

# *Evaluation of Face Recognition Accuracy for Subjects Potentially Wearing Face Masks*

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National Institute of  
Standards and Technology  
U.S. Department of Commerce



INFORMATION  
TECHNOLOGY  
LABORATORY

# Motivation



Widespread requirement/practice of people wearing protective face masks in public places

Operational need for face recognition to be applied to persons wearing masks

Masks present a problem for face recognition, because large regions of the face are occluded

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"Coronavirus (COVID-19) Sheffield, UK" by Tim Dennell is licensed under CC BY-NC 2.0.  
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"Passengers waiting for a flight to Shanghai in March 2020.jpg" by Mx. Granger is licensed under CCO 1.0.

# What we did

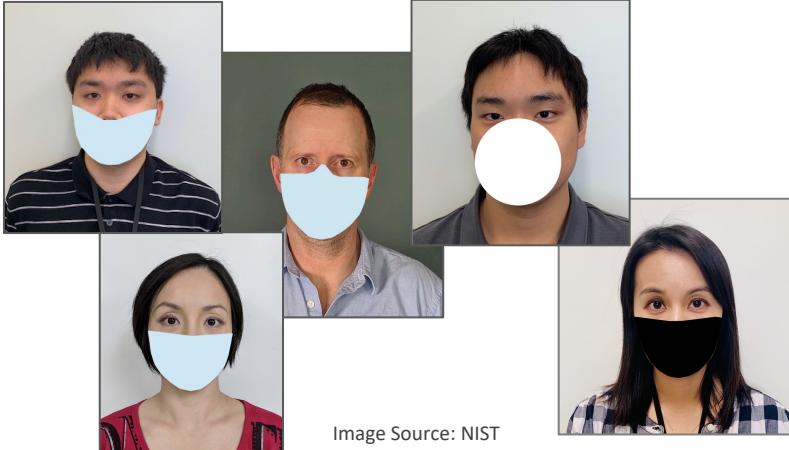
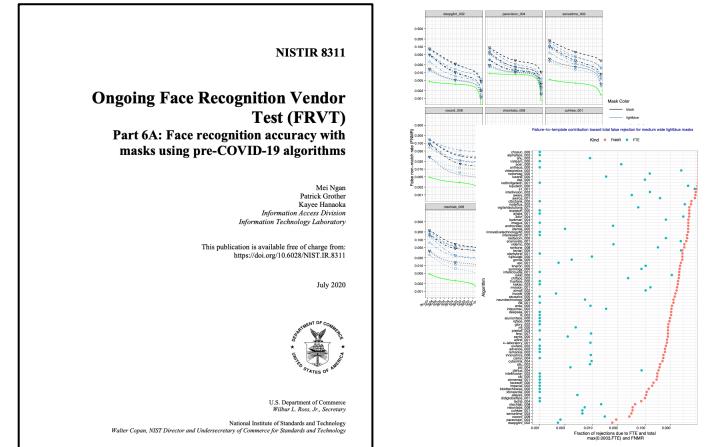


Image Source: NIST

## Applied digital masks to existing test data

Leveraged open-source Dlib face landmark detector + supplemental eye coordinates to draw solid masks on 5.2M photos



## Evaluated “pre-COVID-19” algorithms

- Published results for 89 algorithms submitted to FRVT 1:1 between April 2019 to mid-March 2020
- Unmasked vs. masked probe
  - Impact of mask nose coverage, shape, color

Algorithm	VISABORDER Photos FNR@FMR = 0.00001 (NOT MASKED)	VISABORDER Photos FNR@FMR = 0.00001 (MASKED PROBE) lightblue, wide, medium coverage	Submission Date
deepflipt-002	0.0039 <sup>[11]</sup>	0.0237 <sup>[1]</sup>	2019-11-15
paravision-004	0.0089 <sup>[17]</sup>	0.0281 <sup>[2]</sup>	2019-12-11
xfrwrdar-001	0.0044 <sup>[12]</sup>	0.0289 <sup>[3]</sup>	2020-09-25
visionlabs-009	0.0026 <sup>[1]</sup>	0.0355 <sup>[4]</sup>	2020-07-27
hr-003	0.0044 <sup>[21]</sup>	0.0419 <sup>[5]</sup>	2020-09-25
fujitsulab-001	0.0079 <sup>[39]</sup>	0.0427 <sup>[6]</sup>	2020-09-30
iqface-002	0.0086 <sup>[51]</sup>	0.0446 <sup>[7]</sup>	2020-07-30
pensees-001	0.0104 <sup>[71]</sup>	0.0461 <sup>[8]</sup>	2020-08-17
vocord-008	0.0038 <sup>[8]</sup>	0.0509 <sup>[9]</sup>	2020-01-31
idemia-006	0.0048 <sup>[28]</sup>	0.0539 <sup>[10]</sup>	2020-07-06
semesetime-003	0.0044 <sup>[11]</sup>	0.0544 <sup>[11]</sup>	2019-12-02
tevian-006	0.0039 <sup>[34]</sup>	0.0547 <sup>[12]</sup>	2020-09-11
cuhkee-001	0.0044 <sup>[13]</sup>	0.0572 <sup>[13]</sup>	2020-03-18
visionlabs-006	0.0054 <sup>[2]</sup>	0.0579 <sup>[14]</sup>	2020-01-06
ercat-001	0.0096 <sup>[51]</sup>	0.0614 <sup>[15]</sup>	2020-07-06

