



# This PIN Can Be Easily Guessed

## Analyzing the Security of Smartphone Unlock PINs

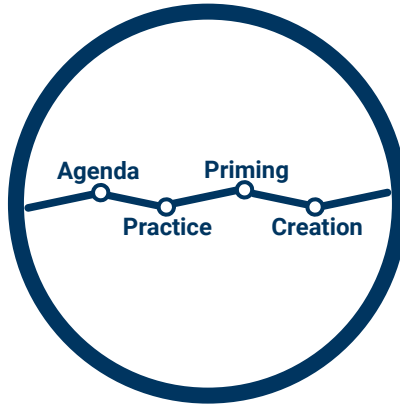
[Philipp Markert](#), Daniel V. Bailey, Maximilian Golla, Markus Dürmuth, and Adam J. Aviv

May 18, 2020 | 41st IEEE Symposium on Security and Privacy

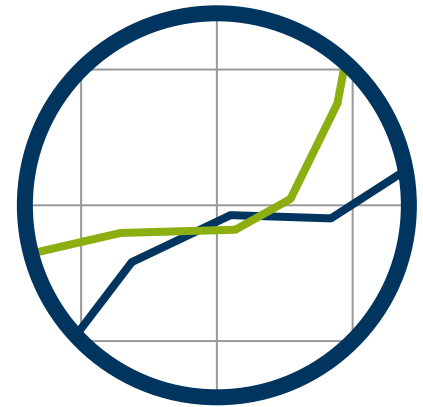
# Overview



Why study PINs?



User Study

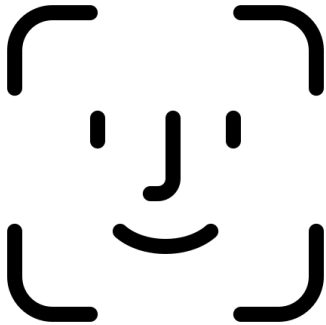


Results

# Why PINs?



Fingerprint



Face



PHOTO: Dan Seifert | The Verge (Vox Media)

Iris

# Who uses PINs?

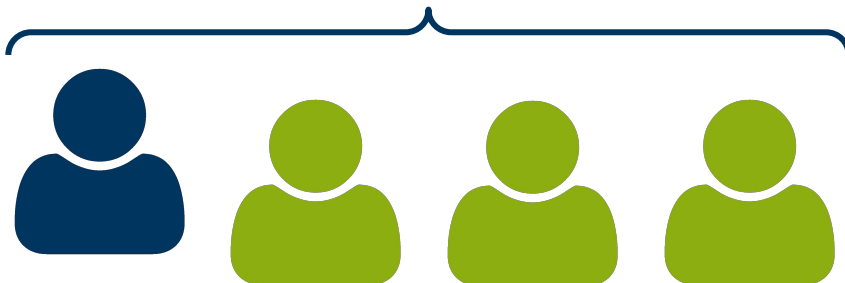
**1220 participants**

**461 do not use a biometric**



**210 use a PIN**

**759 use a biometric**



**595 use a PIN**

**Overall 805 (66%) use a PIN**

## What we know about PINs

- User chosen 4-digit PINs are predictable [1]
- User chosen 6-digit PINs aren't any better [2]
- Blocking popular PINs can increase security [1]

