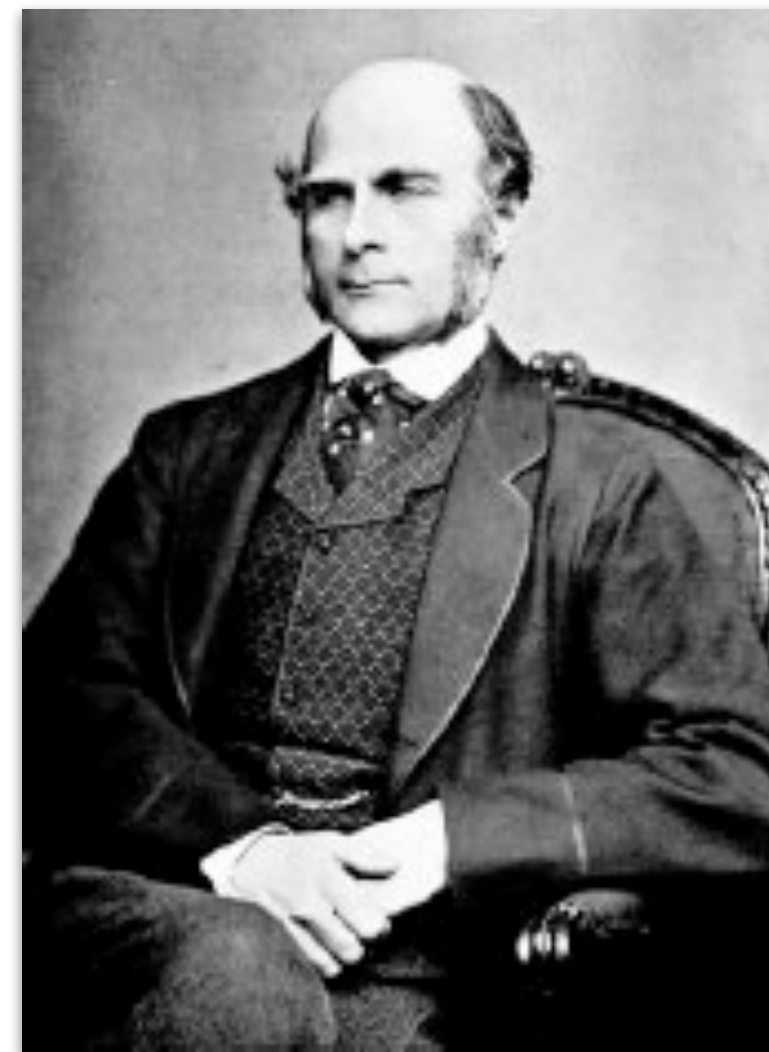


# Fingerprints, Irises vs. Faces

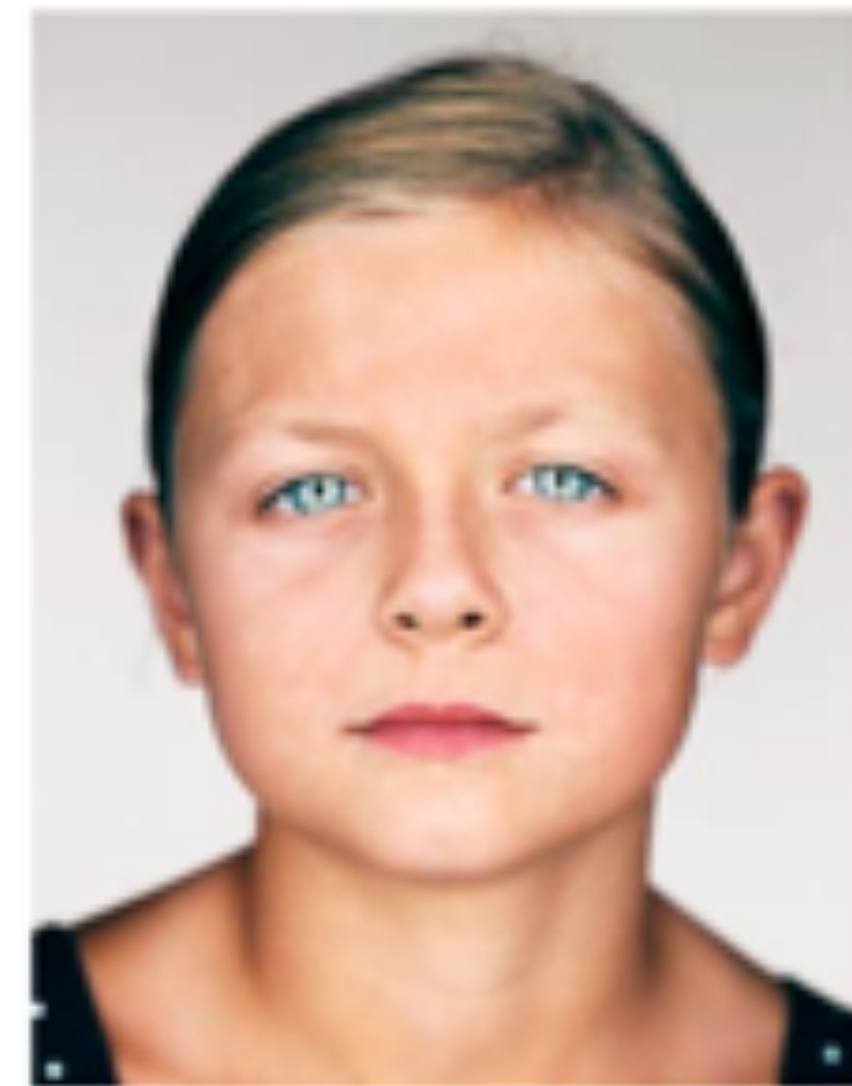
## Uniqueness (2/8)

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





# Identical Twins?

Source: John Daugman  
Lecture Notes, 2018



Source: John Daugman  
Lecture Notes, 2018





# Identical Twins?

Source: John Daugman  
Lecture Notes, 2018



Source: John Daugman  
Lecture Notes, 2018

Source: <http://lubbockonline.com/slideshows/051108/277846477/slide4.shtml>



Mother and daughter.



# Identical Twins?

Source: John Daugman  
Lecture Notes, 2018



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Source: <http://lubbockonline.com/slideshows/051108/277846477/slide4.shtml>



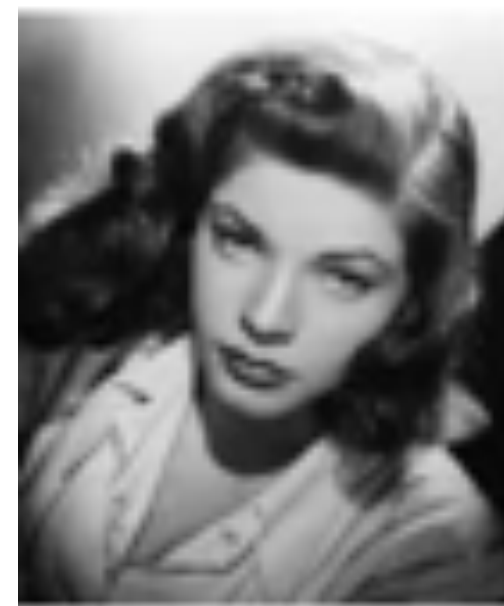
Mother and daughter.