This publication is available free of charge from: <https://doi.org/10.6028/NISTIR.8311>

## Evaluated “post-COVID-19” algorithms

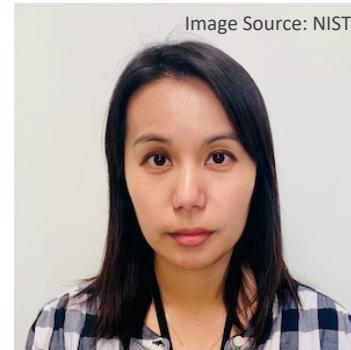
- Results for algorithms submitted to FRVT 1:1 after mid-March 2020
- Single vs. both images masked
  - Cumulative results for all algorithms evaluated to date

Public report TO BE PUBLISHED

# Datasets

## A. Enrollment images:

- 1 019 232 DHS/CIS Application images
- Approximately ISO compliant



## B. Verification images:

- 5 225 633 DHS/CBP Entry images



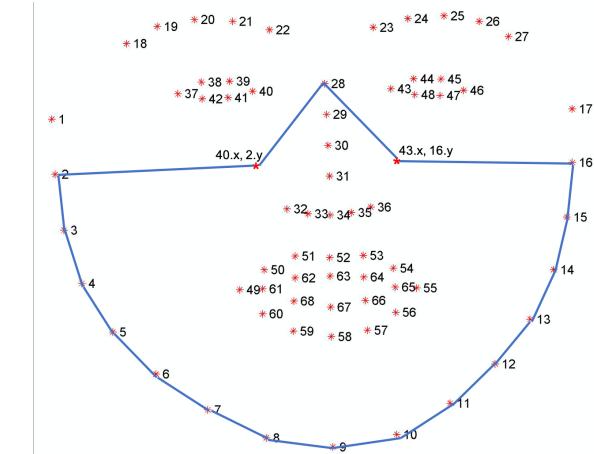
- 3 225 633 genuine comparisons
- 200 000 000 impostor comparisons



DHS Logitech webcam images collected in operational settings using the same camera and procedure as the verification photos (examples are very similar, not actual)

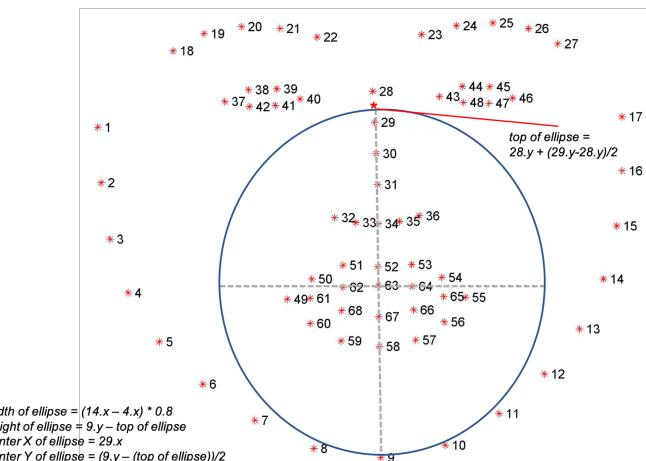
# The masking process

1. Open-source Dlib toolkit used to detect face + generate 68 facial landmarks
2. Facial landmarks were used to generate closed solid polygon drawn over the face



## Limitations:

- Not real masks
- No texture or patterns
- Digital masks are tailored to faces (real ones tend to be one size fit all)
- No camera-mask interactions (exposure)
- No eye occlusion



