

1st Coding Class

COMP 388-002/488-002 Biometrics

Daniel Moreira

Fall 2024



LOYOLA
UNIVERSITY CHICAGO

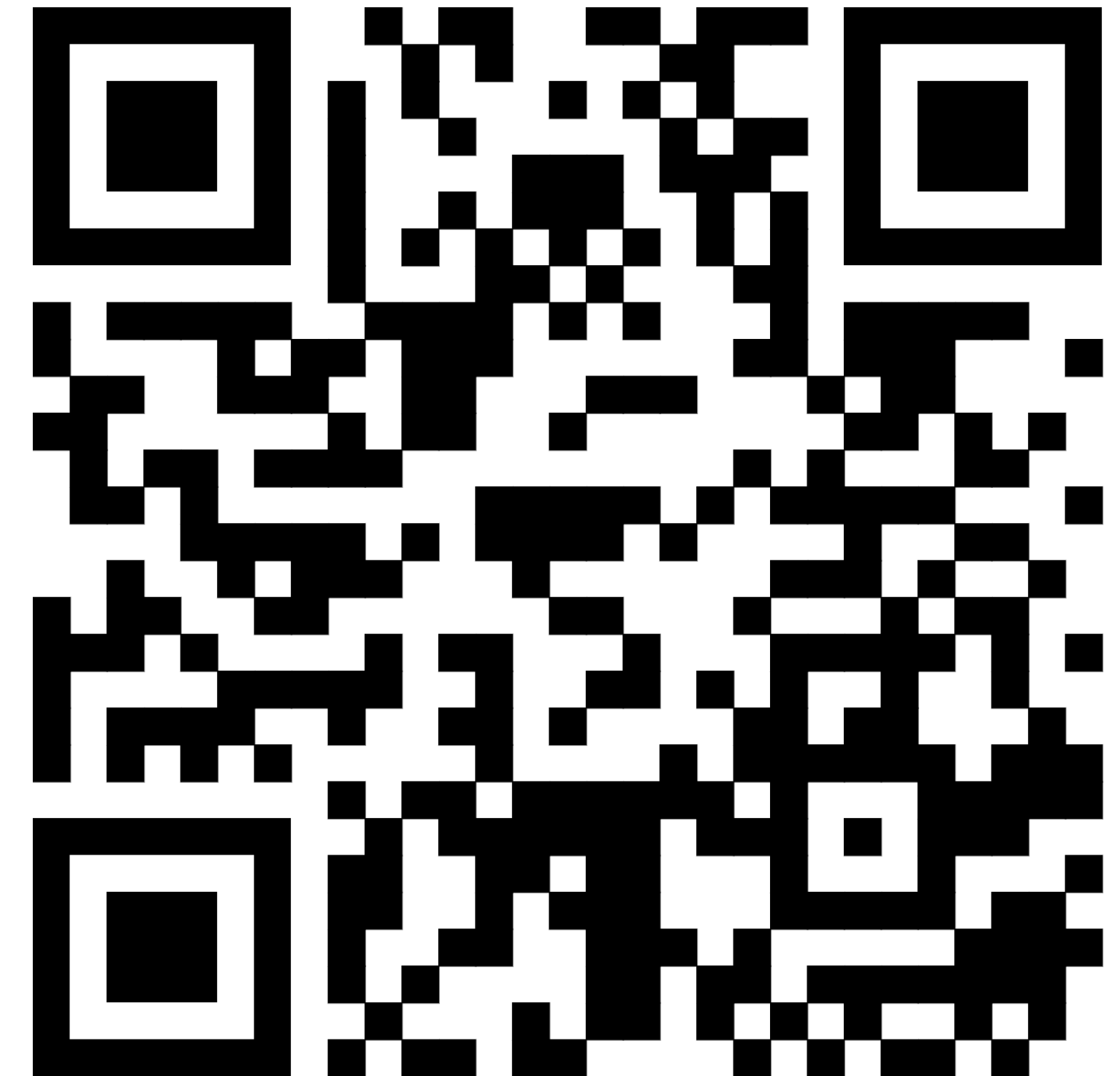
Today we will...

Inspect the
Implementation of metrics to compare
Biometric systems.

Today's Attendance

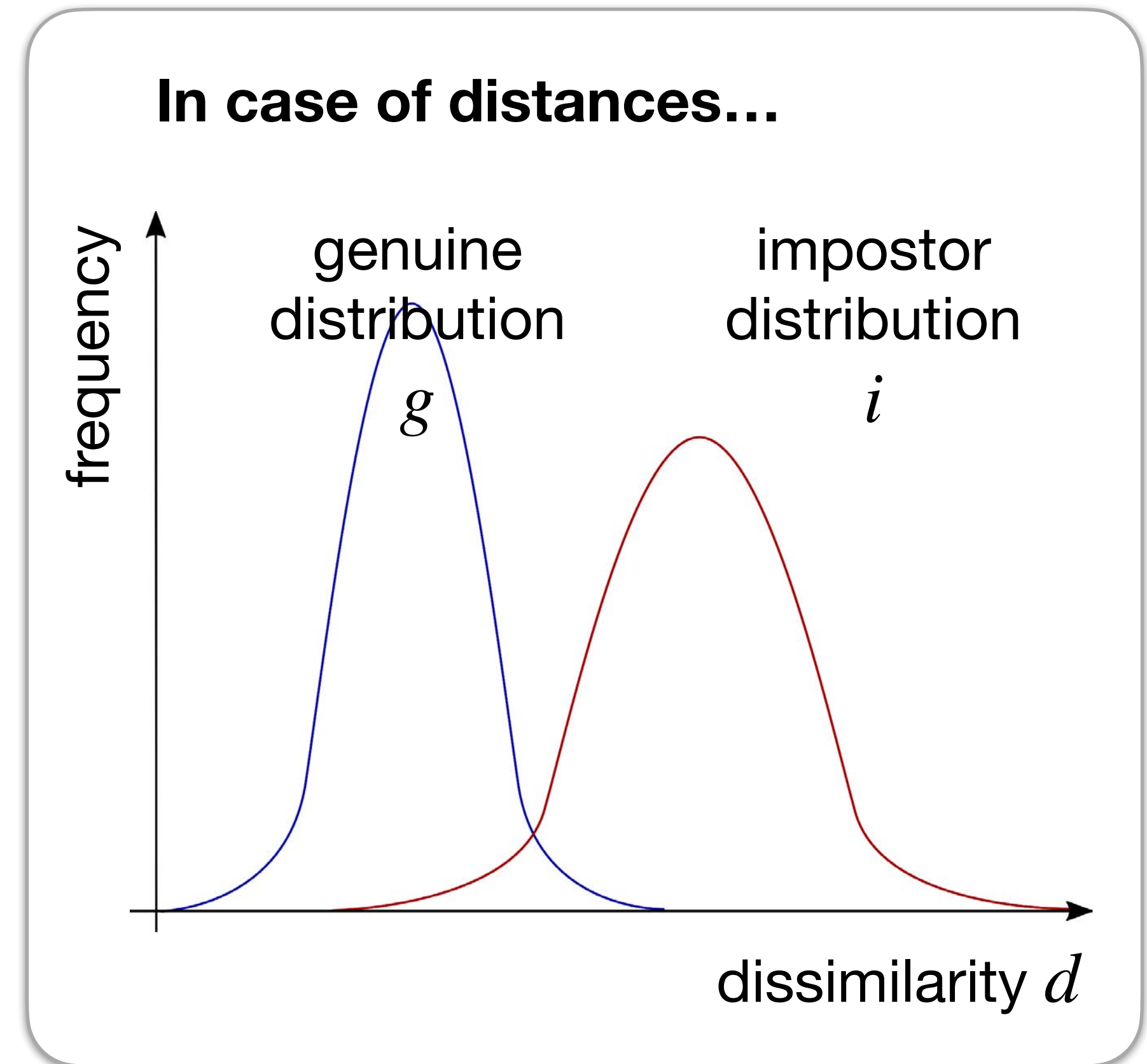
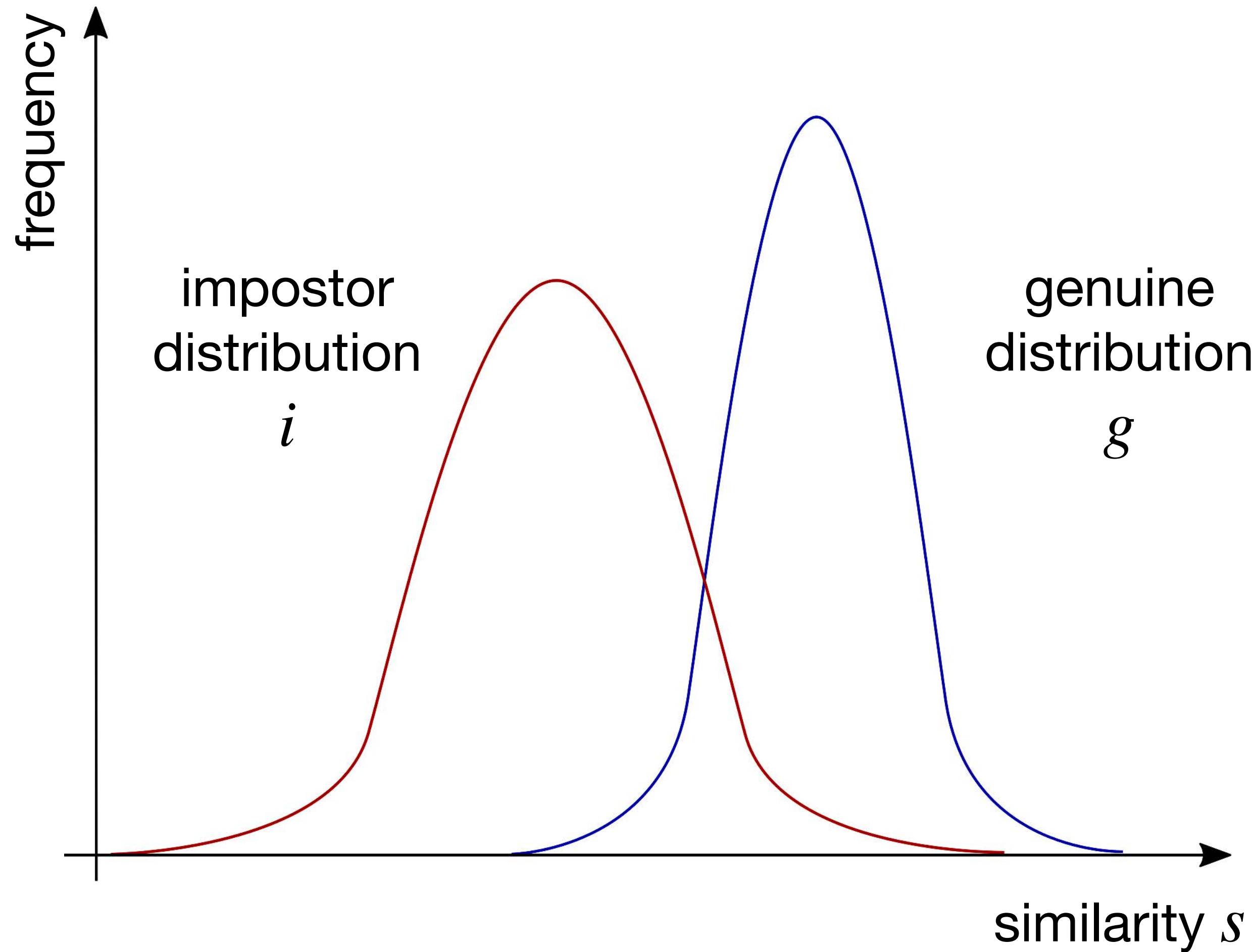
Please fill out the form