Source: John Daugman  
Lecture Notes, 2018

Unrelated.







Completely  
unrelated  
subjects.



Source: John Daugman  
Lecture Notes, 2018





# Fingerprints, Irises vs. Faces

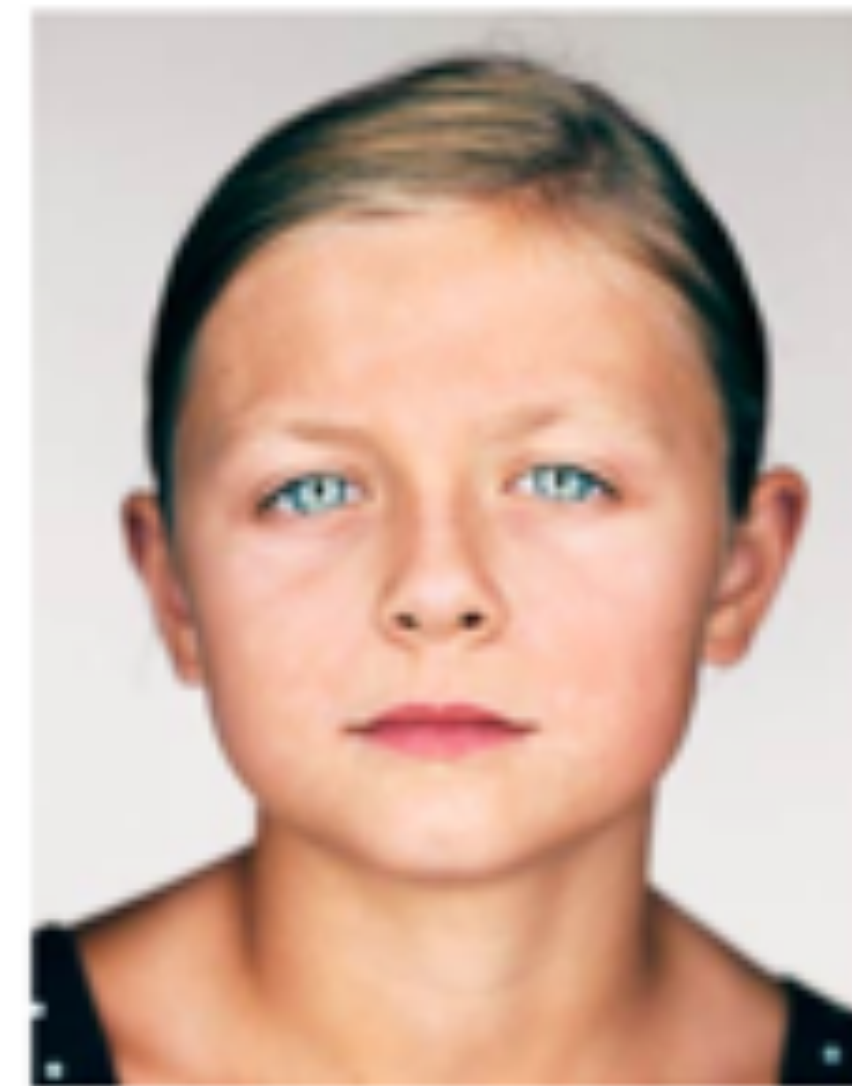
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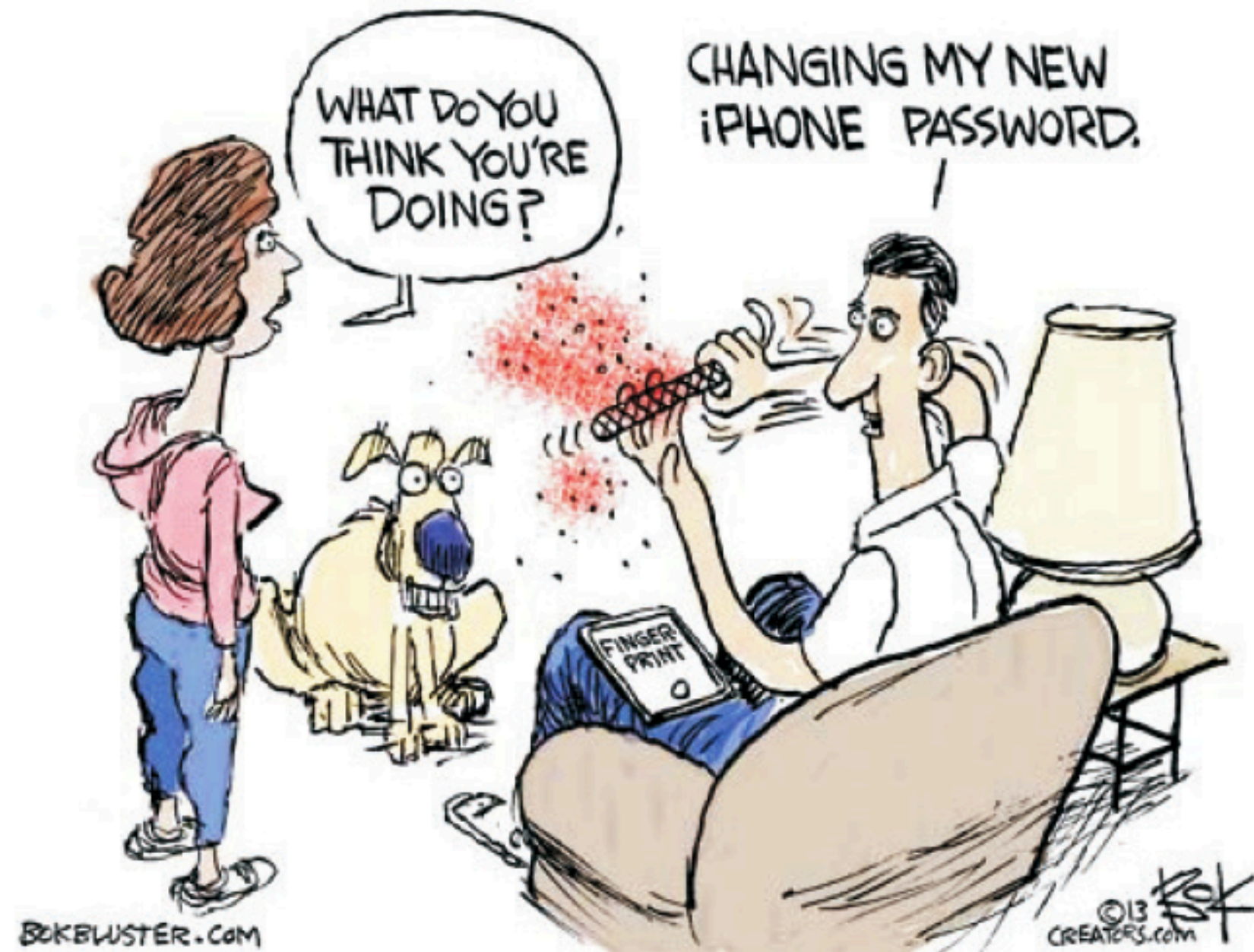
Identical twins.