# Synthetic masks

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## NIST varied

- Nose coverage, shape, color

## Positioning

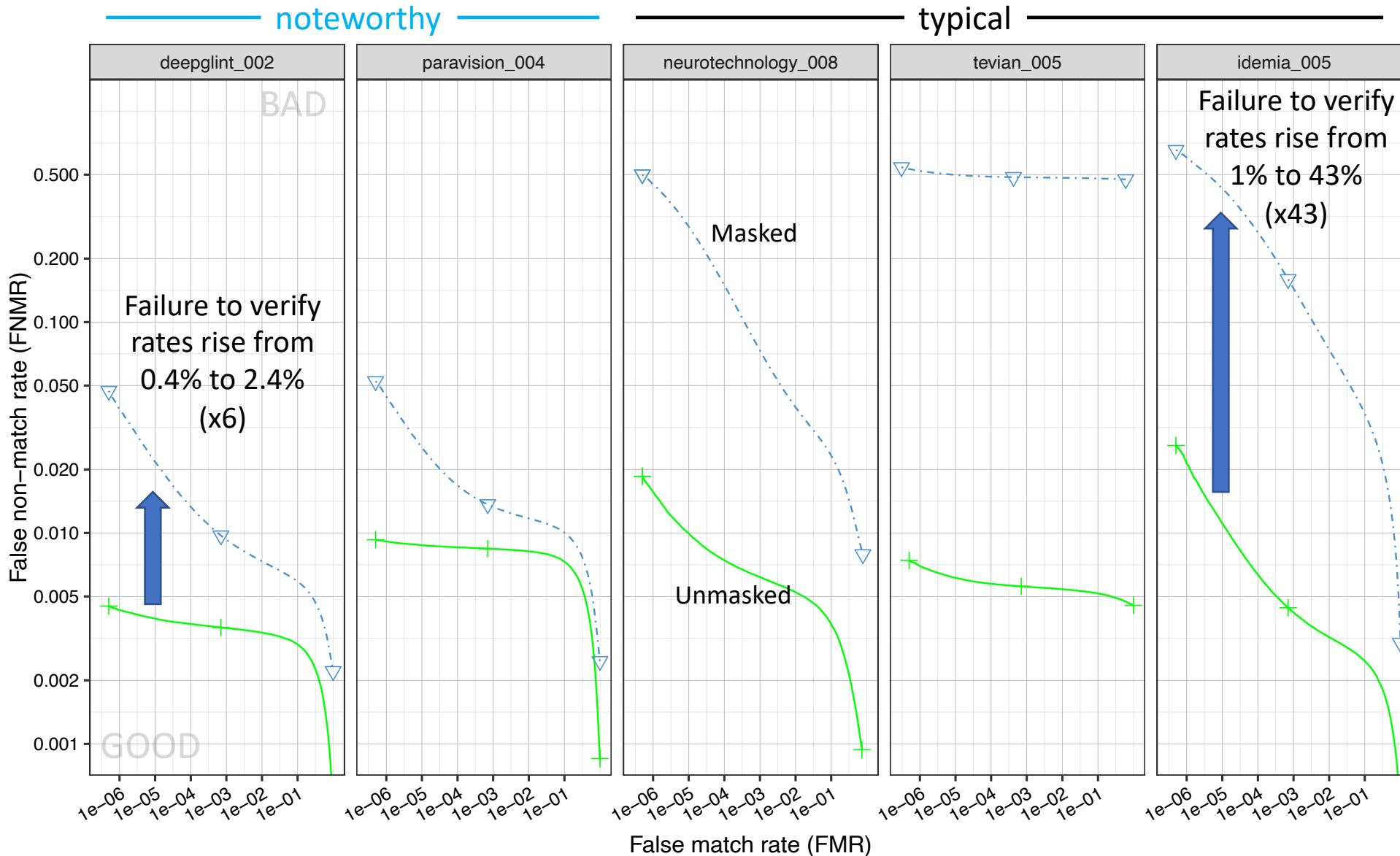
- Relative to landmarks reported by open-source Dlib toolkit
- If Dlib failed, then relative to detected eyes from good FRVT FR algorithms



Image Source: NIST MEDS-II Dataset

# Accuracy with and without masks: PRIOR to mid-March 2020

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wide, lightblue, medium coverage