<https://forms.gle/LHw8biWGQiXMUKbK8>



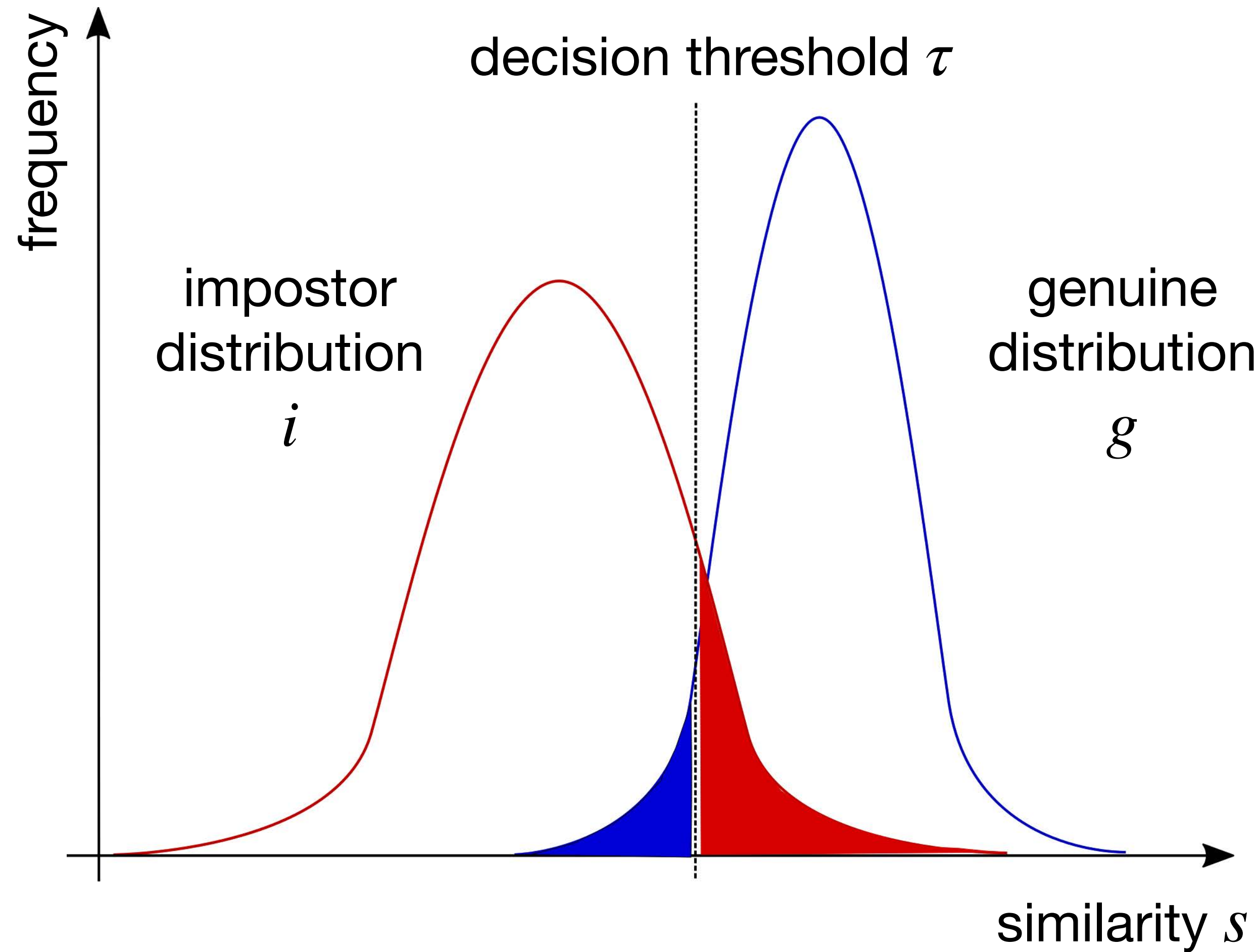
Metrics

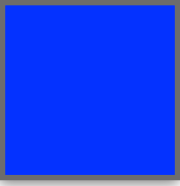
RECAP

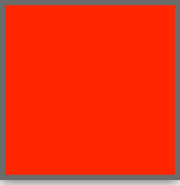


Metrics

RECAP



 $FNM(\tau) = \int_{-\infty}^{\tau} g(s) ds$

 $FM(\tau) = \int_{\tau}^{\infty} i(s) ds$

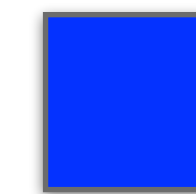
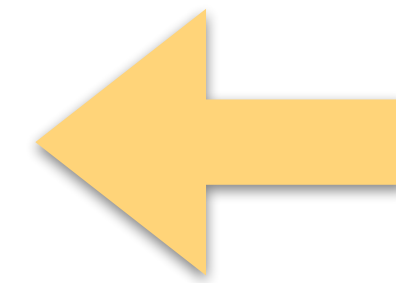
Metrics

RECAP

In Practice

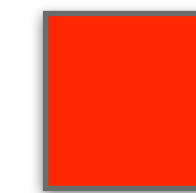
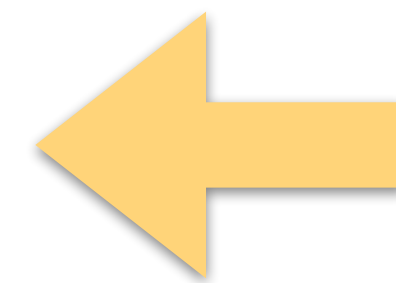
False Non-Match Rate (FNMR) and False Match Rate (FMR)

$$FNMR(\tau) = \frac{\#(\text{false nonmatches for } \tau)}{\#(\text{genuine comparisons})}$$



$$FNM(\tau) = \int_{-\infty}^{\tau} g(s) ds$$

$$FMR(\tau) = \frac{\#(\text{false matches for } \tau)}{\#(\text{impostor comparisons})}$$



$$FM(\tau) = \int_{\tau}^{\infty} i(s) ds$$

Metrics

RECAP

In Practice

False Non-Match Rate (FNMR) and False Match Rate (FMR)

$$FNMR(\tau) = \frac{\#(\text{false nonmatches for } \tau)}{\#(\text{genuine comparisons})}$$

How many of the genuine comparisons are wrongly computed by the system?

$$FMR(\tau) = \frac{\#(\text{false matches for } \tau)}{\#(\text{impostor comparisons})}$$

How many of the impostor comparisons are wrongly computed by the system?

Metrics

RECAP

In Practice

Interpretation of *R values.

Suppose a face recognition system with FMR=0.1%

FMR=0.001, one error in every 1K comparisons.

Is it good?



Suppose the Newark airport

5K people per hour, 14h per day (70K people per day)

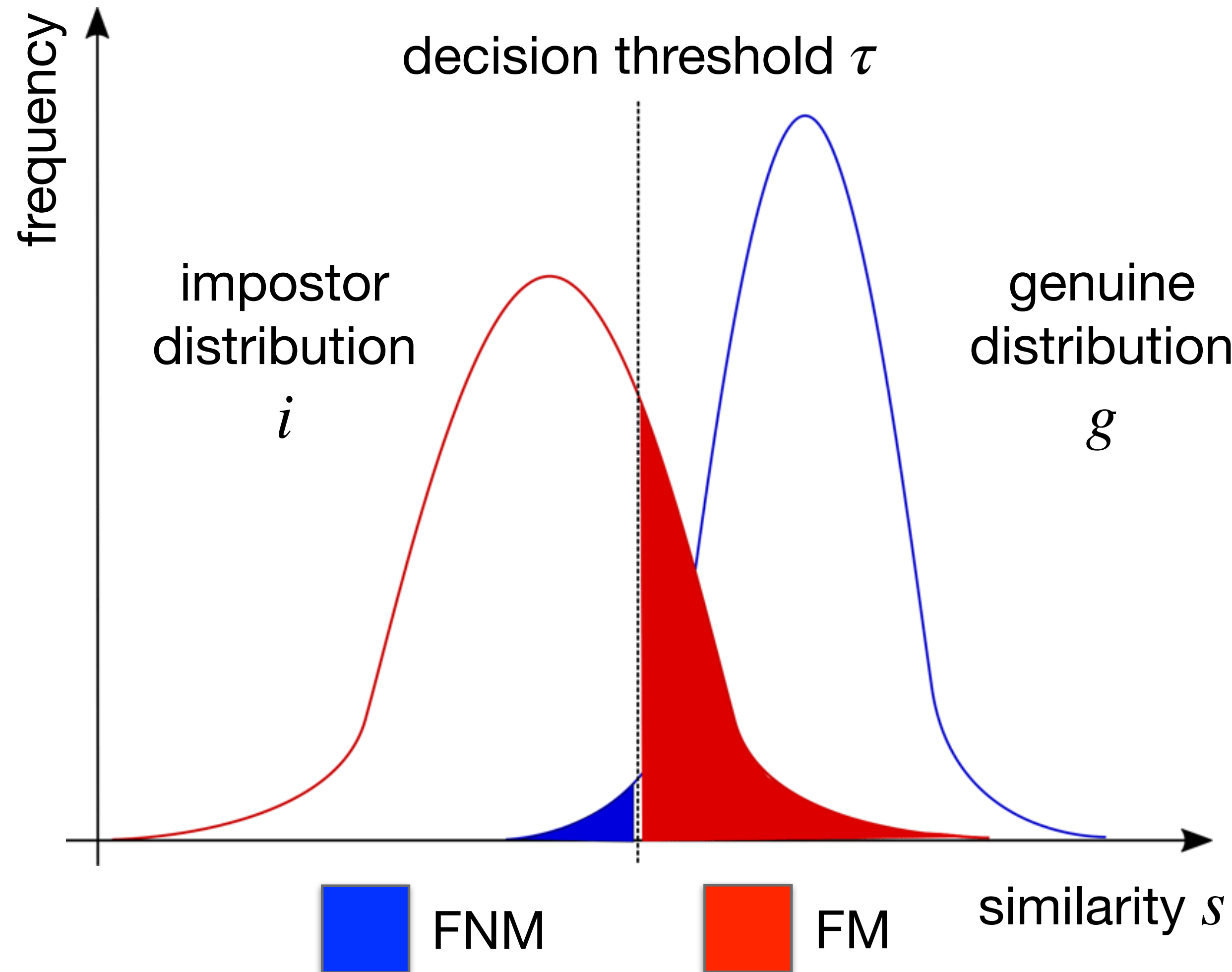
Suppose a suspect watch list with 100K people: 7 billion comparisons per day.

Average number of false matches per day: 7 million people to double check every day.

Terrorist watch list in 2016: 1,8 million people

Metrics

RECAP



What is the impact of changing the decision threshold?

The larger the value of τ :
The larger the value of FNM;
The smaller the value of FM.

FNM and FM are inversely proportional.