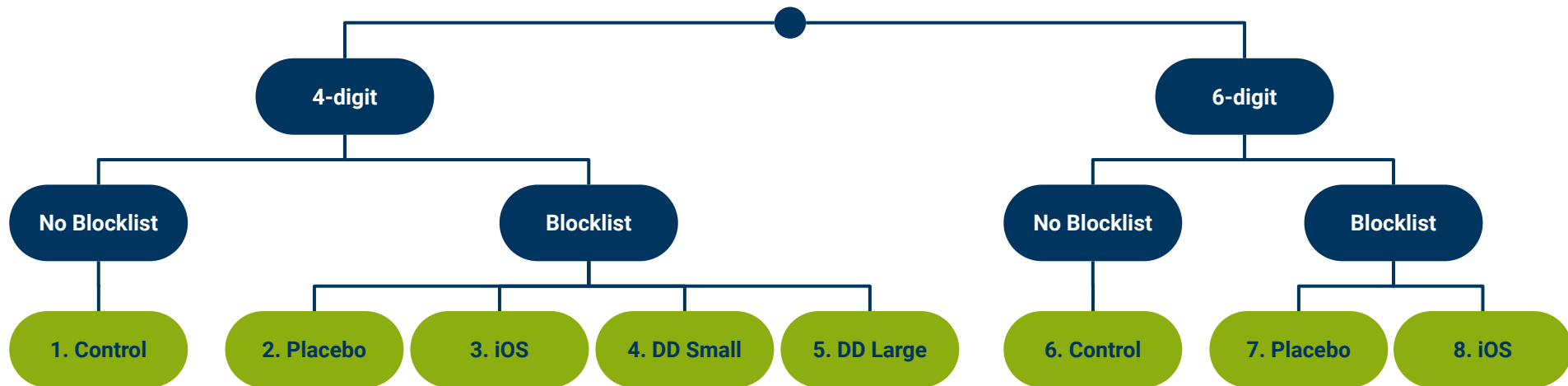
## What we don't know

- How secure are 4- or 6-digit PINs in the smartphone unlock setting?
- What are the effects of different blocklists on the security of PINs?
- How to balance security and usability when composing a blocklist?

[1] J. Bonneau, S. Preibusch, and R. Anderson. **A Birthday Present Every Eleven Wallets?** The Security of Customer-Chosen Banking PINs. FC '12

[2] D. Wang, Q. Gu, X. Huang, and P. Wang. **Understanding Human-Chosen PINs:** Characteristics, Distribution and Security. AsiaCCS '17

# Treatments



## Placebo

“Test general effect of warning”

Blocklist:

- “1st choice” blocked
- Any other PIN allowed

## iOS

“Test effect of iOS blocklists”

Blocklist:

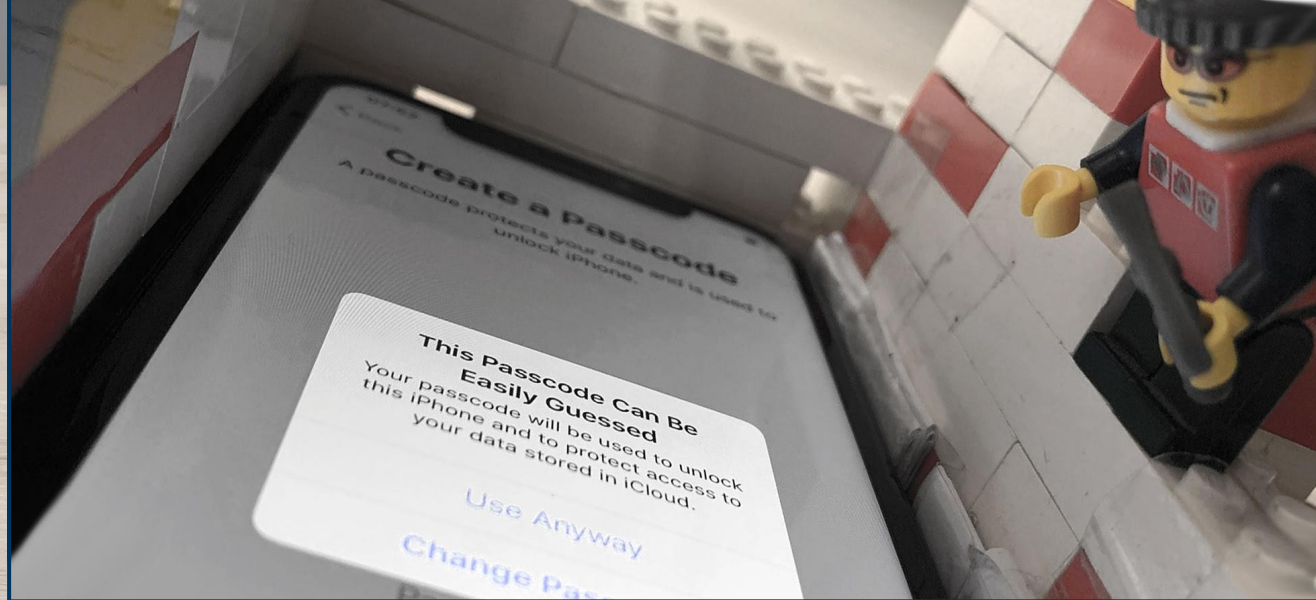
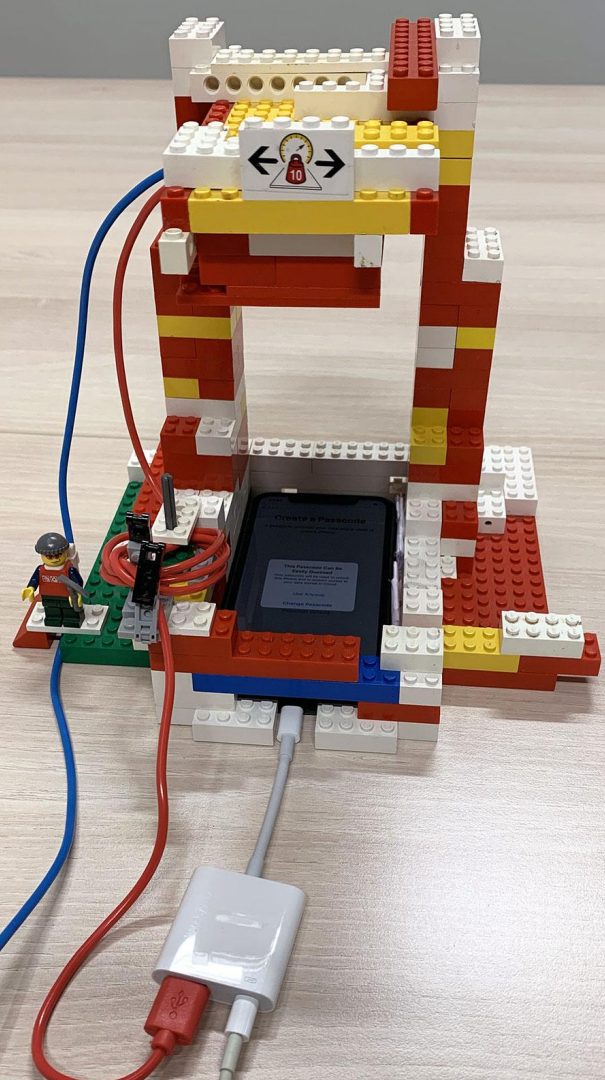
- 274 PINs (4-digit)
- 2910 PINs (6-digit)

## Data-Driven (DD)

“Test effect of different blocklist sizes”

Blocklist:

- Top 27 PINs of Amitay (small)
- Top 2740 PINs of Amitay (large)



# User Study



INFO

5/14

### Create a 4-digit PIN

A PIN protects your data and is used to unlock your smartphone.

#### This PIN Can Be Easily Guessed

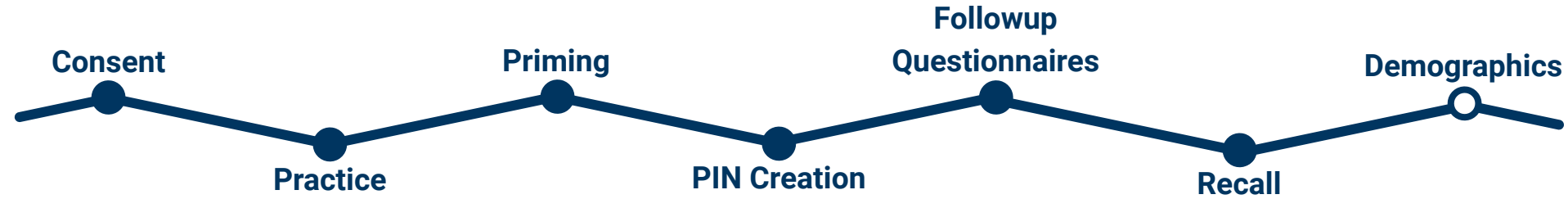
Your PIN will be used to unlock your smartphone and to protect access to your data.