# Accuracy with and without masks: (AFTER mid-March 2020)

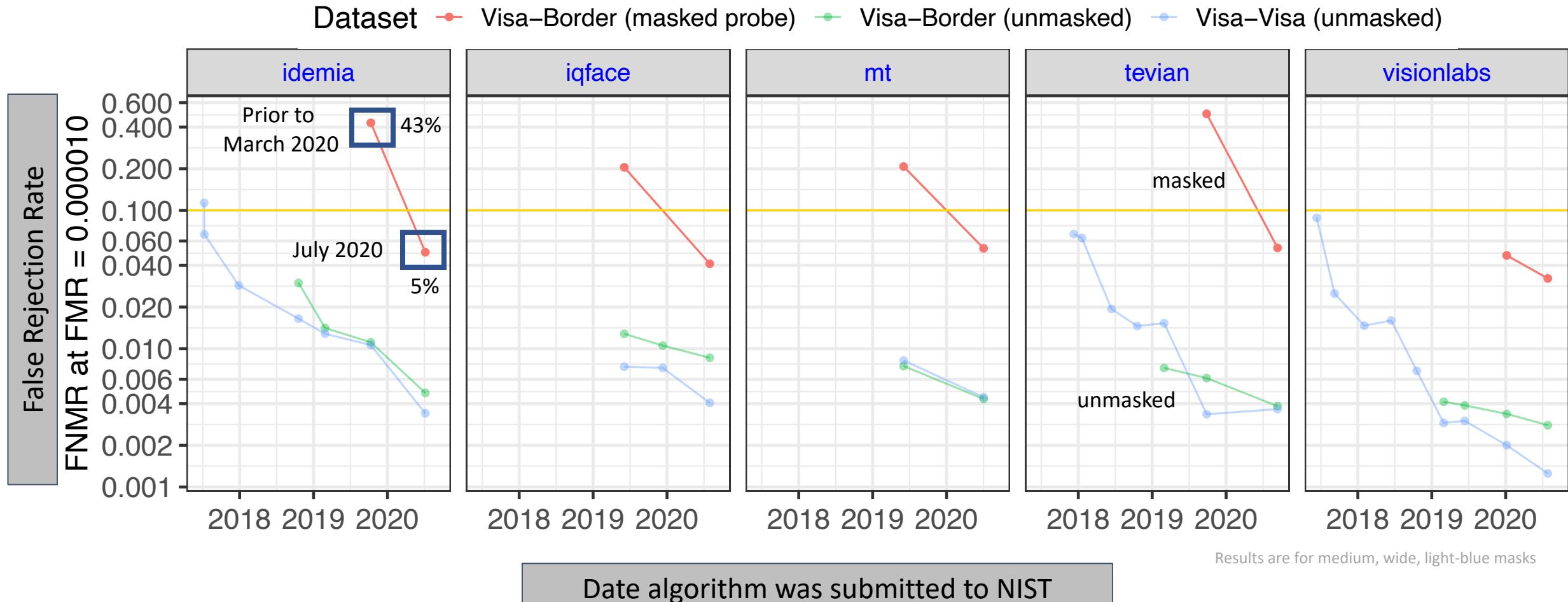


Algorithm	VISABORDER Photos FNMR @ FMR $\leq 0.00001$ <b>UNMASKED</b>	VISABORDER Photos FNMR@FMR $\leq 0.00001$ (MASKED PROBE) <b>MASKED</b>	Submission Date
deepglint-002	0.0039 <sup>(11)</sup>	0.0237 <sup>(1)</sup>	2019-11-15
paravision-004	0.0088 <sup>(57)</sup>	0.0281 <sup>(2)</sup>	2019-12-11
xforwardai-001	0.0041 <sup>(12)</sup>	0.0289 <sup>(3)</sup>	2020-09-25
visionlabs-009	0.0028 <sup>(1)</sup>	0.0355 <sup>(4)</sup>	2020-07-27
hr-003	0.0049 <sup>(21)</sup>	0.0419 <sup>(5)</sup>	2020-09-25
fujitsulab-001	0.0078 <sup>(50)</sup>	0.0427 <sup>(6)</sup>	2020-09-30
iqface-002	0.0086 <sup>(55)</sup>	0.0445 <sup>(7)</sup>	2020-07-30
pensees-001	0.0106 <sup>(71)</sup>	0.0461 <sup>(8)</sup>	2020-08-17
vocord-008	0.0038 <sup>(8)</sup>	0.0500 <sup>(9)</sup>	2020-01-31
idemia-006	0.0048 <sup>(20)</sup>	0.0539 <sup>(10)</sup>	2020-07-06
sensetime-003	0.0045 <sup>(19)</sup>	0.0544 <sup>(11)</sup>	2019-12-02
tevian-006	0.0038 <sup>(10)</sup>	0.0547 <sup>(12)</sup>	2020-09-11
cuhkee-001	0.0041 <sup>(13)</sup>	0.0572 <sup>(13)</sup>	2020-03-18
visionlabs-008	0.0034 <sup>(3)</sup>	0.0579 <sup>(14)</sup>	2020-01-06
ercacat-001	0.0096 <sup>(65)</sup>	0.0616 <sup>(15)</sup>	2020-07-06

FNMR values are reported at a fixed threshold calibrated to give FMR = 0.00001 on unmasked images. Algorithms in **black** were submitted prior to mid-March 2020, and algorithms in **blue** were submitted thereafter.