Metrics

RECAP

What to choose?

Small FNMR

Suitable to avoid denial of access and repudiation.

Increases intrusion probability, though.

Small FMR

Suitable to avoid intrusion.

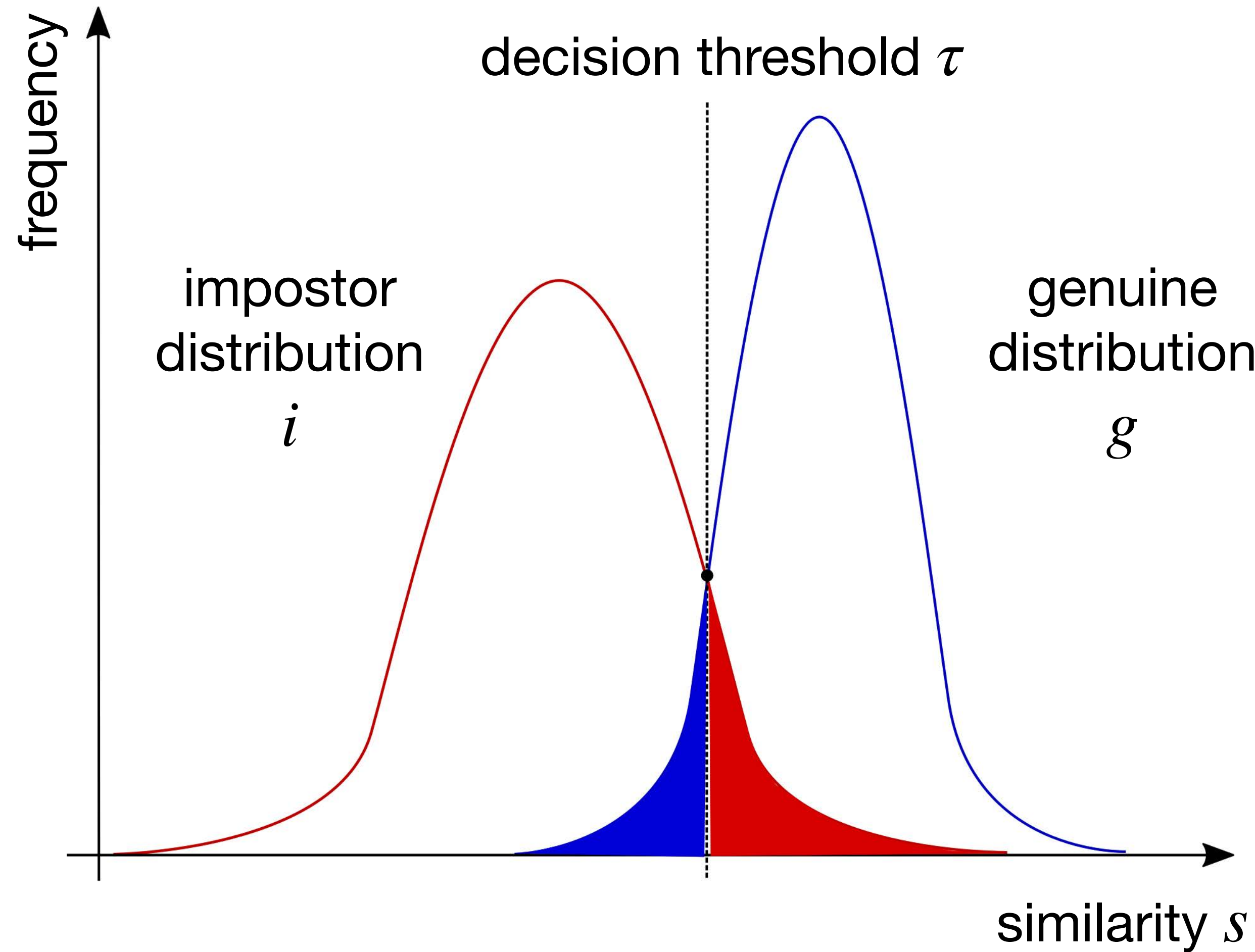
Increases denial of service and repudiation probability, though.



LOYOLA
UNIVERSITY CHICAGO

Metrics

RECAP



What to choose?

Equal Error Rate (EER)

Common practice.

Pick the threshold where
 $\text{FNMR} = \text{FMR}$.

Metrics

RECAP

How to compare two different systems?

Biometric systems *A* and *B*.

**Compare both systems' FNMR and FMR
at EER (1/3)**

Take the one with smaller FNMR and FMR values.

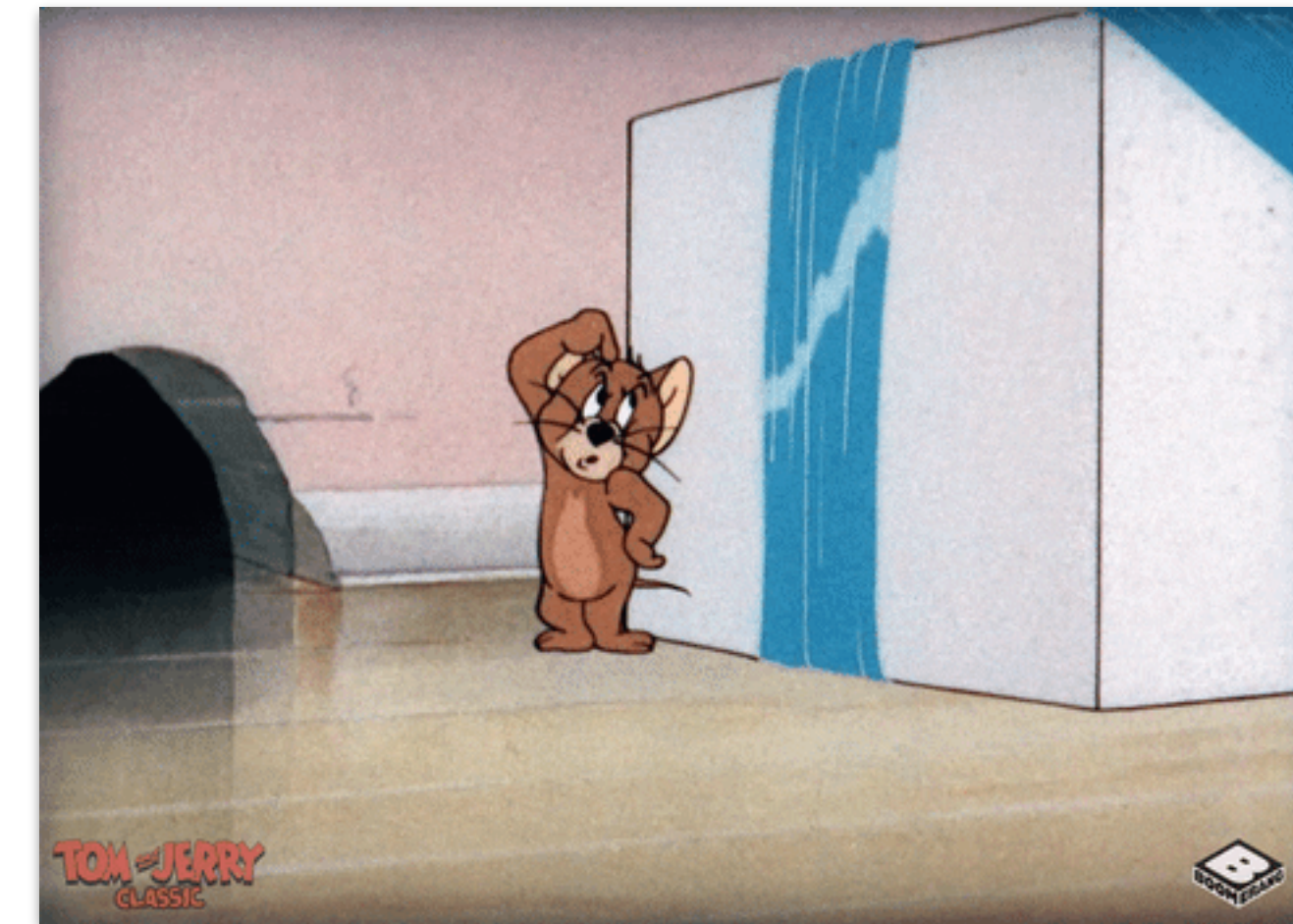


Metrics

RECAP

How to compare two different systems?
Biometric systems *A* and *B*.

Use a Receiver Operating Characteristic (ROC) curve (2/3)