[Change PIN](#)

7 PQRS 8 TUV 9 WXYZ

⌫ 0 CLEAR

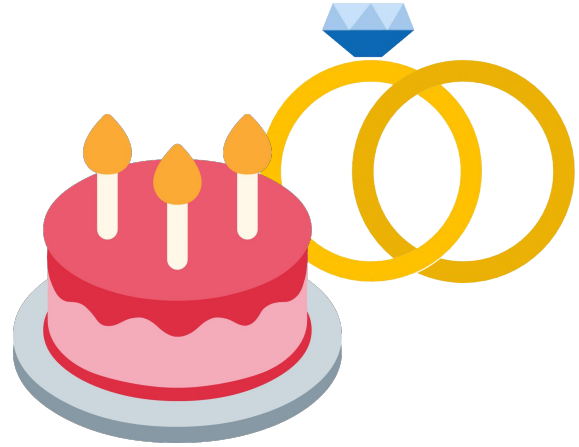
# User Study



# Attacker Model



- No information about the victim



# Attacker Model



- No information about the victim

1   
2   
3 

- Guesses PINs in decreasing probability order

Rank	4-digit PINs	6-digit PINs
1	1234	123456
2	0000	123123
3	2580	111111
⋮	⋮	⋮

# Attacker Model



- No information about the victim



- Guesses PINs in decreasing probability order



- Slowed down by rate-limiting

You have incorrectly typed your PIN  
5 times.

Try again in 30 seconds.

OK

	Android	iOS
10 Guesses	30s	1h 36m 0s
100 Guesses	10h 45min 30s	—

# Attacker Model



- No information about the victim



- Guesses PINs in decreasing probability order



- Slowed down by rate-limiting



- Knows the blocklist and skips impossible choices

Rank	4-digit PINs	6-digit PINs
1	1234	123456
2	<i>not allowed</i> <del>0000</del>	
3	2580	
⋮	⋮	

## This PIN Can Be Easily Guessed


Your PIN will be used to unlock your smartphone and to protect access to your data.

[Change PIN](#)