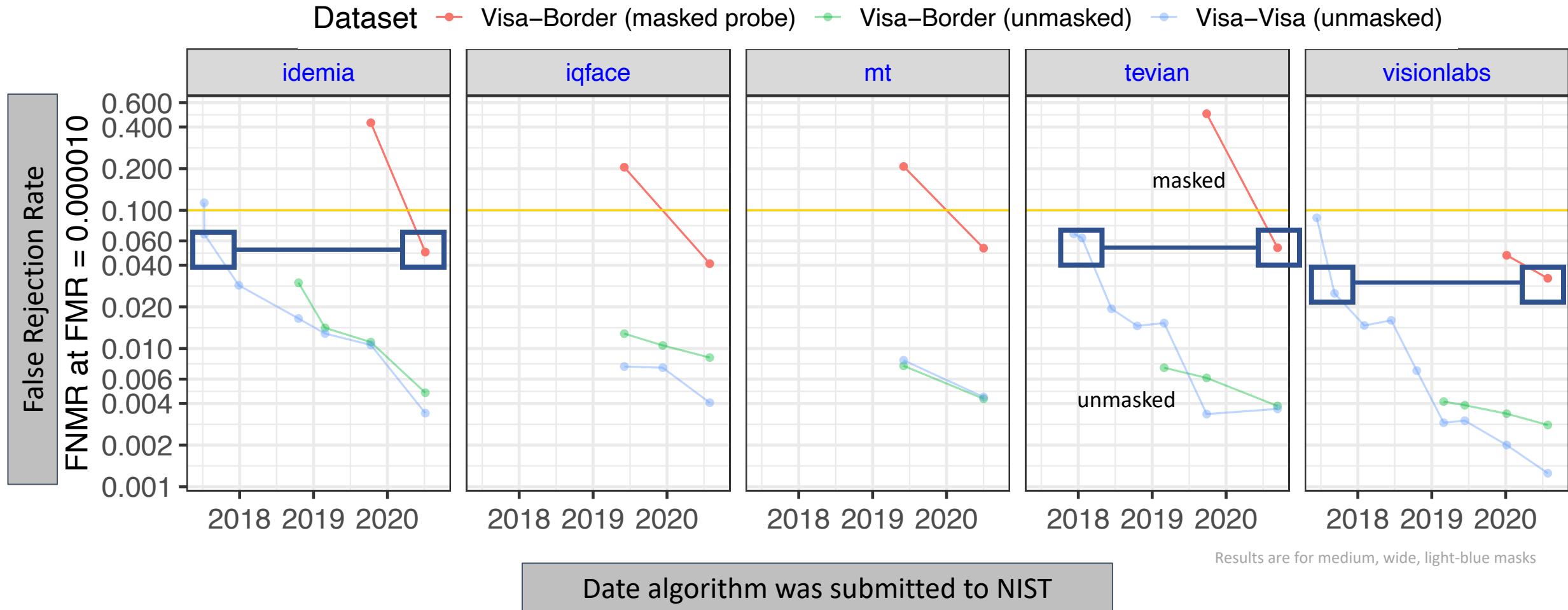
# Masks: Developer evolution

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# Masks: How much of a setback?

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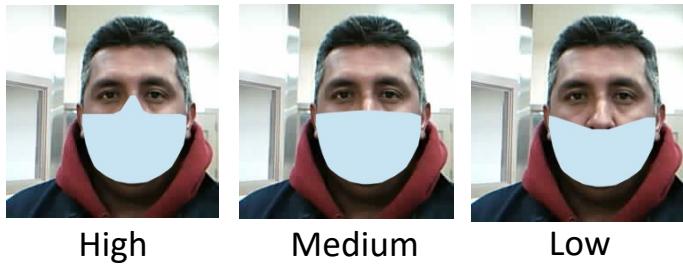
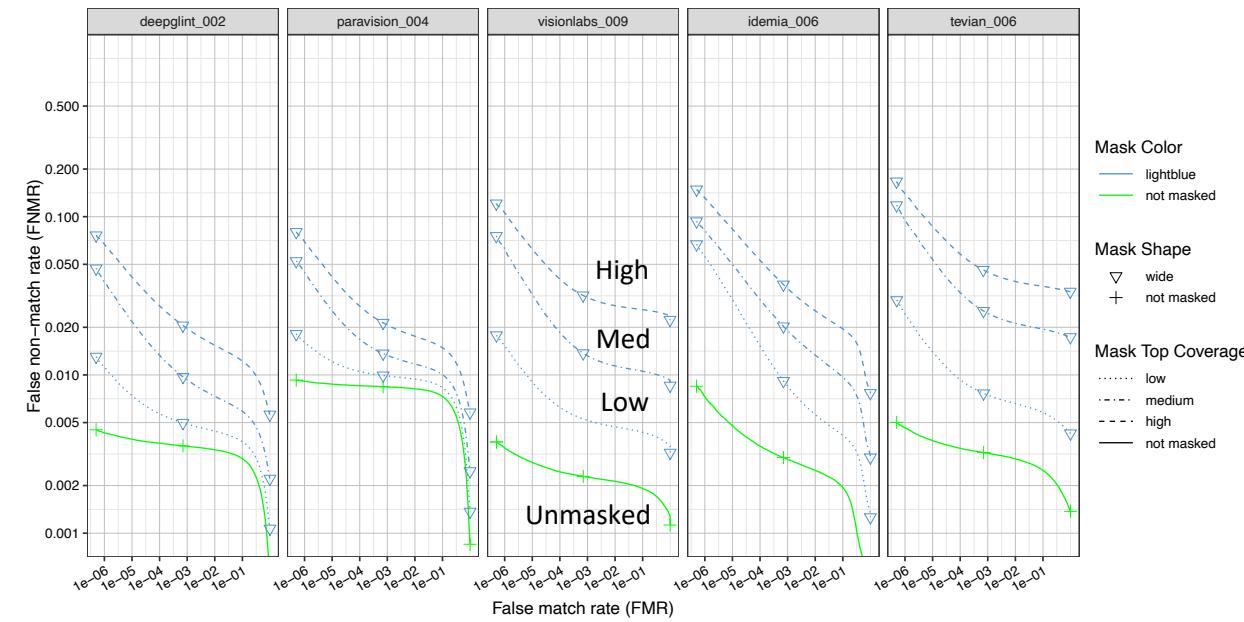