# 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?

Source: Lantinis

*A survey of the effects of aging on biometric identity verification*

International Journal of Biometrics 2(1), 2010

## Aging





# 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





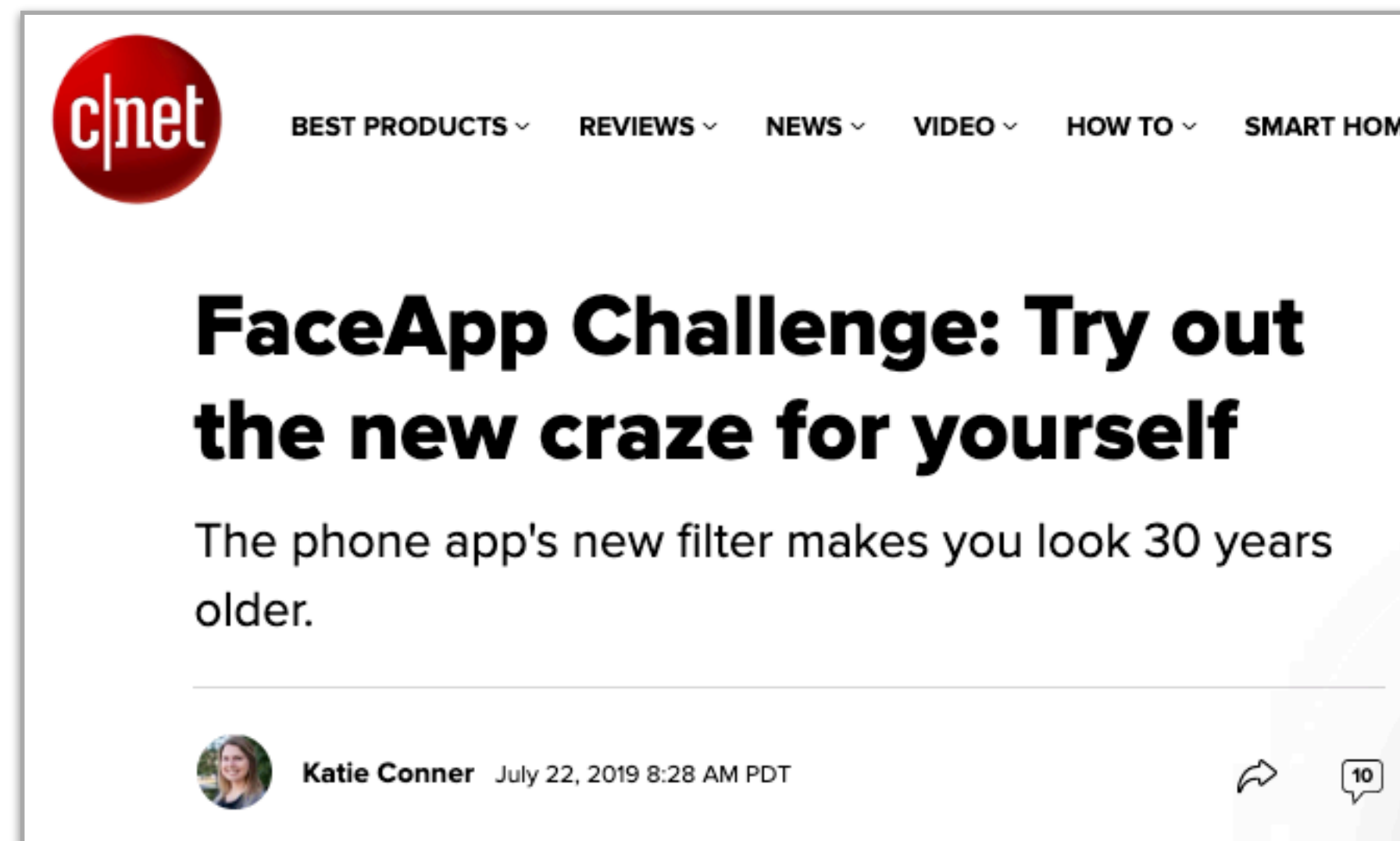
# Fingerprints, Irises vs. Faces

## Permanence (3/8)

How easily does the trait change?

## Aging

Will it always be a challenge?