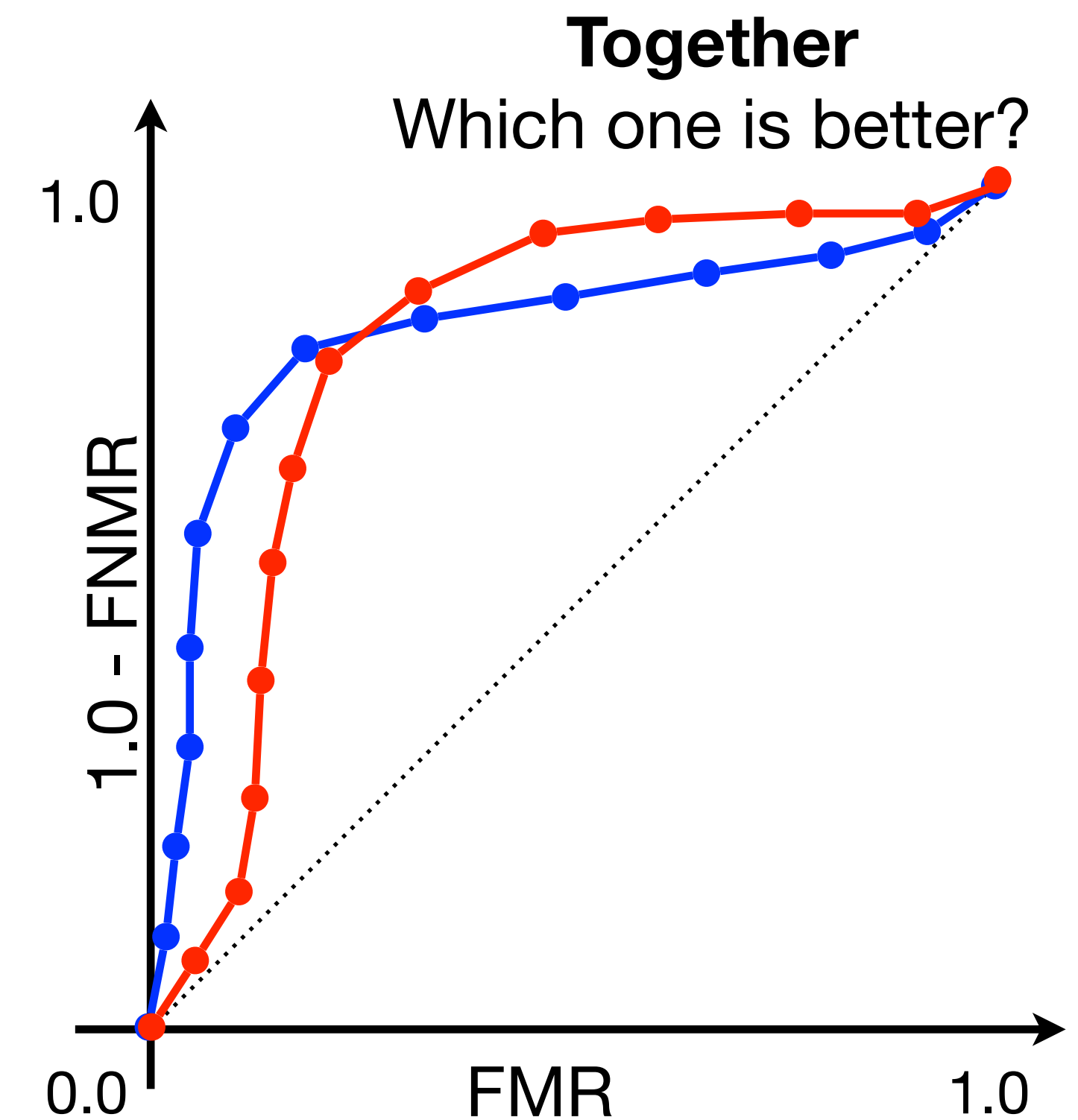
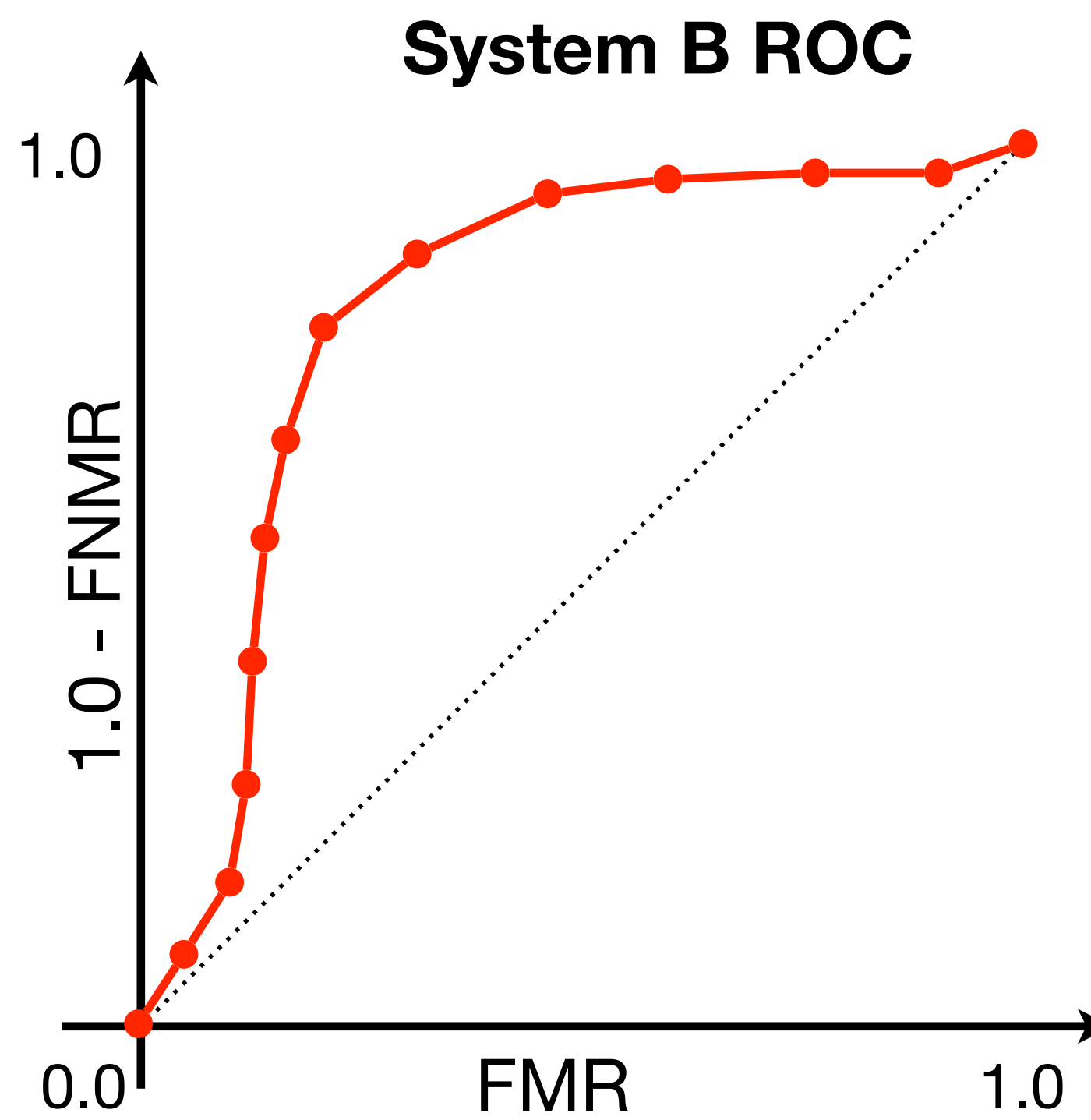
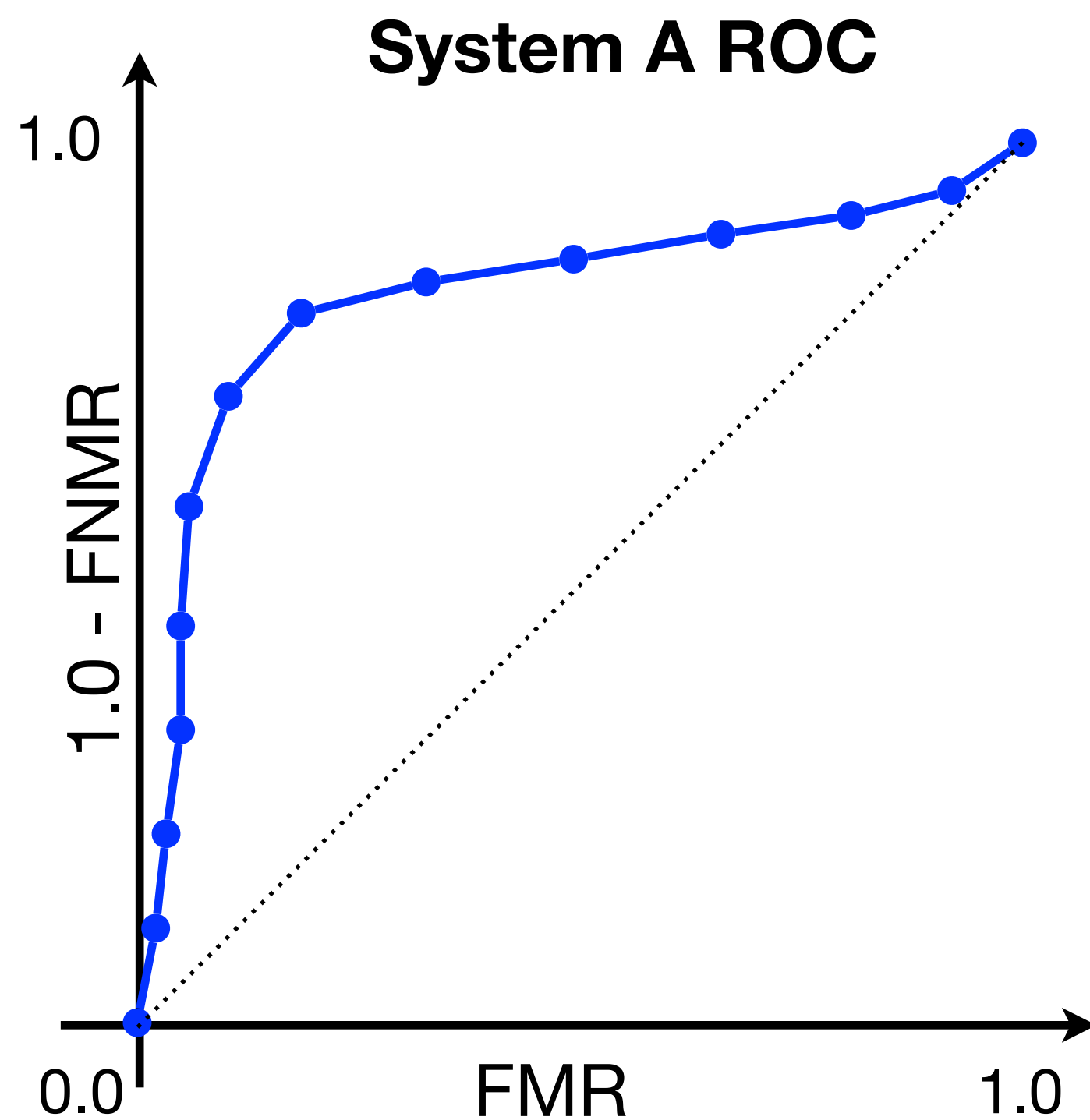
Metrics

RECAP

How to compare two different systems?

Biometric systems *A* and *B*.

Compute FMR and FNMR for a variety of thresholds.