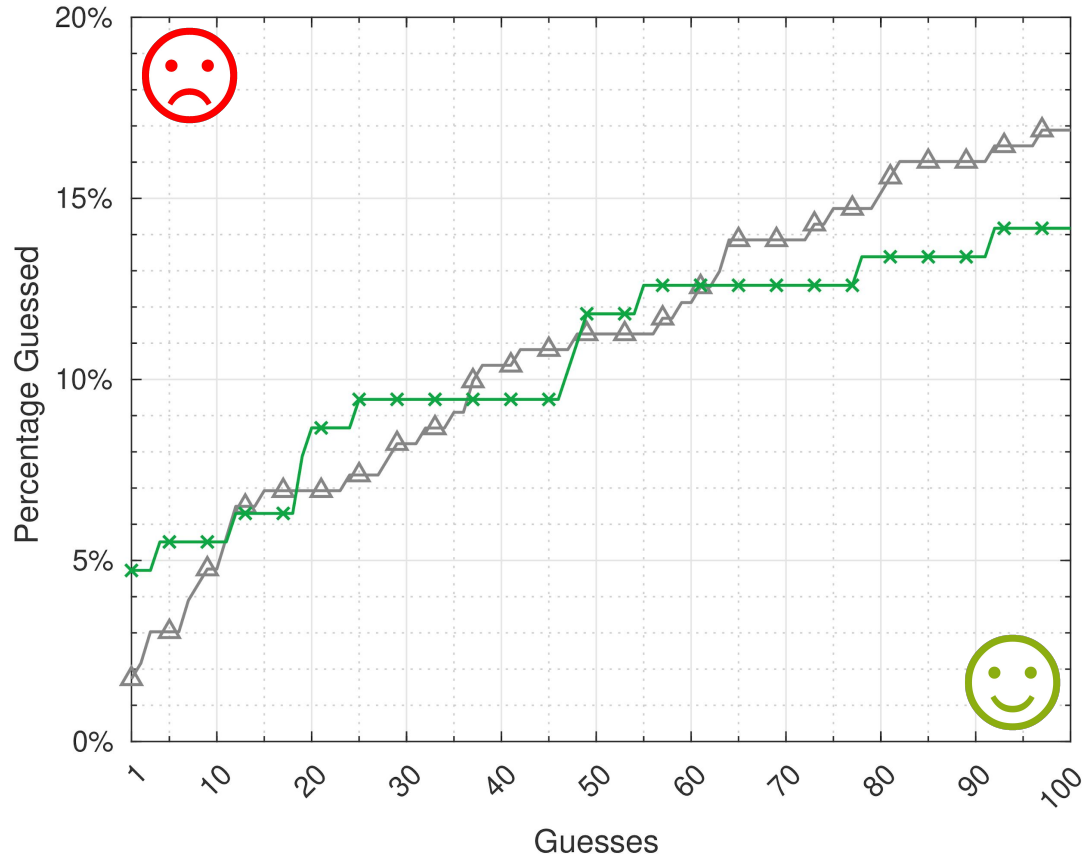
# Research Questions

**4 vs. 6** **RQ1:** How secure are 4- and 6-digit PINs in the smartphone unlock setting?

**Small?  
Medium?  
Large?** **RQ2:** What are the effects of different blocklists on the security of PINs?

 **RQ3:** How to balance security and usability when composing a blocklist?

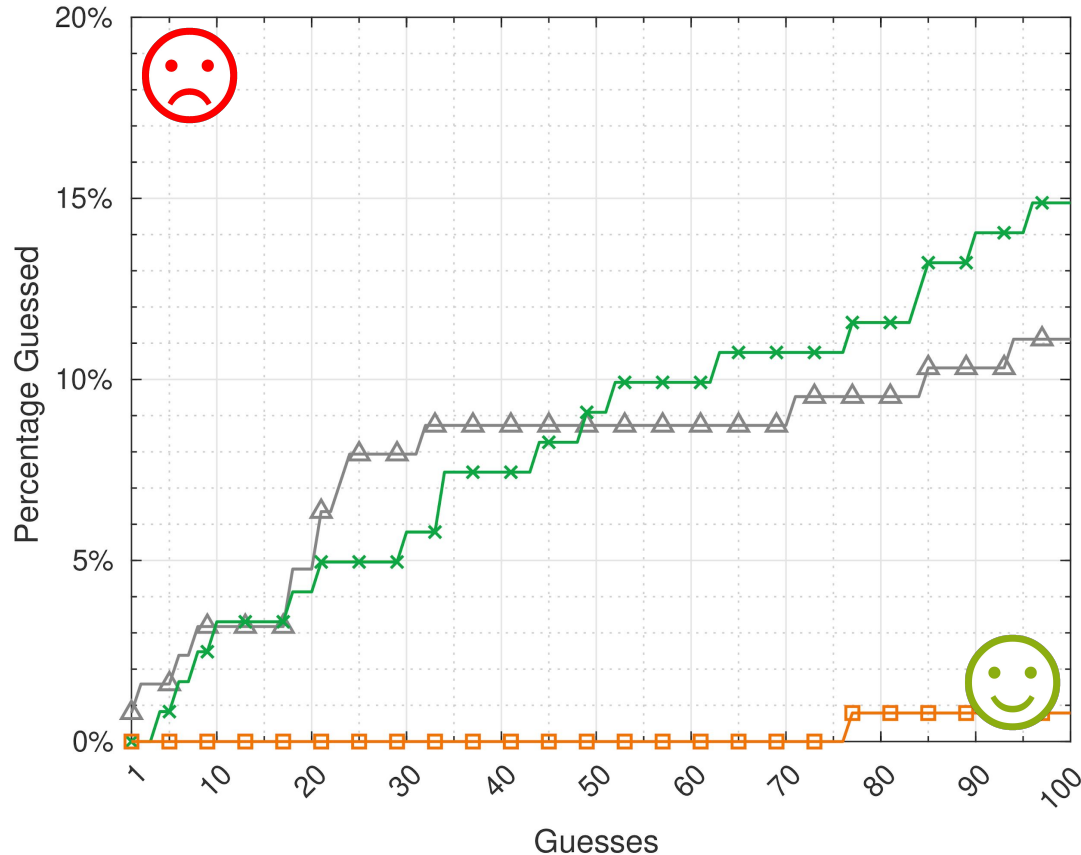