*The presence of masks has set face recognition technology back 2-3 years*

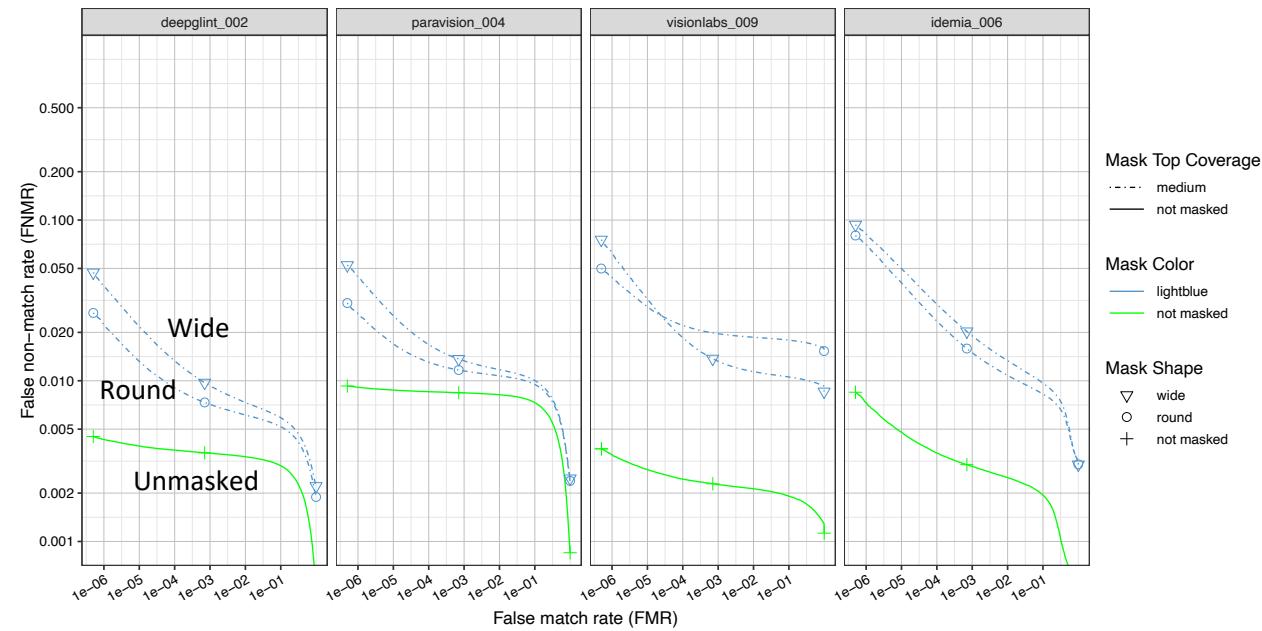
# Mask coverage + shape matters

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“High” masks generate more errors than “low” masks