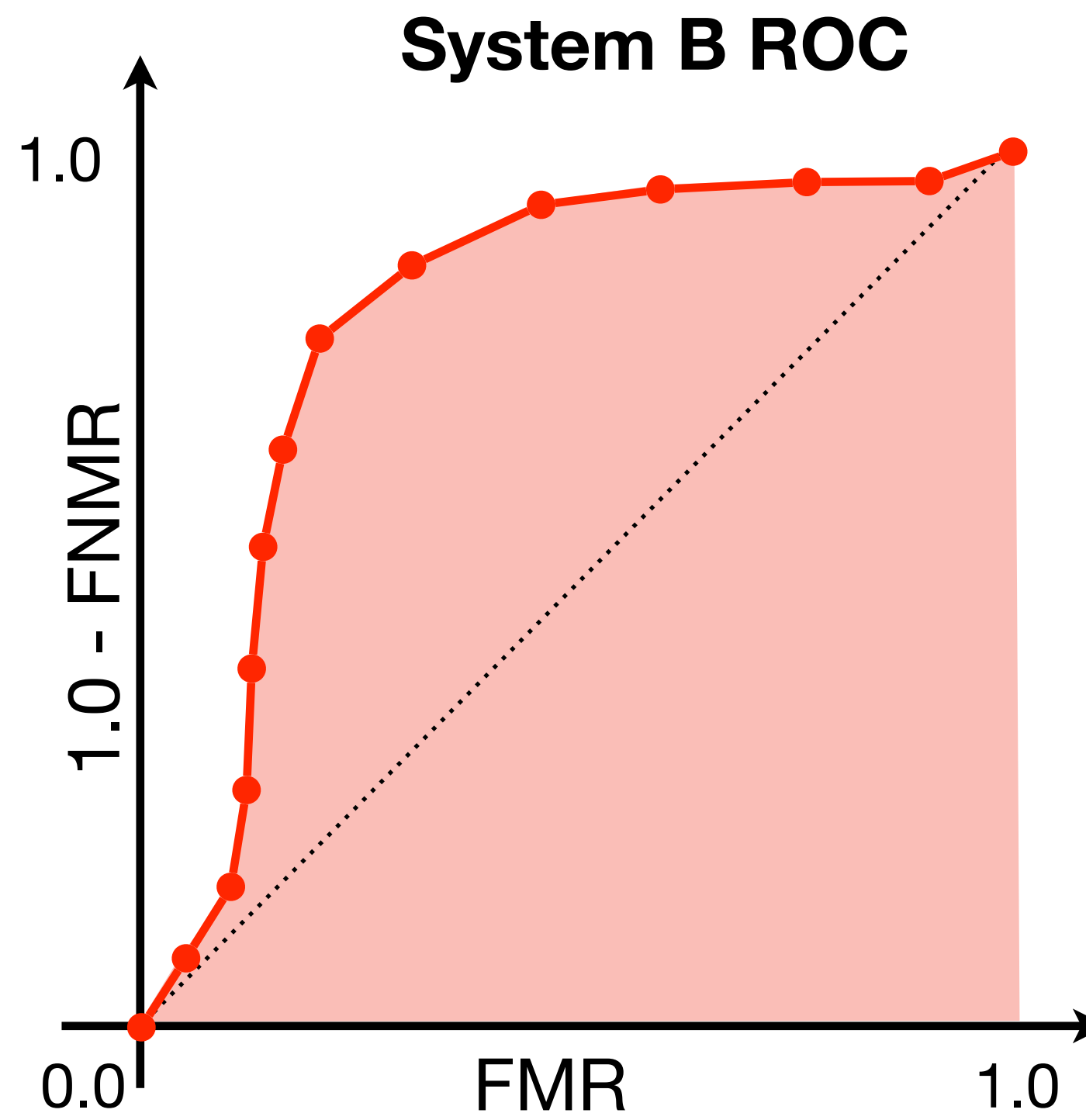
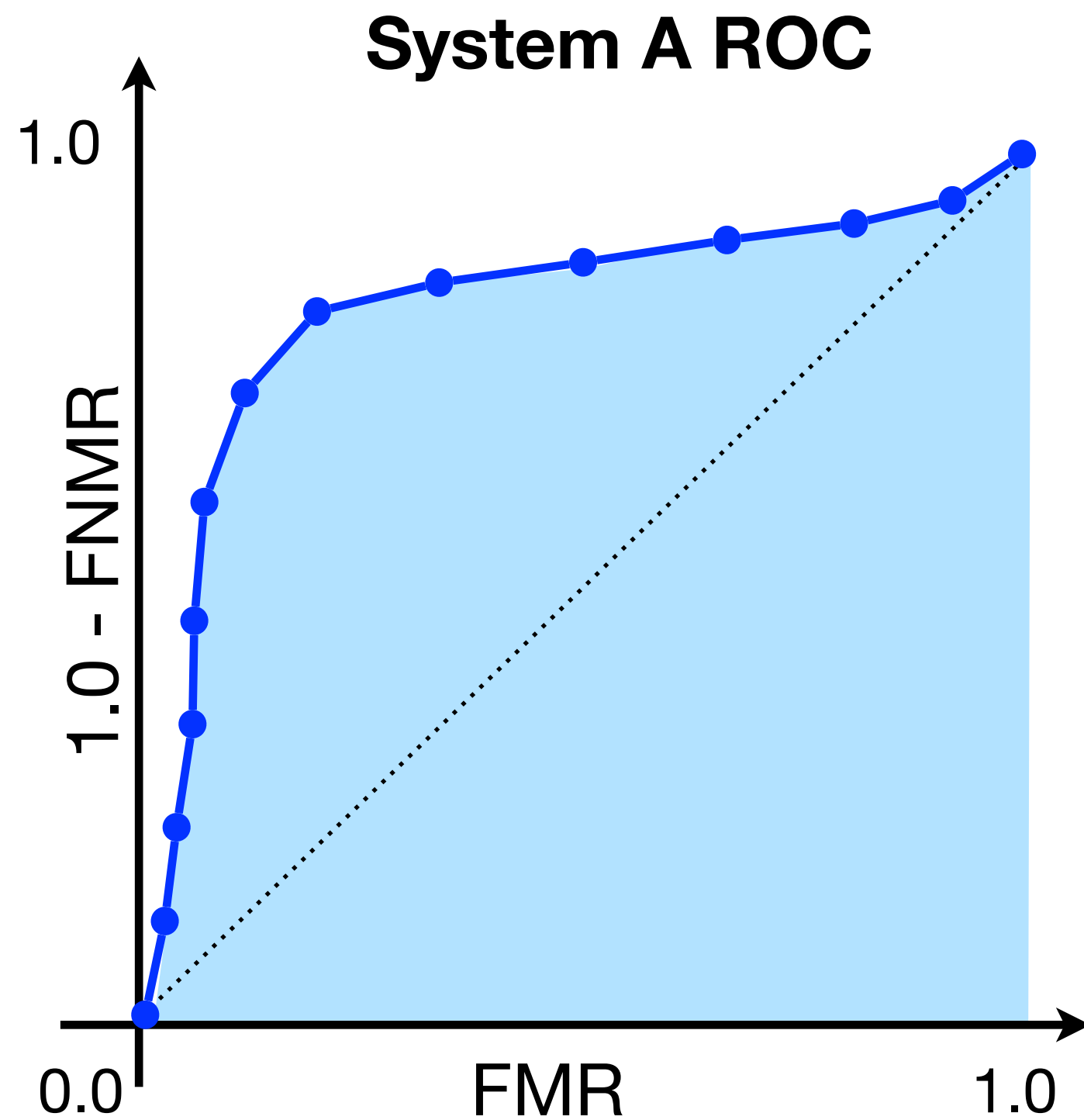


Metrics

RECAP

How to compare two different systems?

Biometric systems *A* and *B*.



Which one is better?

Compute the Area Under The Curve (AUC).

The best solution presents larger AUC.

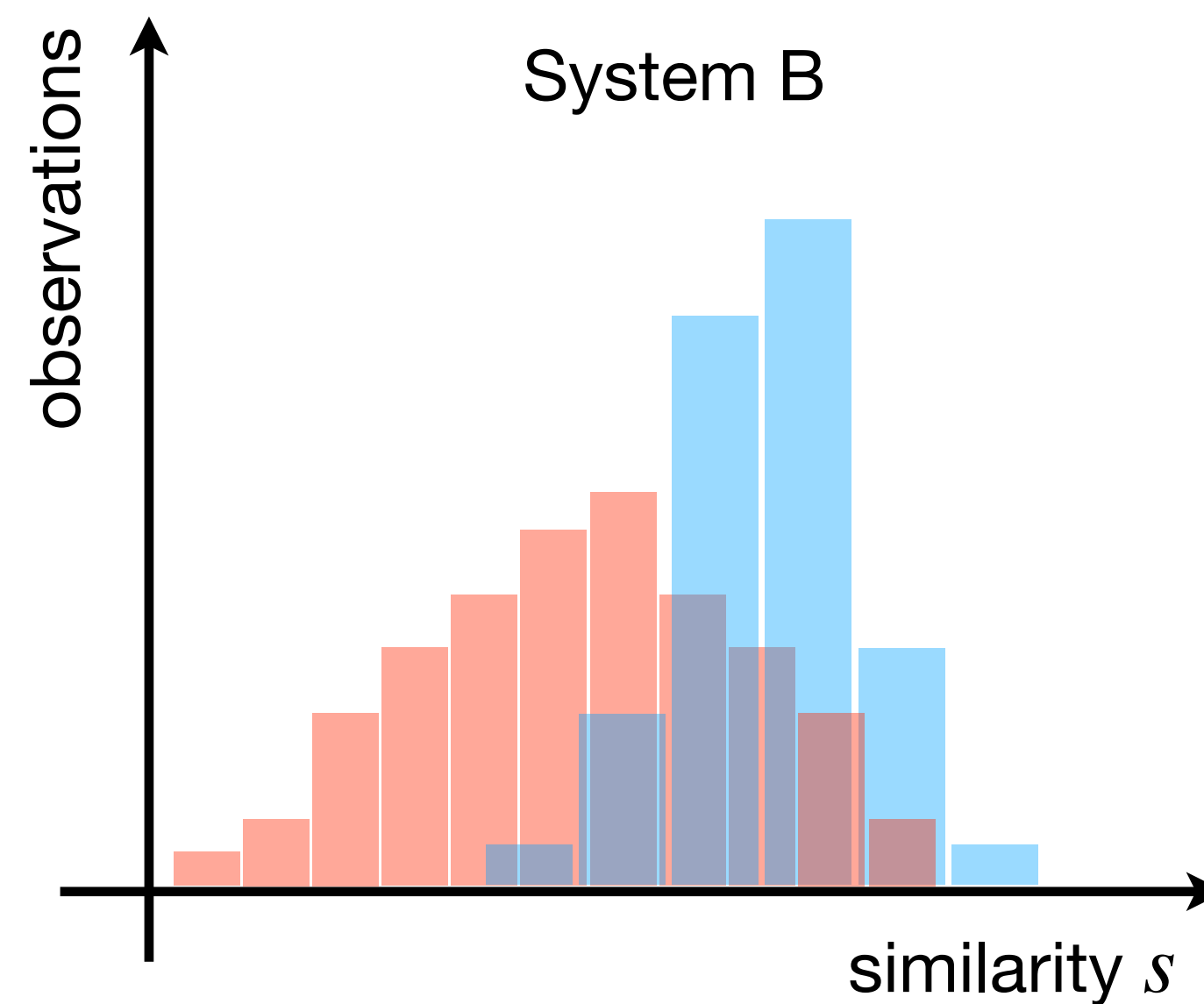
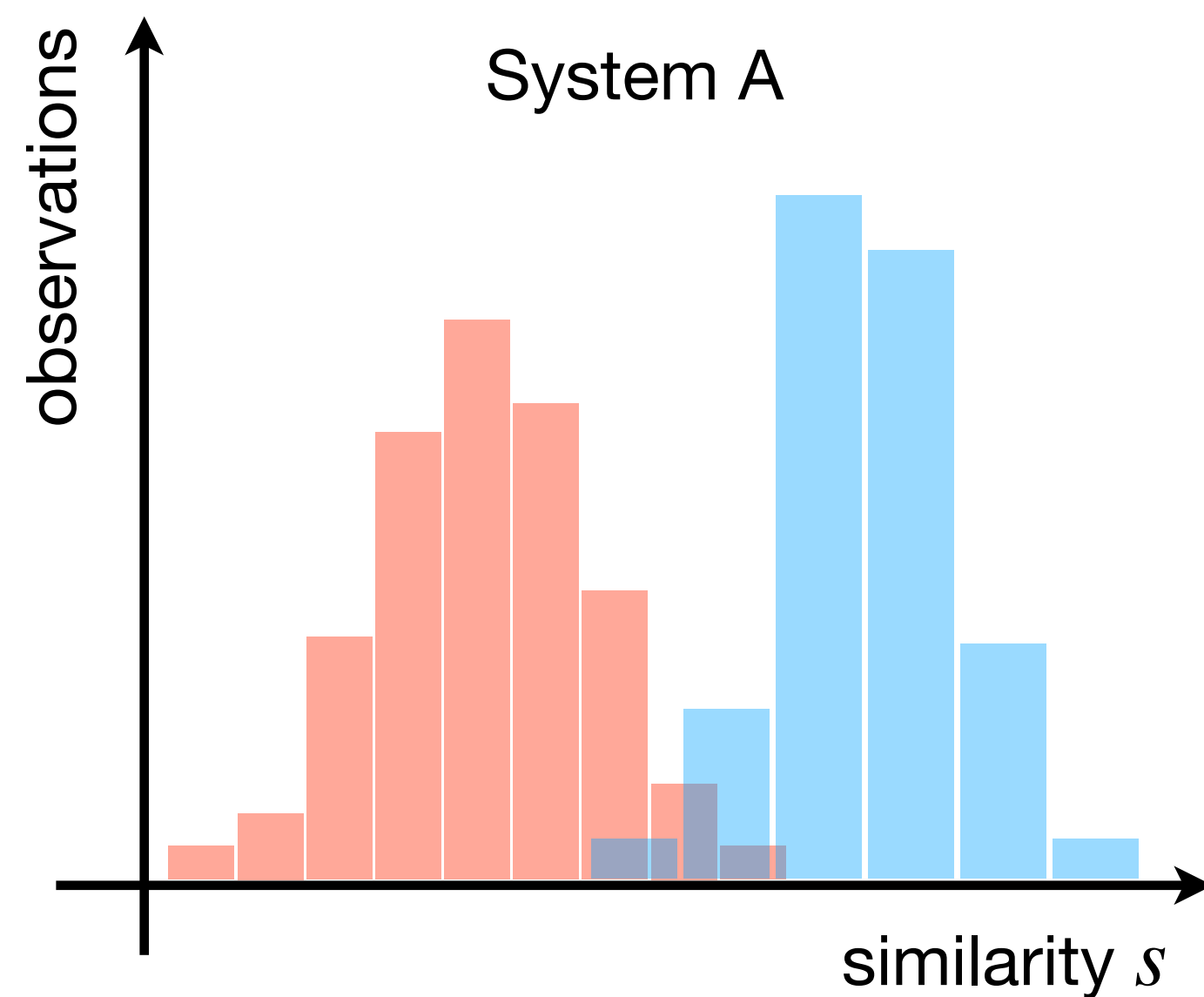
Metrics