<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





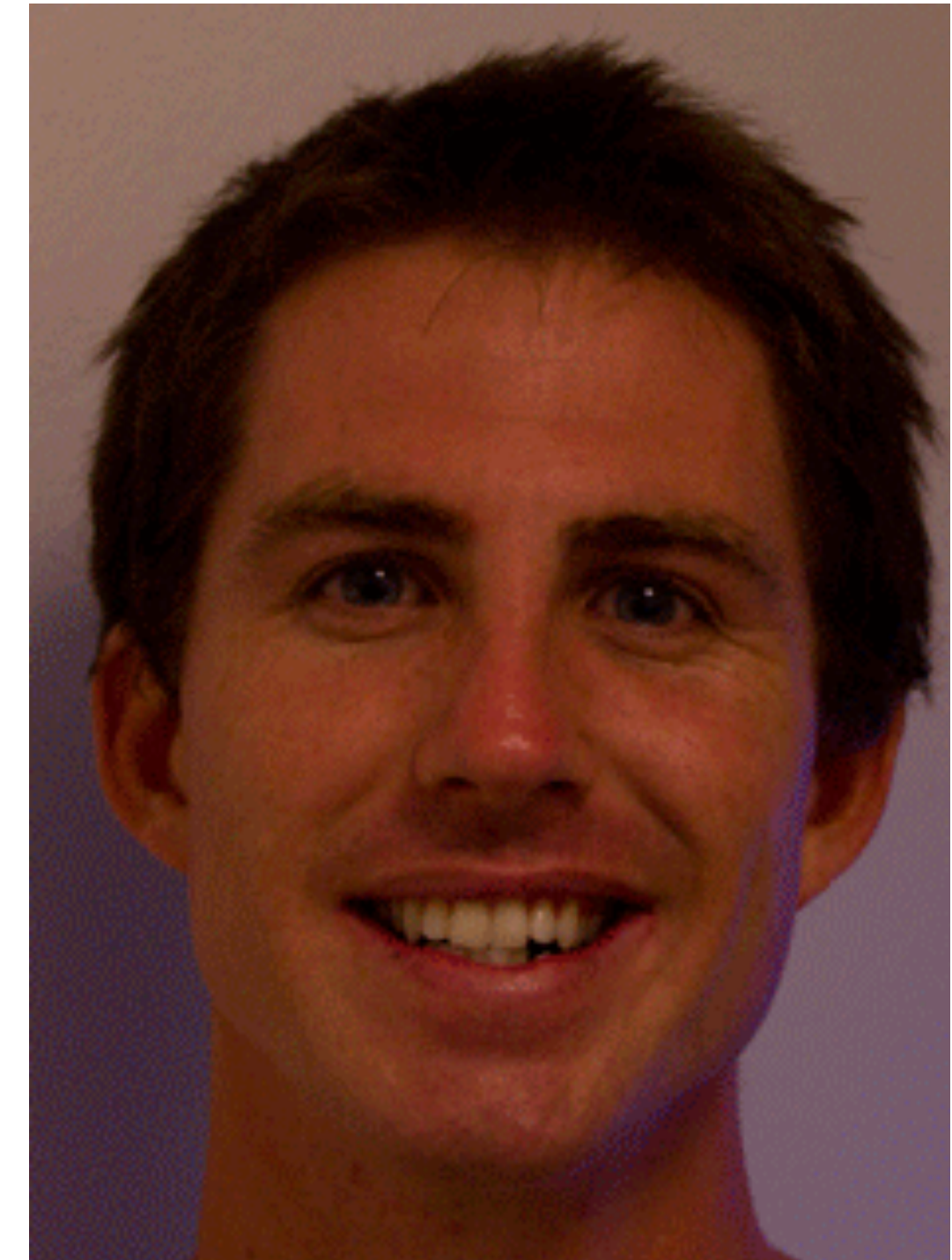
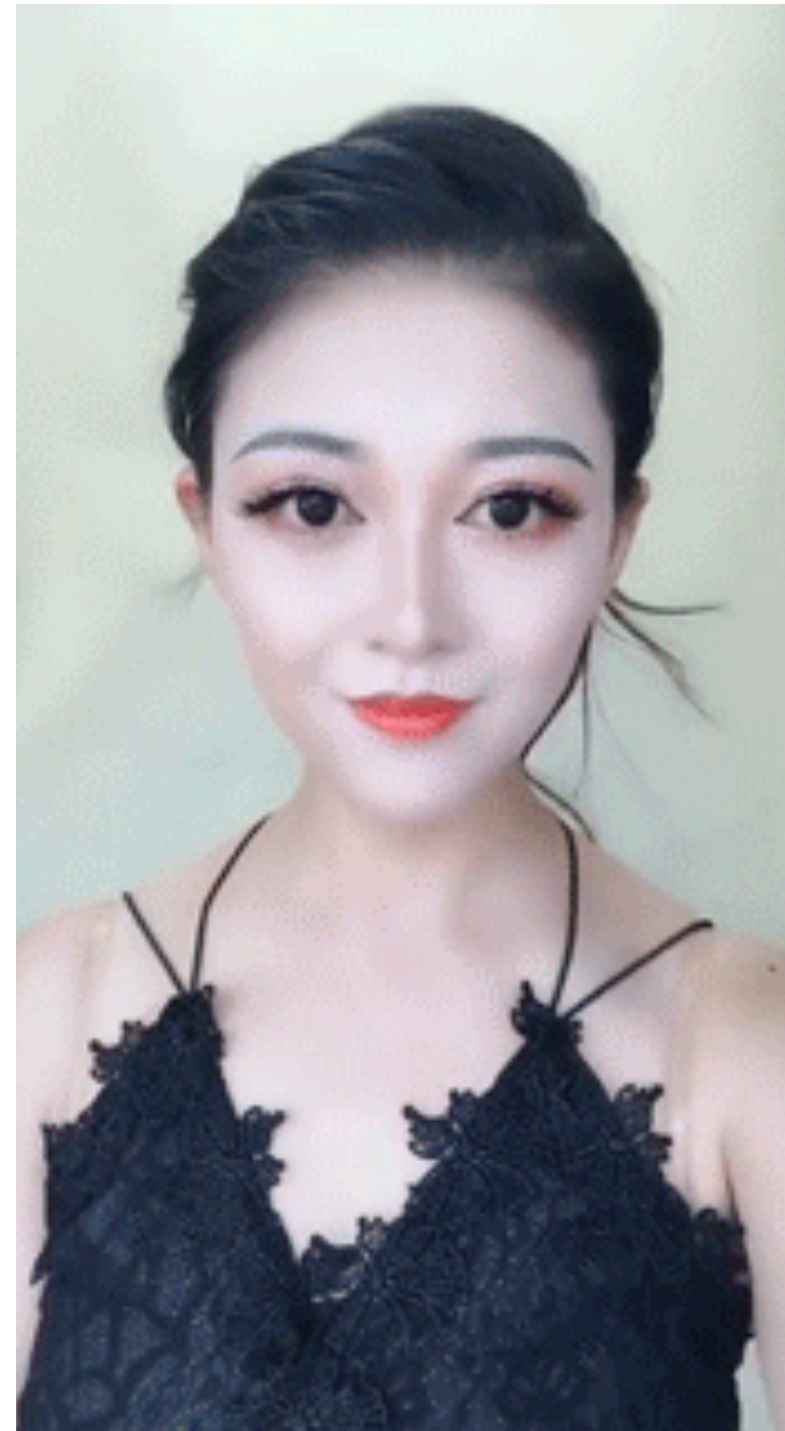
# Fingerprints, Irises vs. Faces

## Permanence (3/8)

How easily does the trait change?

