

EmojiAuth:

Quantifying the Security of Emoji-based Authentication

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Great

How are you?

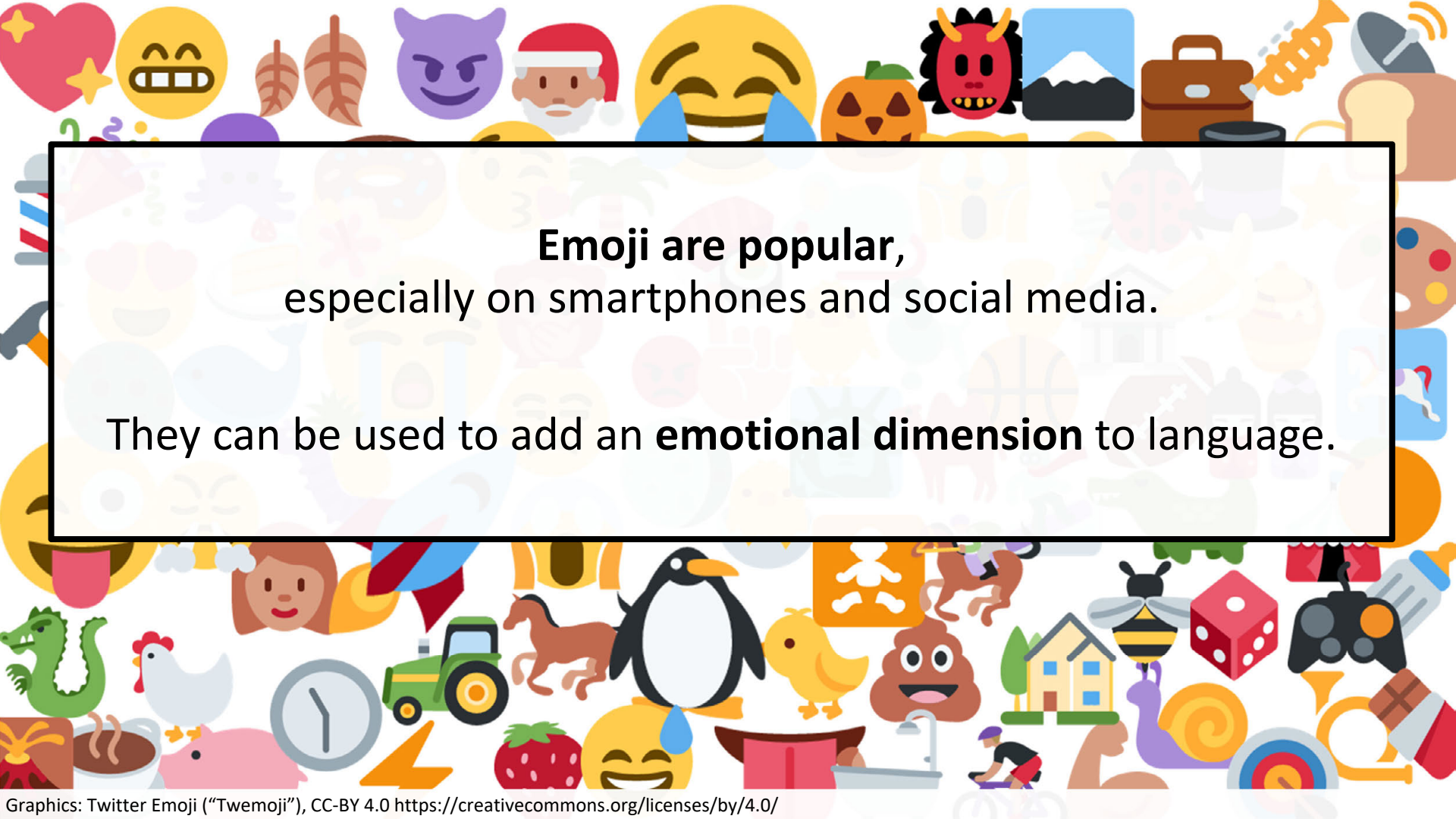
Great 😊 🦄

Great 😡

How are you?