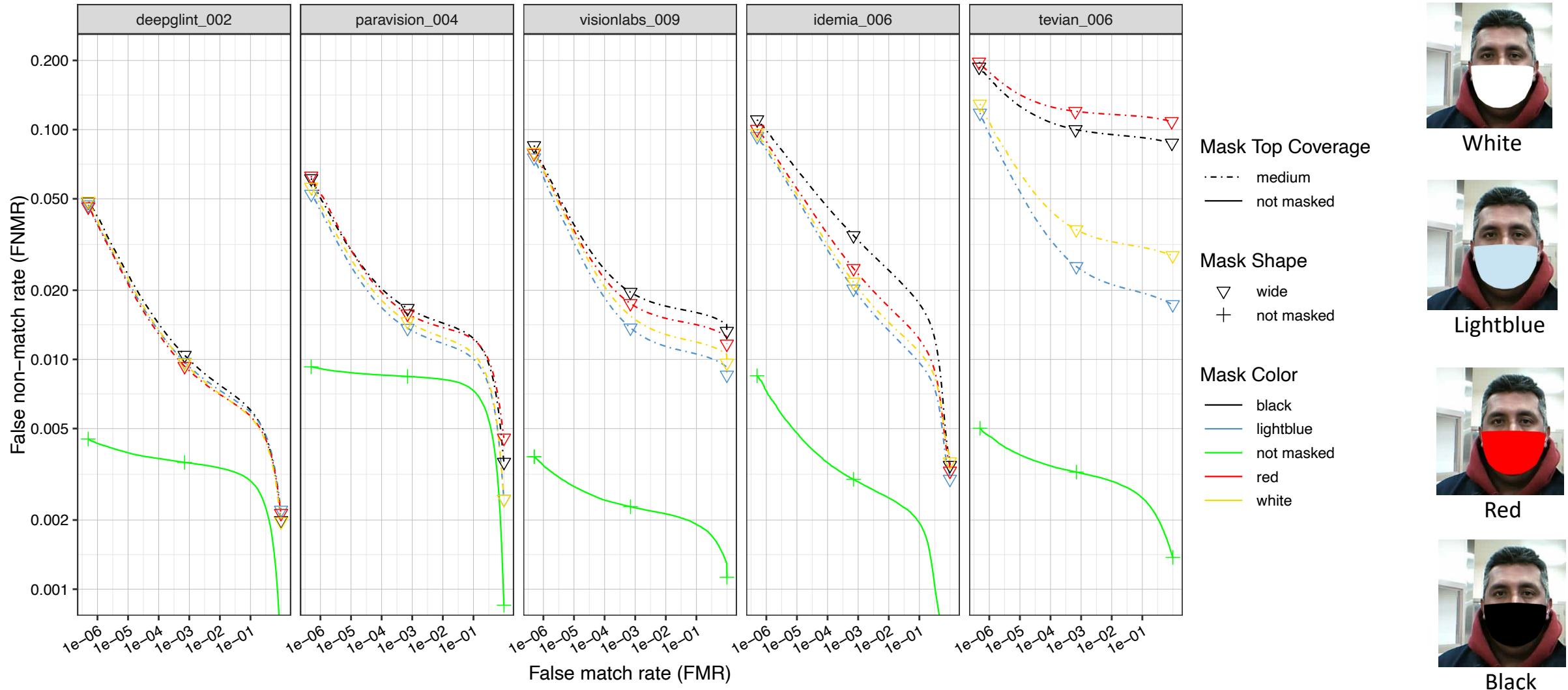


“Wide” masks generate more errors than “round” masks

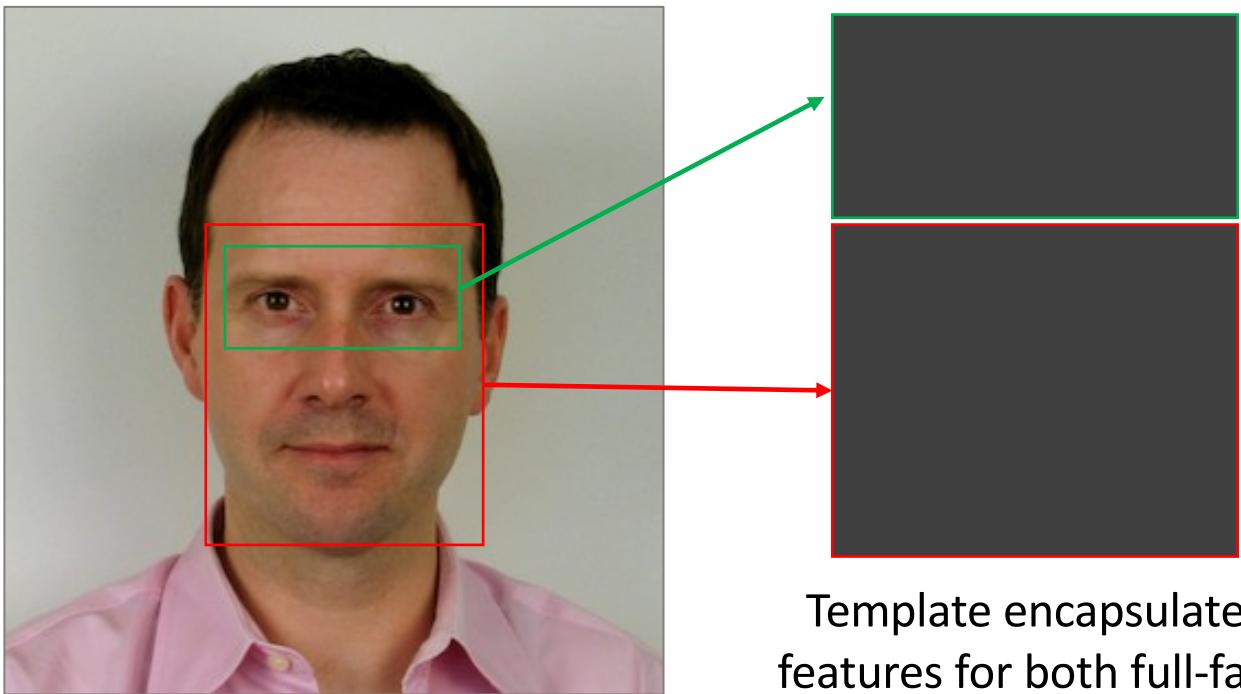
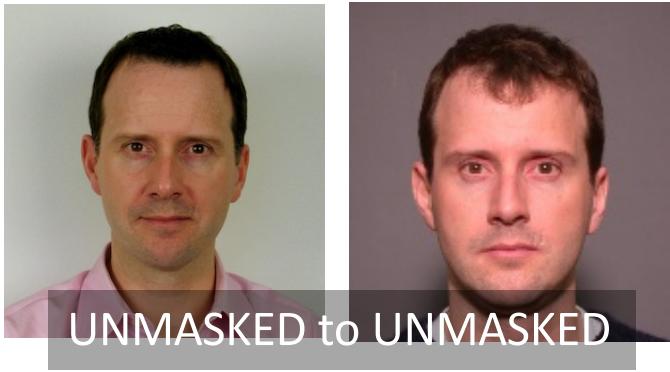