RECAP

How to compare two different systems?

Biometric systems A and B .

Compute the difference between impostor and genuine distributions for each system (3/3)



impostor genuine

Which one is better?

Take the one with better separation of impostor and genuine observations.

It is System A!
How do we compute it?

Metrics

RECAP

How to compare two different systems?

Biometric systems A and B .

Compute the difference between impostor and genuine distributions for each system (3/3)

Which one is better?

Take the system with larger **d-prime**:

$$d' = \frac{\sqrt{2} \times |\mu_{genuine} - \mu_{impostor}|}{\sqrt{\sigma_{genuine}^2 + \sigma_{impostor}^2}}$$

Hypothesis: the distributions are Gaussians (with mean μ and standard deviation σ).

The larger the separation between the distributions, the larger the value of d-prime.

Metrics

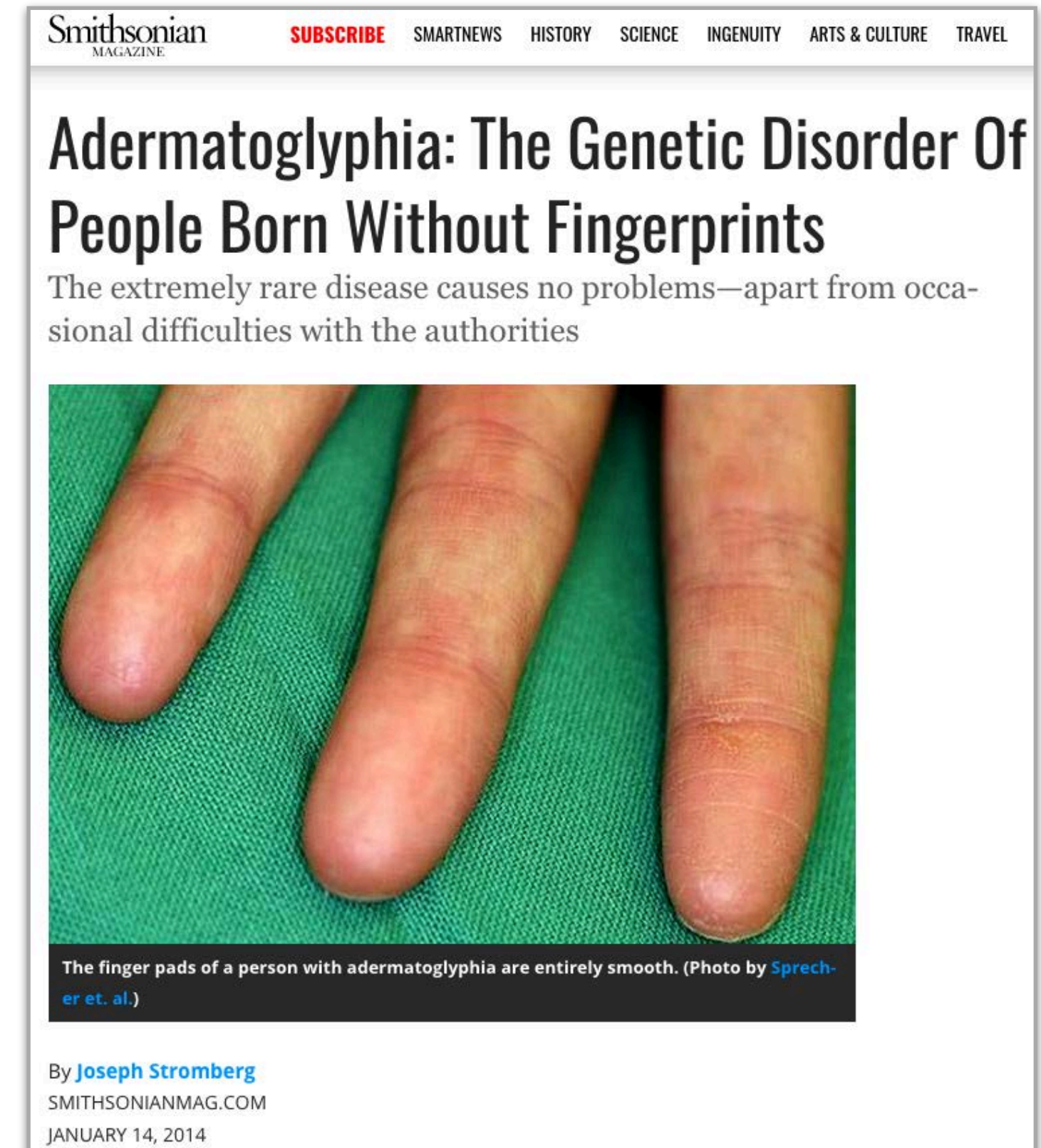
Other Metrics (1/4, 2/4)

Failure to Acquire (FTA)

Rate of falsely rejected biometric samples due to problems in acquisition.

Failure to Enroll (FTE)

The same as FTA, but during enrollment.



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

Metrics

Other Metrics (3/4, 4/4)

Positive Metrics

True Non-Match Rate (TNMR)

$$\text{TNMR} = 1.0 - \text{FMR}$$

True Match Rate (TMR)