Happy Birthday Kate 🎉 🎊
Enjoy the 🍰 But please don't
overdo it like last year 😞

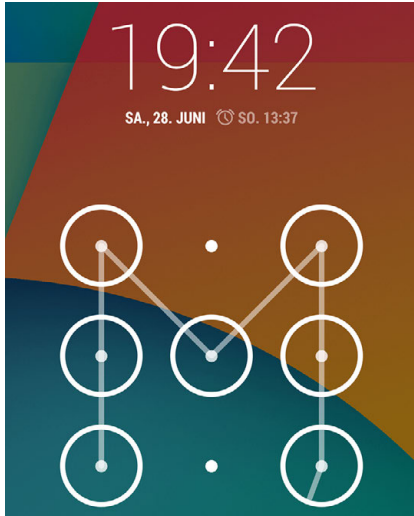
Too late 😏

A dense collage of various emojis surrounds the central text box. The top row features a heart with stars, a grinning face with tongue sticking out, autumn leaves, a purple devil face, Santa Claus, a laughing face with tears, a jack-o'-lantern, a red devil face, a mountain landscape, a brown briefcase, a satellite dish, and a slice of toast. The bottom row includes a green dragon, a white chicken, a clock, a green tractor, a brown horse, a penguin, a yellow chick, a brown poop emoji, a house, a bee, a red die, a black game controller, a purple snail, a rainbow, a person on a bicycle, a pink pig, a strawberry, a smiling face with a sweat drop, a person washing their face, and a red gift box.

Emoji are popular,
especially on smartphones and social media.

They can be used to add an **emotional dimension** to language.

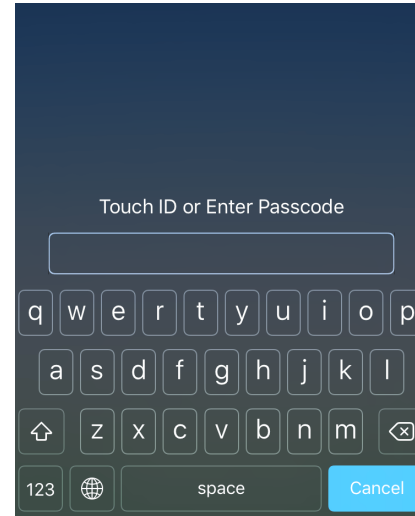
Smartphone Unlock Issues



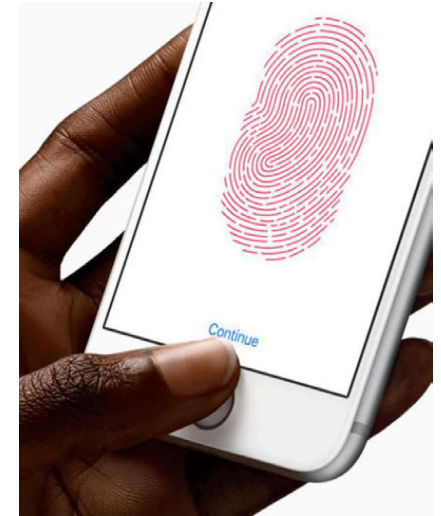
Unlock Patterns



4/6-digit PINs

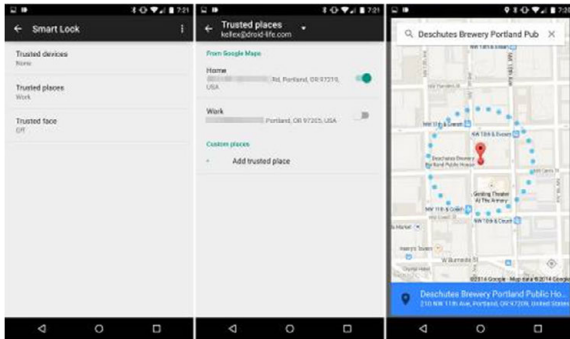


Passwords



Fingerprints

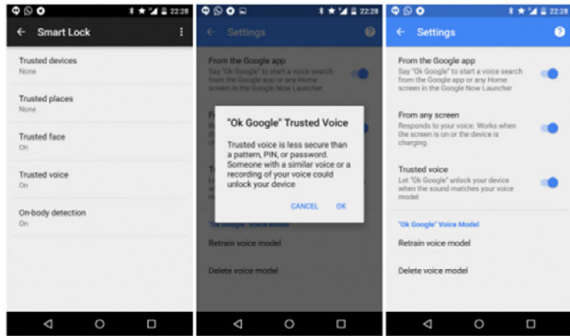
There Are More ...