## RQ1: 4- vs. 6-digit PINs



### Observations:

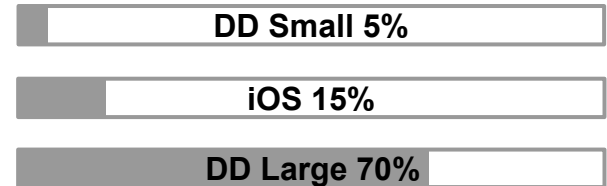
- Overall comparable security of 4- and 6-digit PINs in the defined attacker model
- Differences depending on the number of guesses

## RQ2: Different Blocklist Sizes

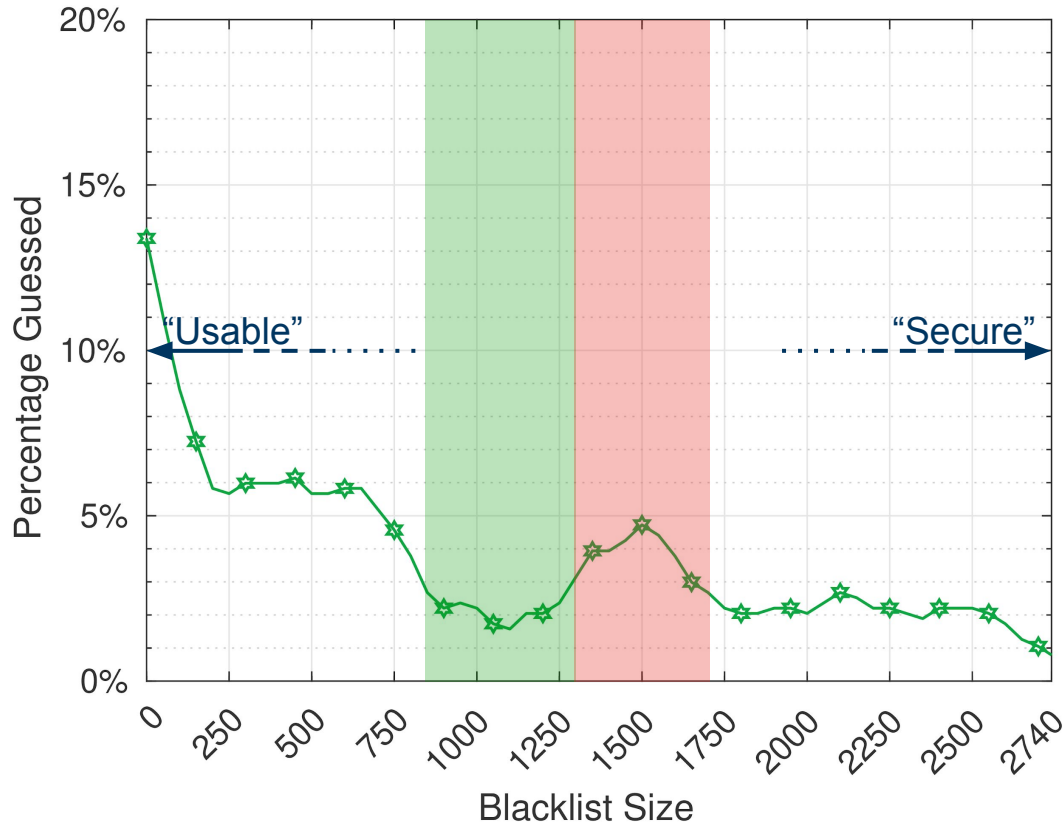


### Observations:

- *iOS* and *Data-Driven Small* offer comparable security
- *Data-Driven Large* drastically increases the security
- Blocklist Hitrate:



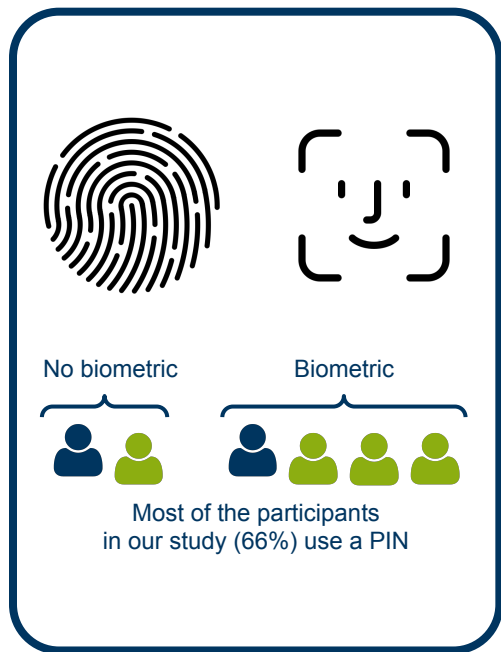
## RQ3: Balancing Security and Usability



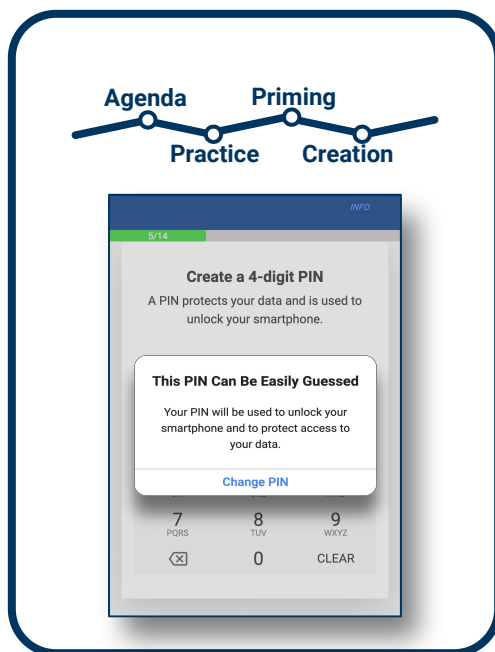
### Observations:

- Different extrema throughout the curve
- Maxima: users choose popular PINs
- Minima: users choose unpopular PINs
- Blocking ~10% is ideal

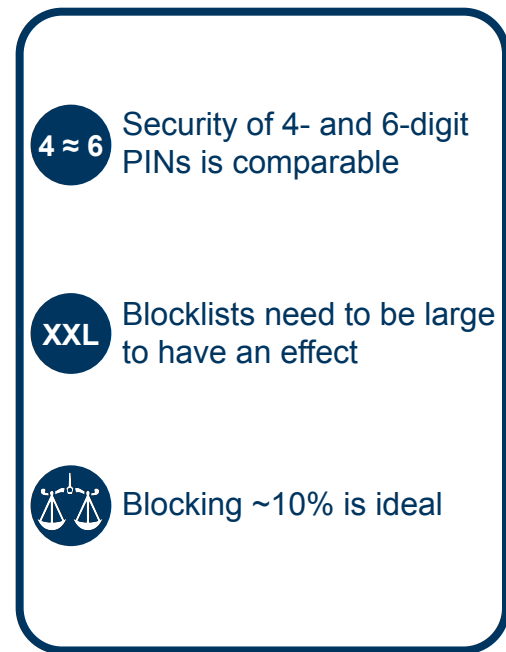
# Takeaways



## Why study PINs?



## User Study



## Results