## Deliberate Changes

<https://www.youtube.com/watch?v=Z4nc6OYY3no>



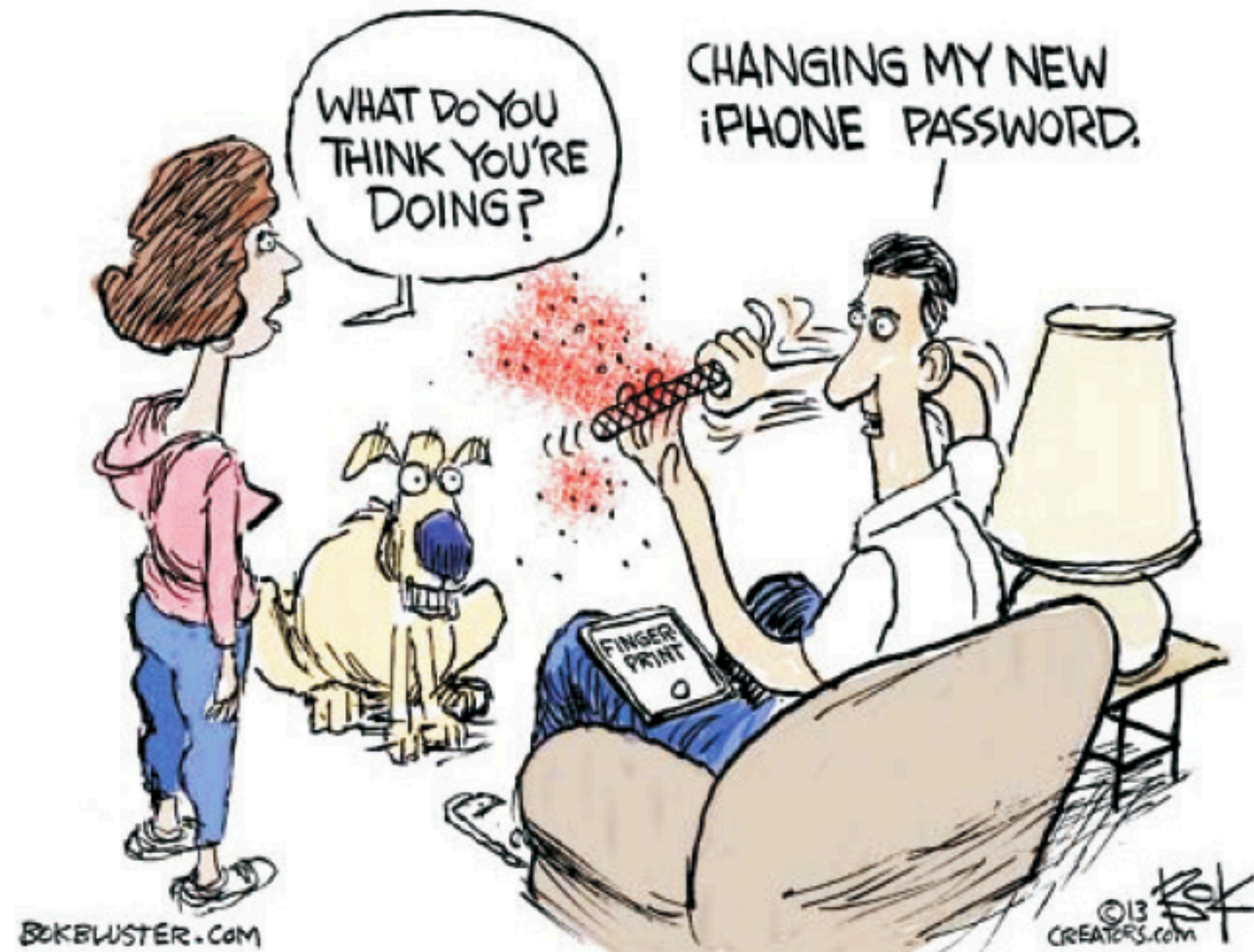




# Fingerprints, Irises vs. Faces

## 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)

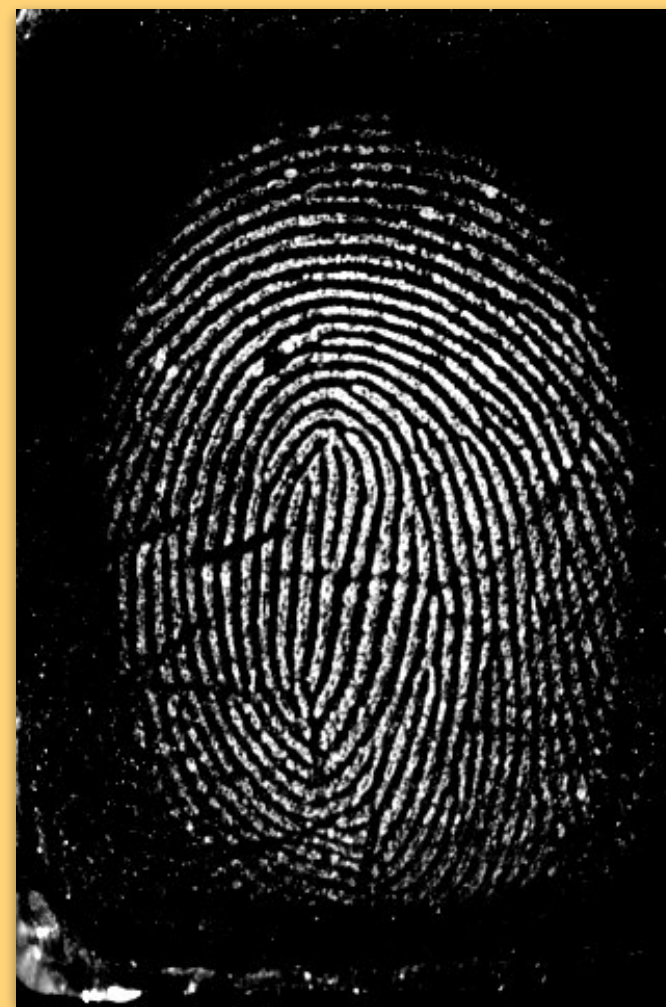


# Fingerprints, Irises vs. Faces

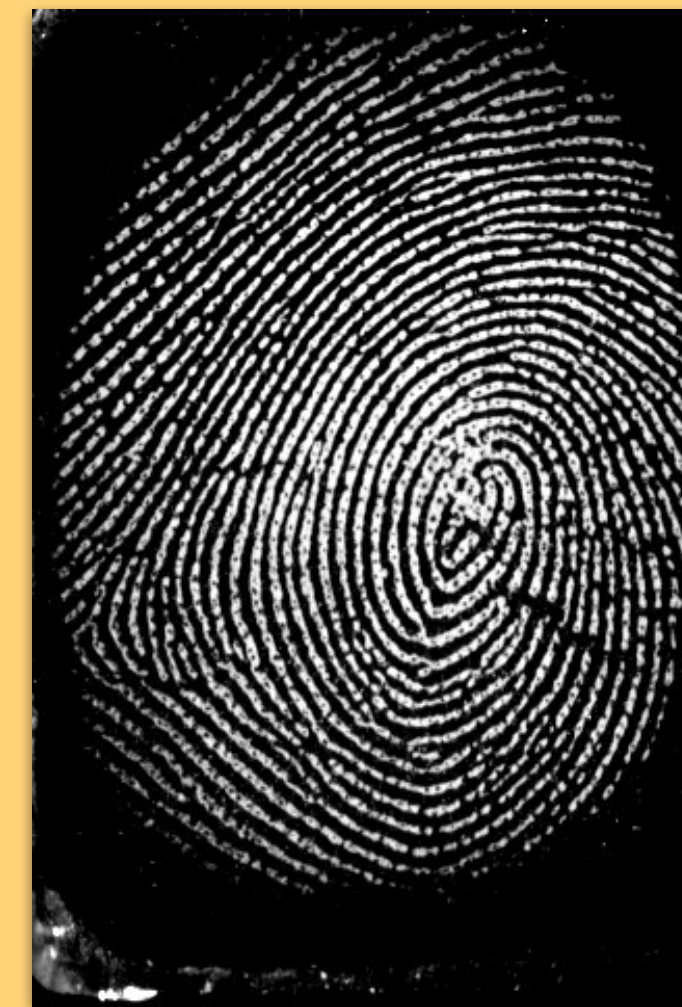
## Acceptability (5/8)

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



**Latent Fingerprint**

**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?



# Fingerprints, Irises vs. Faces

## Acceptability (5/8)

Will individuals collaborate during data collection?