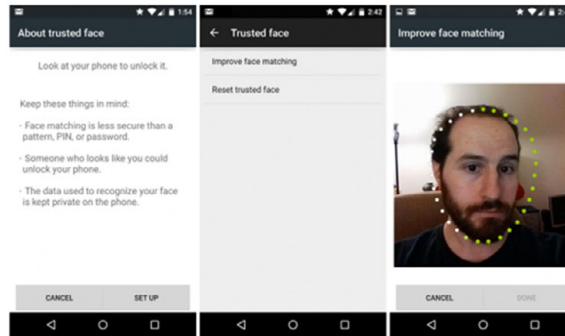
Trusted Location



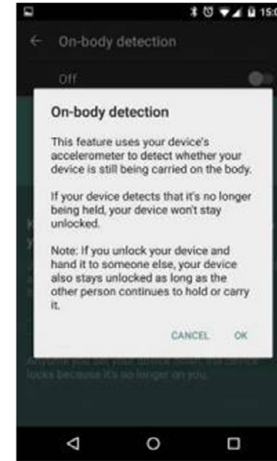
Trusted Device



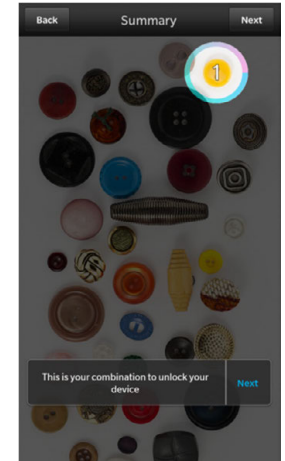
Trusted Voice



Trusted Face



On-Body Detection



Picture Password

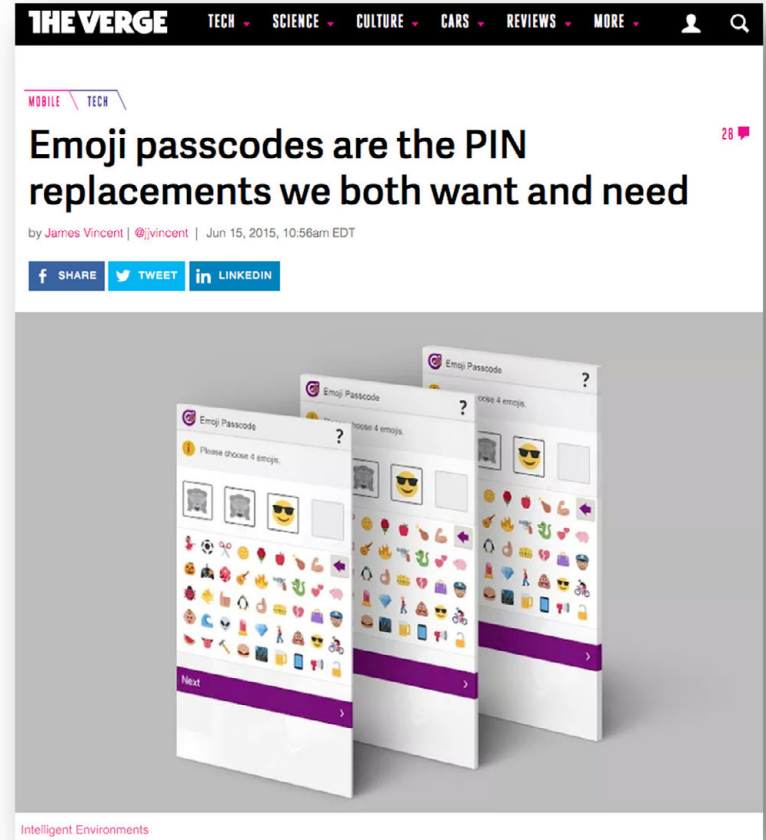
Emoji Passcodes

In 2015, Intelligent Environments proposed emoji-based authentication. [1]

- The obvious next step?
- In 2016, Kraus et al. analyzed the implications of emoji-based passwords. [2]

Is it really a good idea?

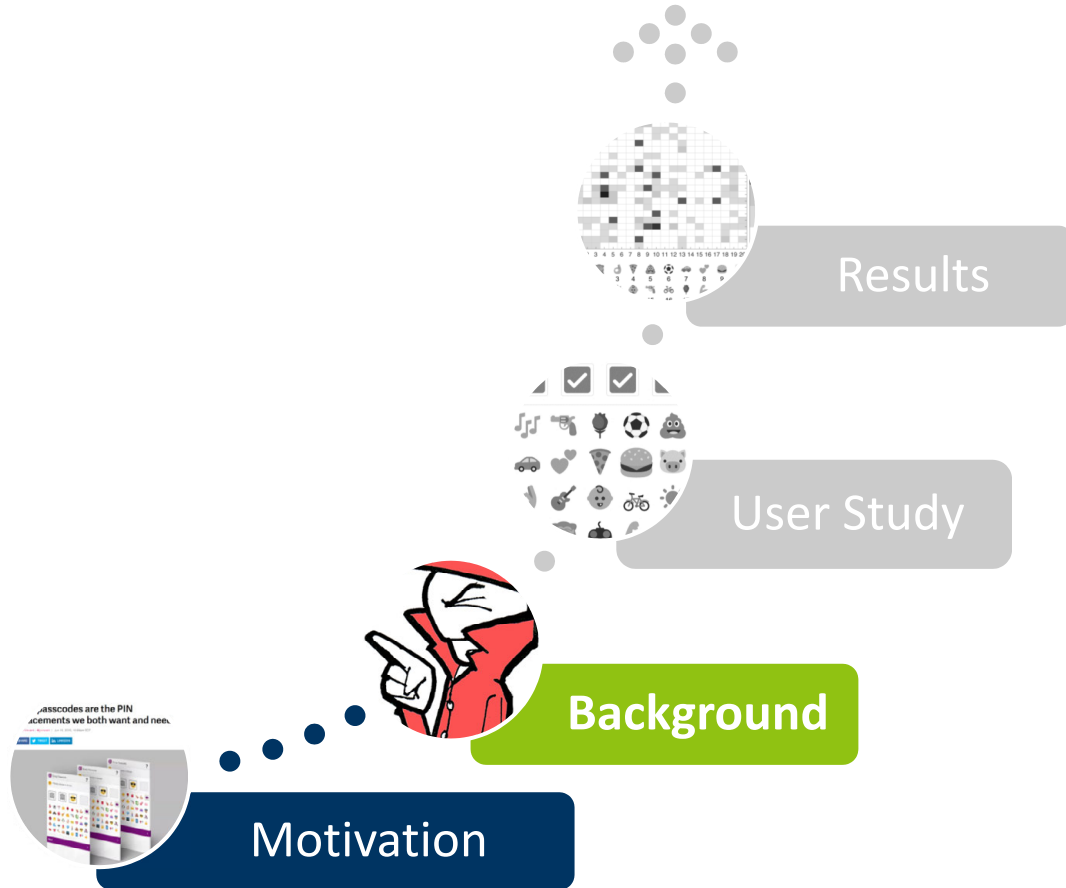
- How secure is emoji-based authentication?
- How do selection strategies differ from PIN selection?