$$\text{TMR} = 1.0 - \text{FNMR}$$

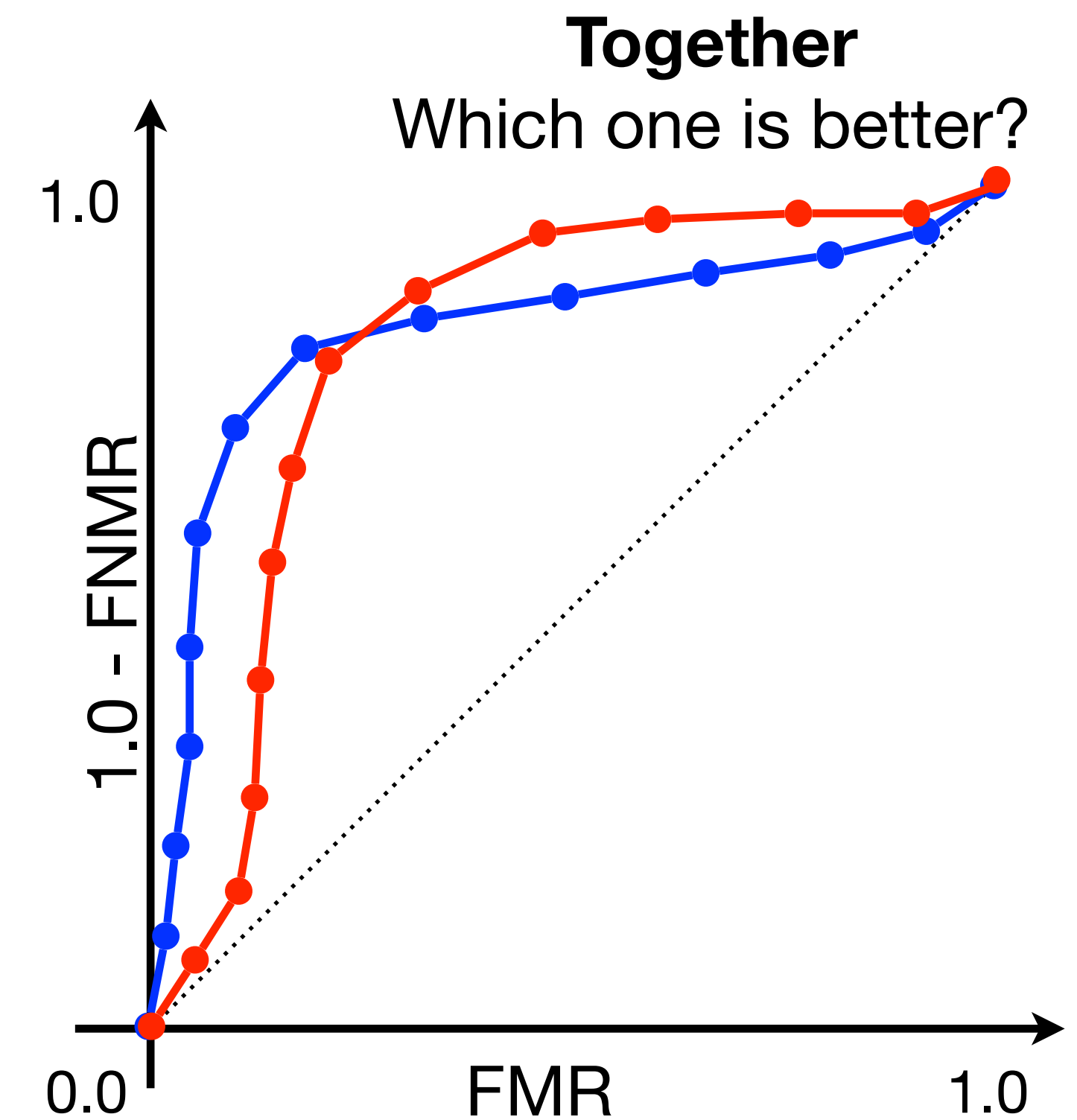
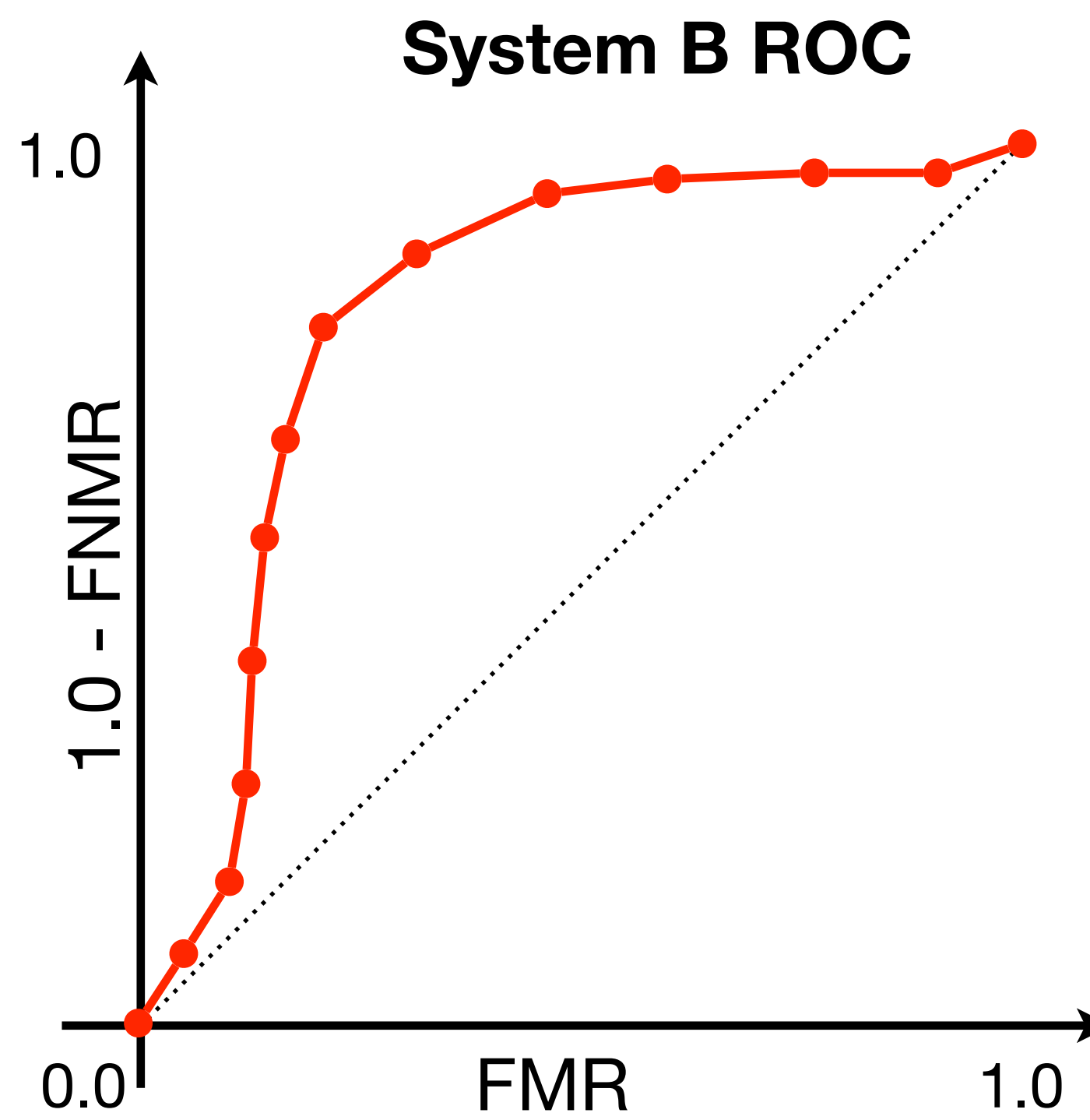
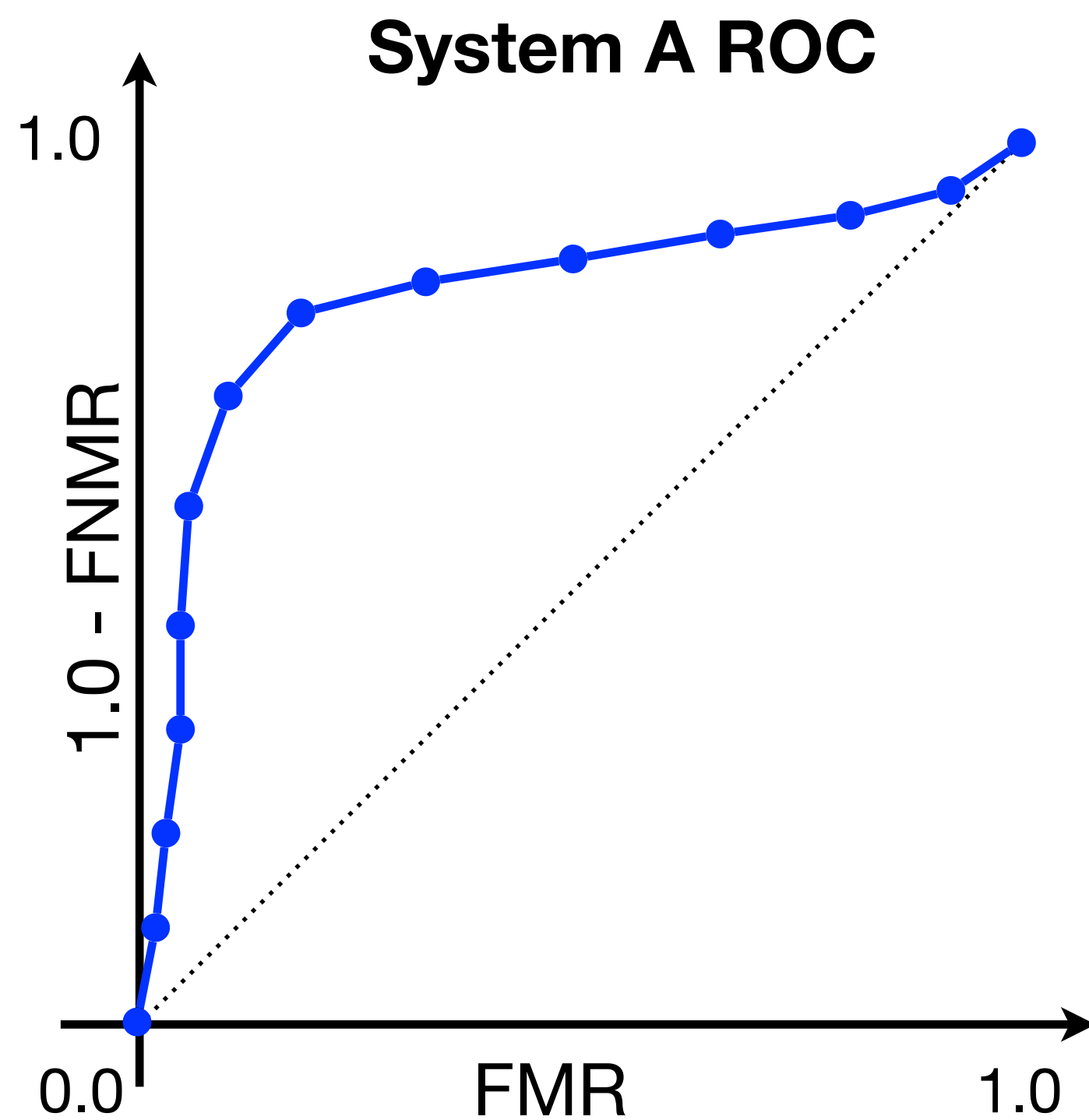
You want to maximize these instead of minimizing.



Metrics

How to compare two different systems?
Biometric systems *A* and *B*.