## Privacy Concerns



**“Latent Face”**

**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.



# 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”**



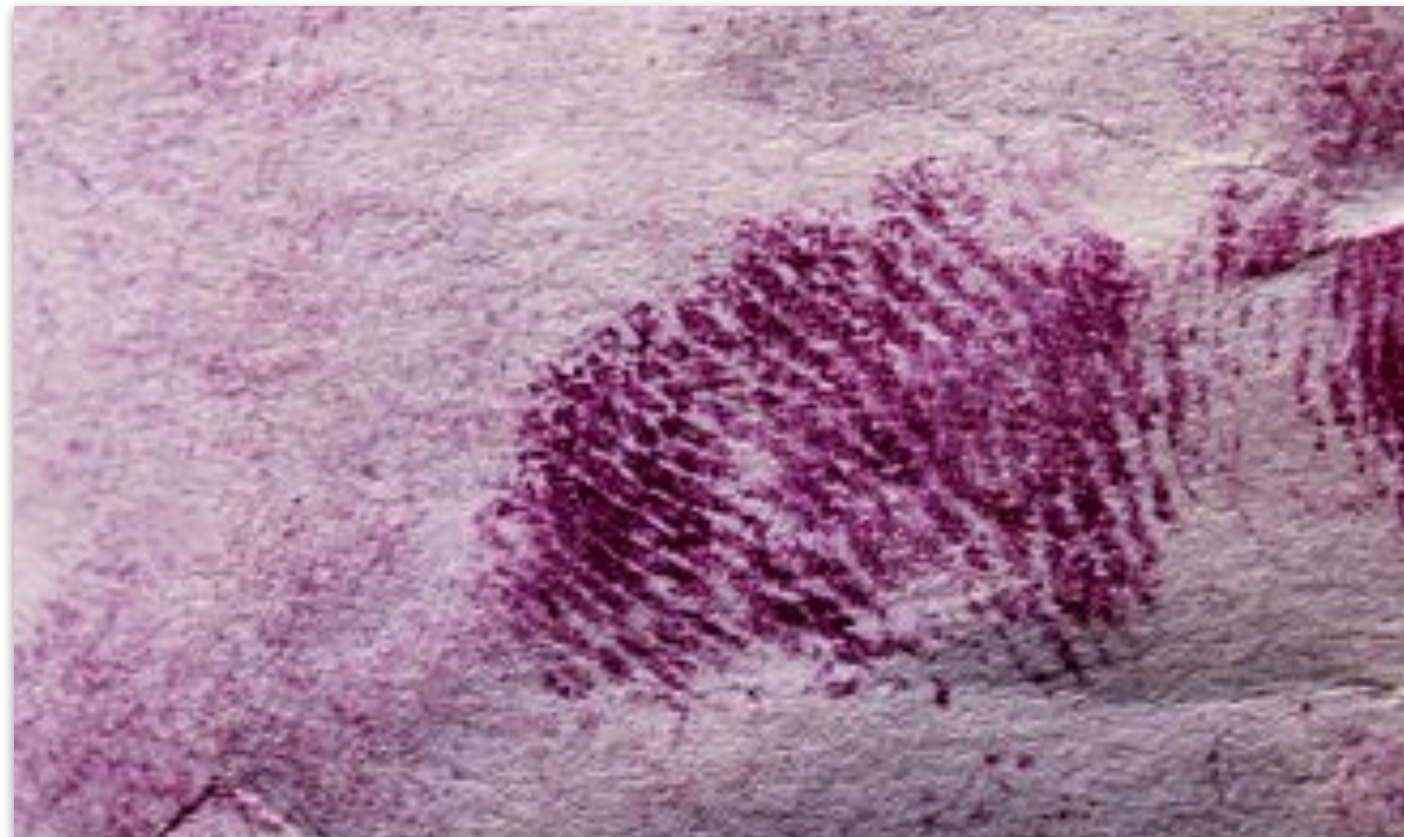
# Fingerprints, Irises vs. Faces

## 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=KdycMYILTr0>



**We are not there yet!**

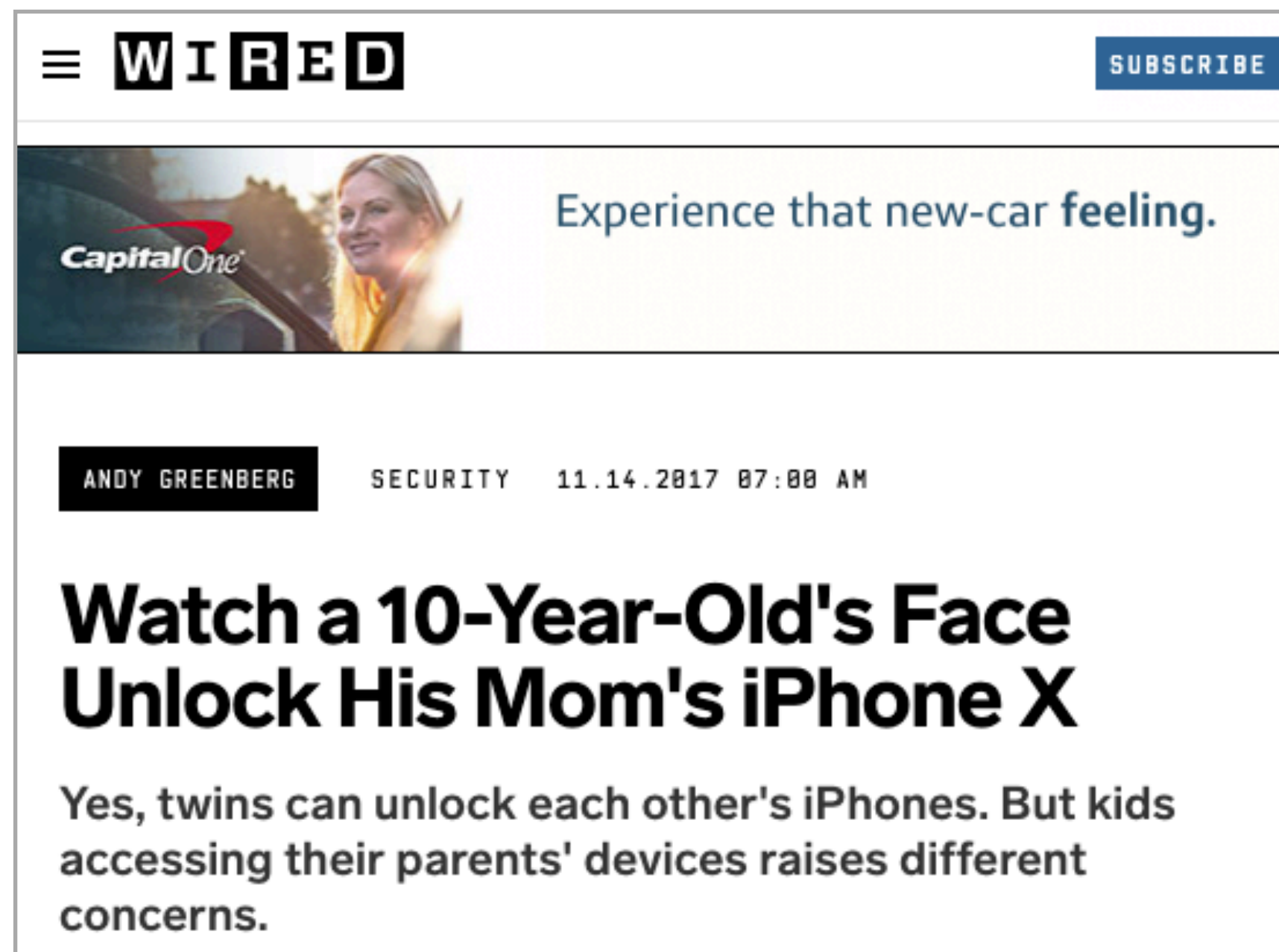


# Fingerprints, Irises vs. Faces

## Circumvention (6/8)

How easy can the trait be forged or imitated?