# Mask color matters

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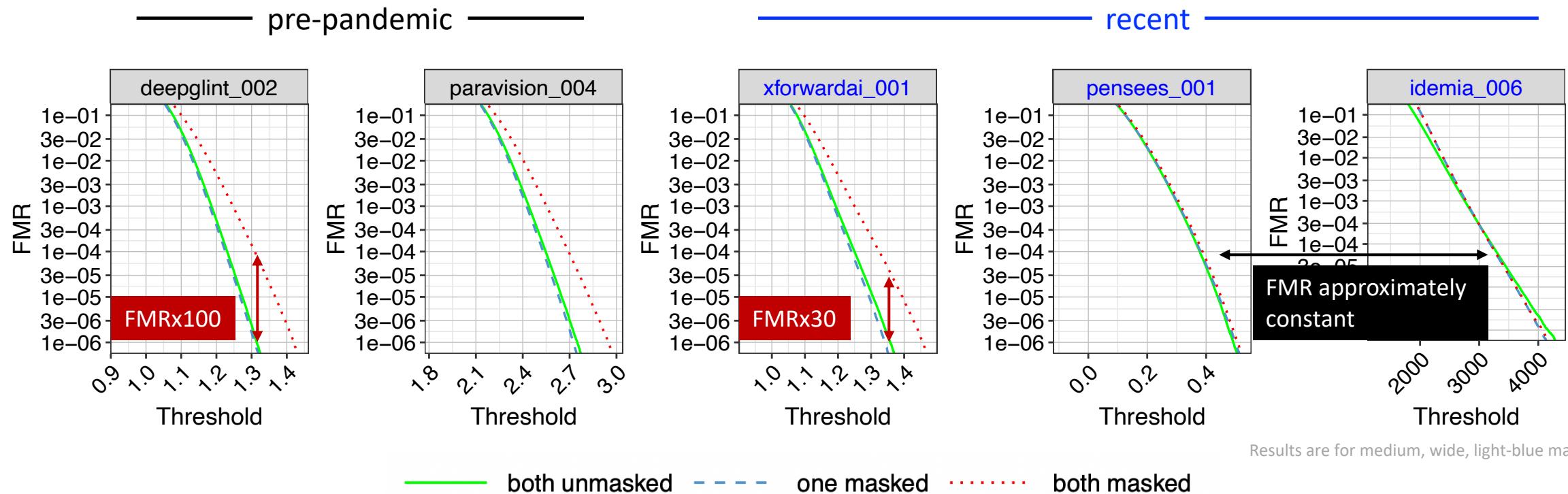


# Mask-agnostic face recognition: Some transactions involve a mask (and some do not):



# False Match Rates

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## RESULTS

- Face masks have set face recognition accuracy ~2-3 years back
  - But some algorithms may still be usable, depending on the application
- Better accuracy with
  - Low masks (vs. high)
  - Round masks (vs. wide)
  - Light colors (vs. black)
- Elevated false match rates when both enrollment and verification images are masked
  - With the exception of idemia\_006 and pensees\_001

## LIMITATIONS/CONTEXT

- No real masks, no textured masks
- No eye-occlusion
- No camera-mask interactions (exposure)

## WHAT'S NEXT

- Report #2: Face recognition accuracy with face masks using “post-pandemic” algorithms (Nov. 2020 est.)
- Report #3: Evaluation of 1:N algorithms with masks (1Q 2021 est.)

# Thank you!

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