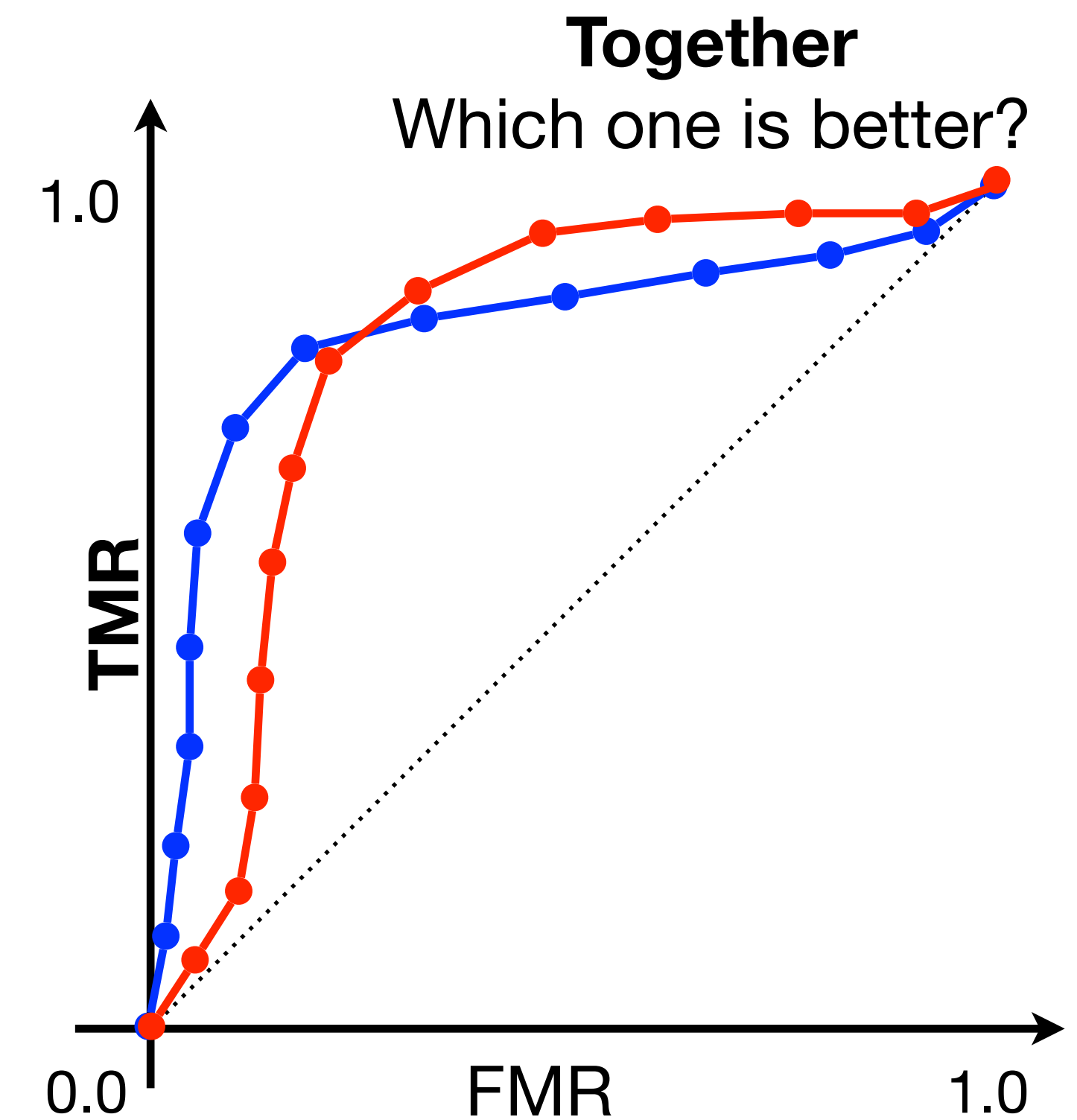
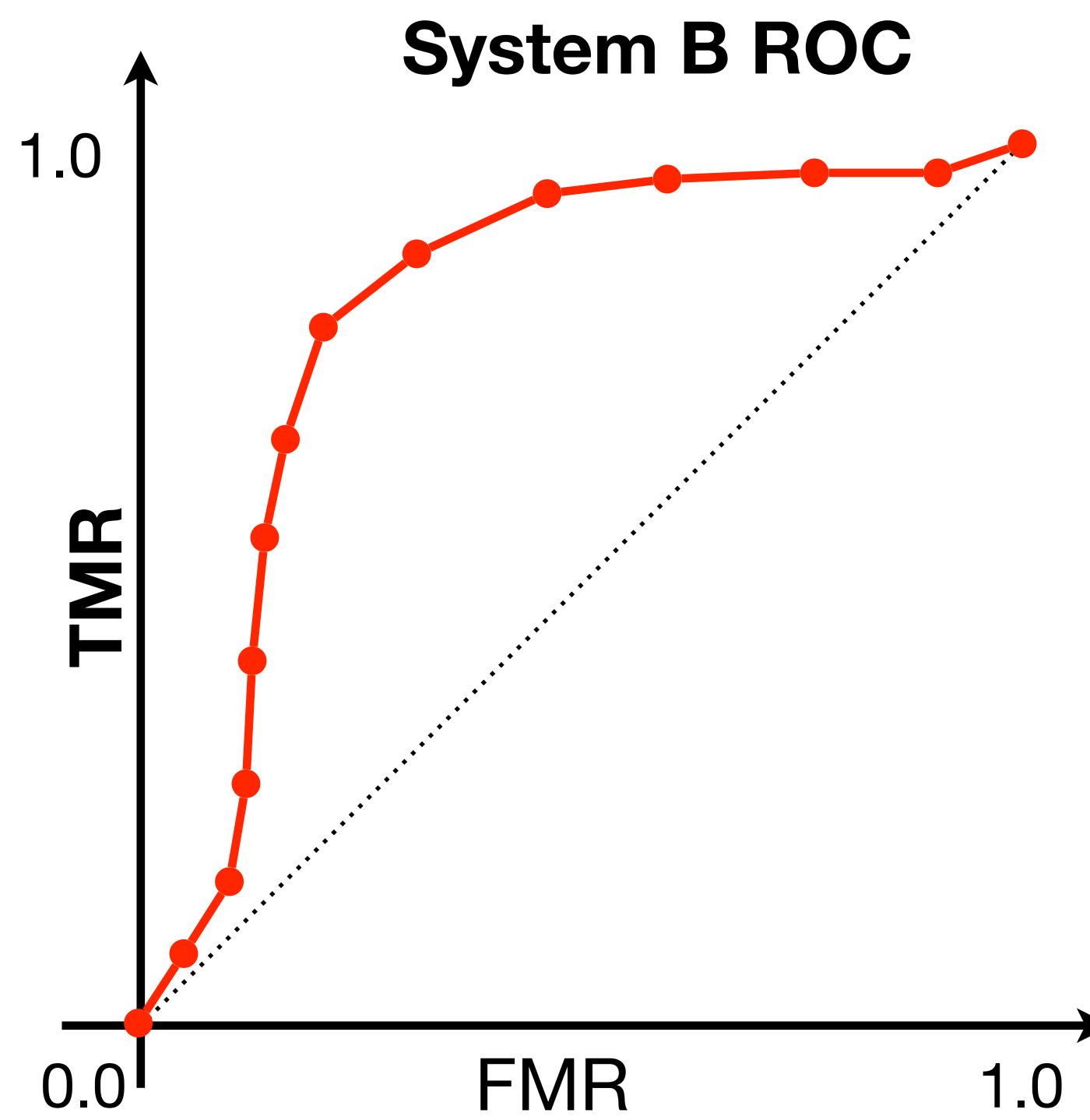
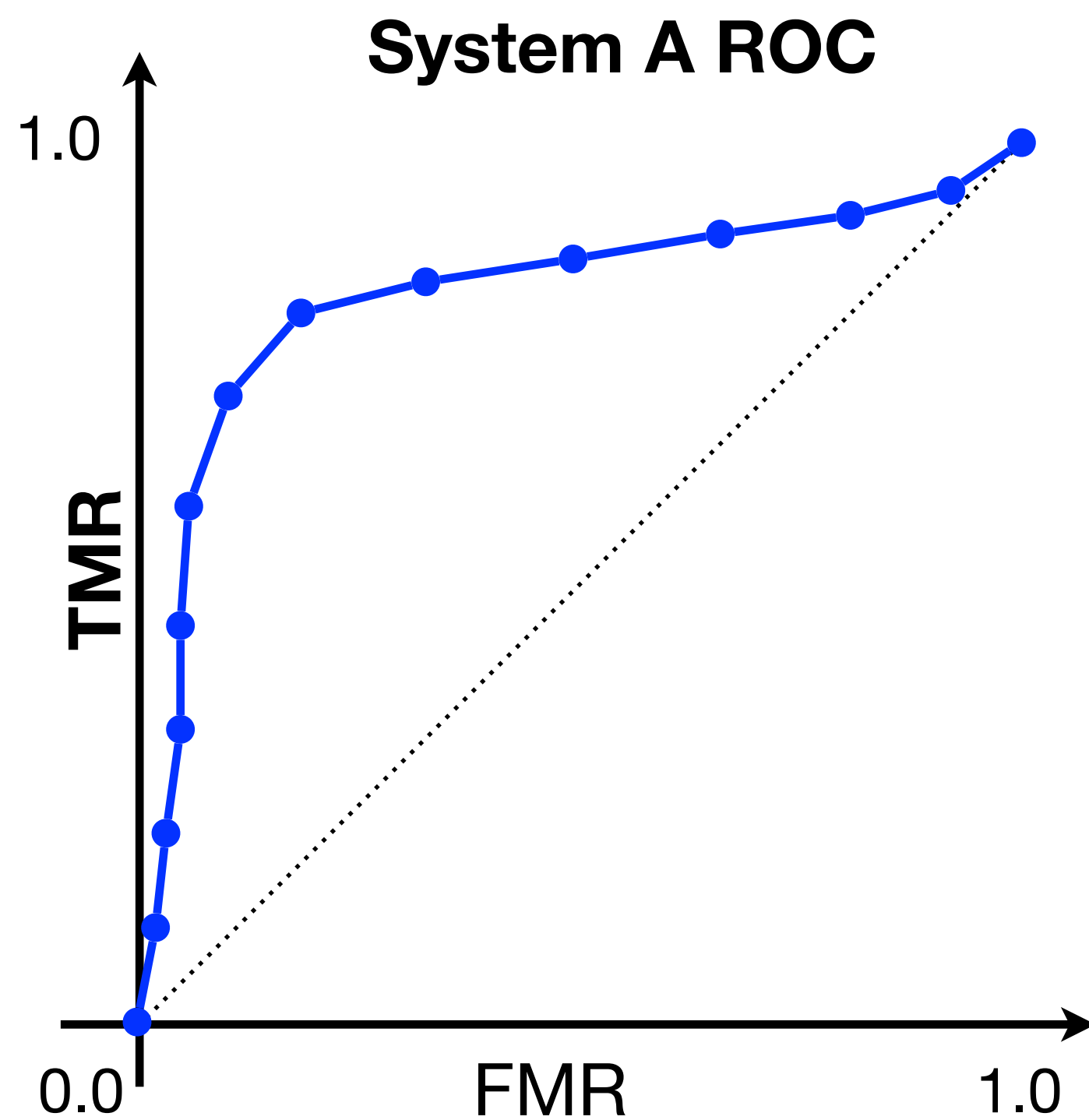
Compute FMR and FNMR for a variety of thresholds.



Metrics

How to compare two different systems?
Biometric systems *A* and *B*.

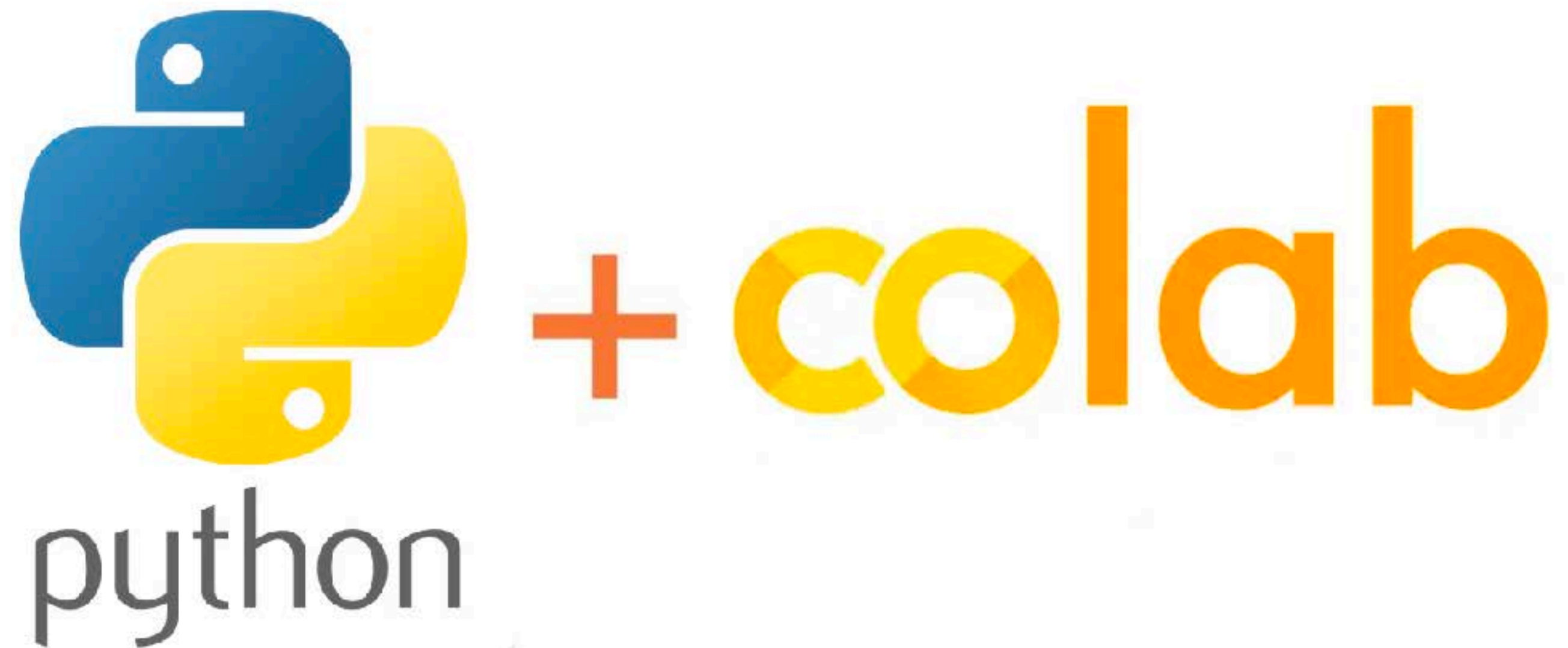
Compute FMR and FNMR for a variety of thresholds.



Implementation

Please open

<https://tinyurl.com/ya2zj7vu>



What's Next?

Biometric System Attacks

Threat model and attack types.

Fingerprint Recognition

History and features.



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

<https://sakai.luc.edu/x/HAZC1P>.