## Limitations



<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

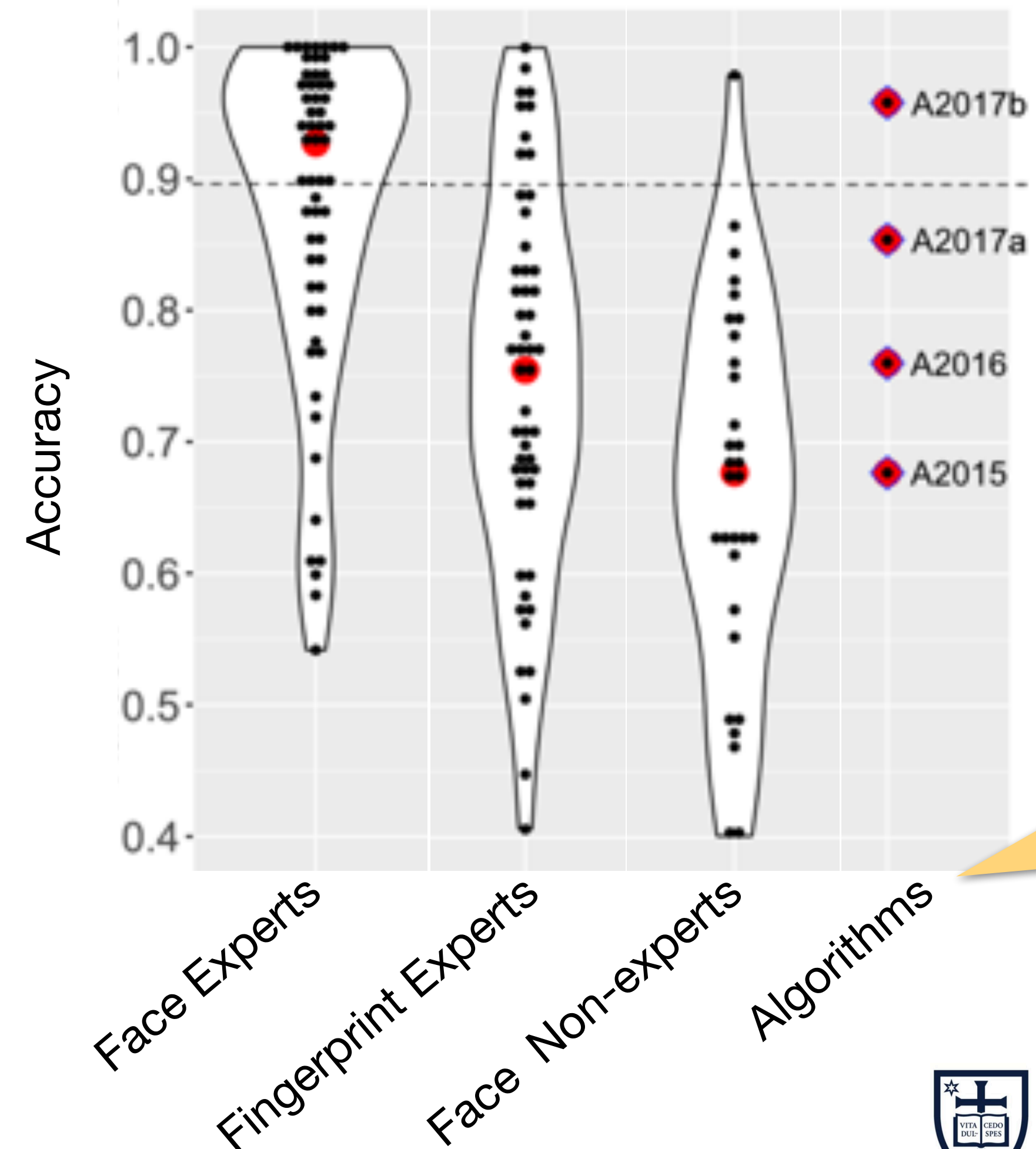
Methods are improving quickly.  
Benefits from deep learning.

## Publication

Phillips et al.

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

PNAS, 2018

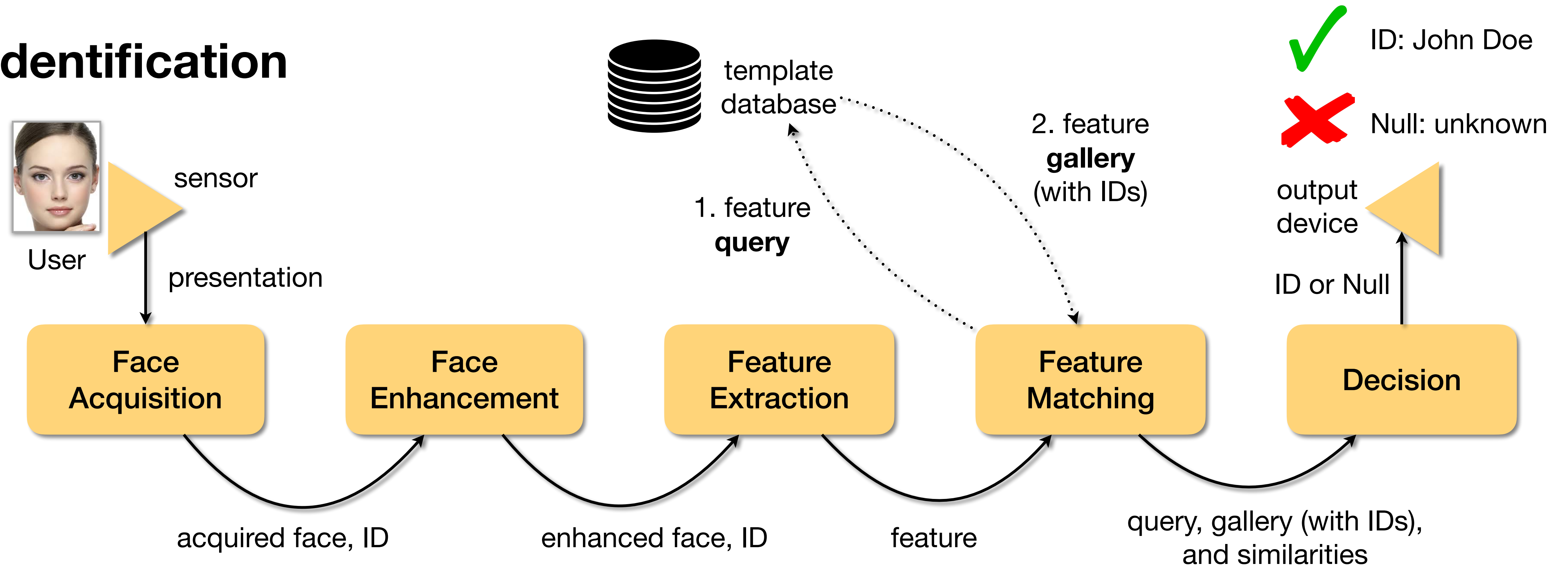


Deep Learning



# Face Recognition

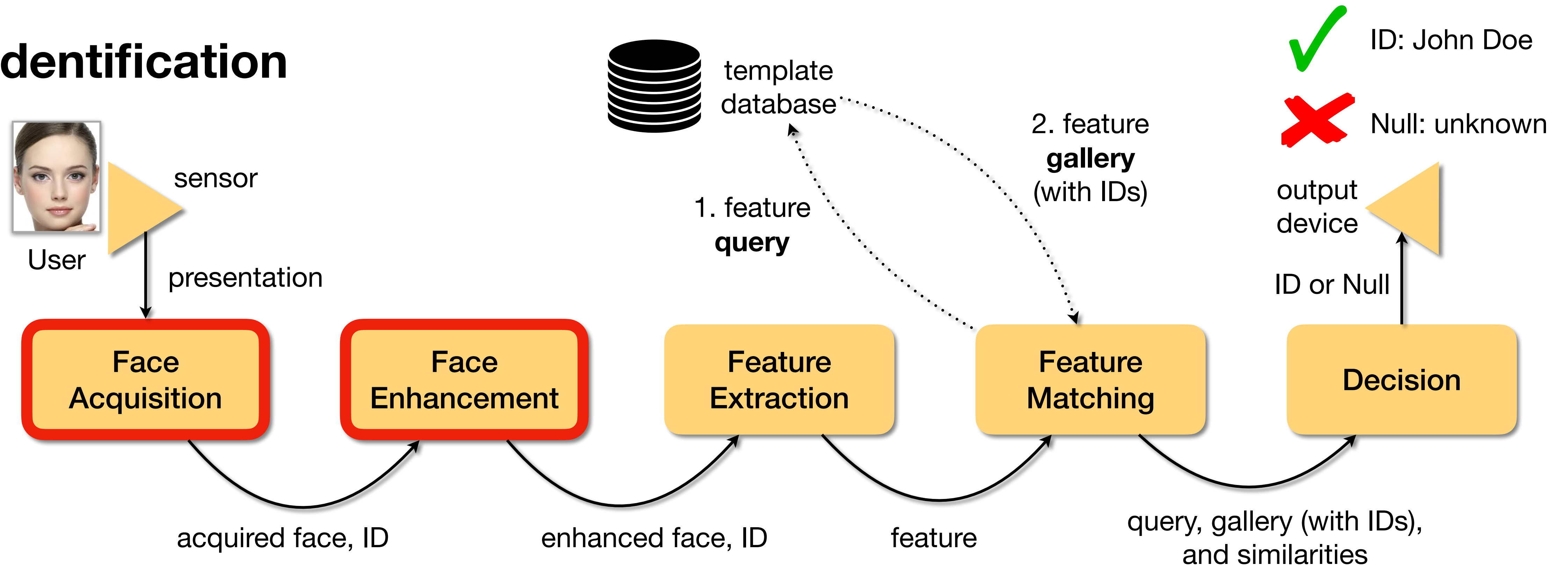
## Identification





# Face Recognition

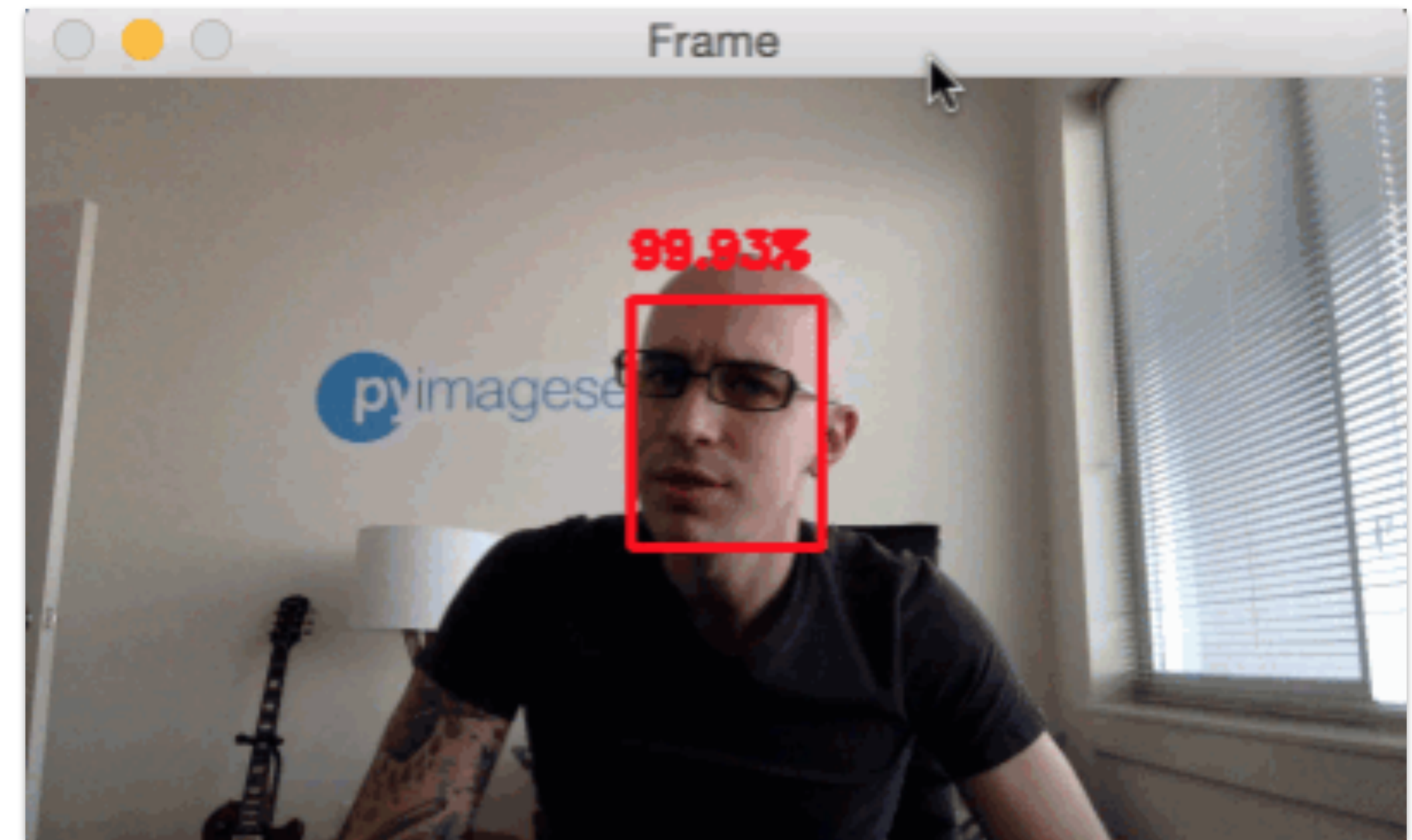
## Identification





# 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>