[Ref. 1] Intelligent Environments: Now You Can Log Into Your Bank Using Emoji. (intelligentenvironments.com, 2015)

[Ref. 2] Lydia Kraus et al.: Implications of the Use of Emojis in Mobile Authentication. (WAY '16)

Outline



EmojiAuth

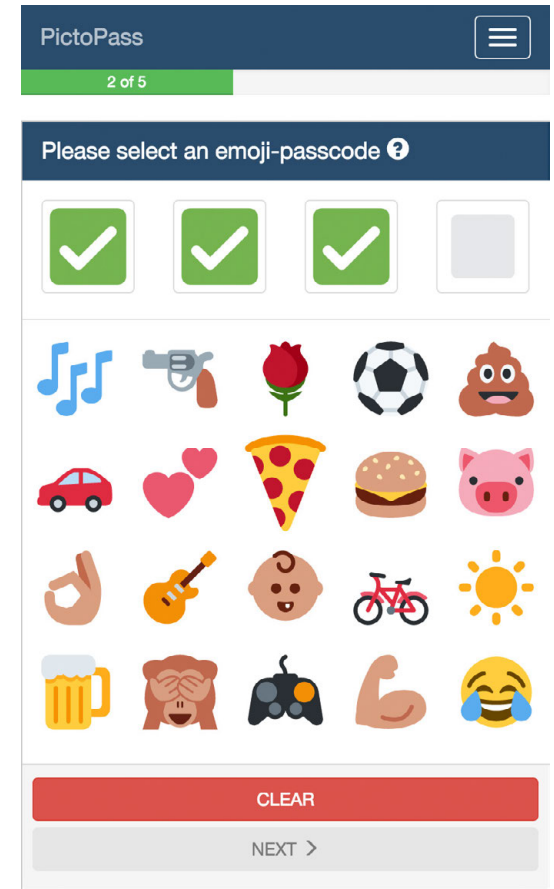
Similar to 4-digit PIN-based authentication.

Step 1: Enrollment

- User selects 4 emoji as a passcode
- No restrictions on selection
- User repeats passcode to prevent mistypes + training

Step 2: Authentication

- User enters the passcode to login
- User is allowed to make three login attempts



Approach

Online user study, collect emoji-passcodes

Estimate Security Level:

1. Build Markov model-based emoji guesser
2. Compare with existing schemes (limited)

Selection Strategy:

Questionnaire:

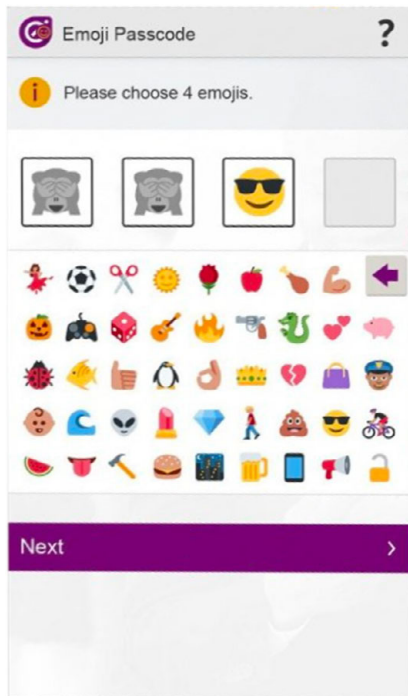
“How did you choose your emoji passcode?”



[3]

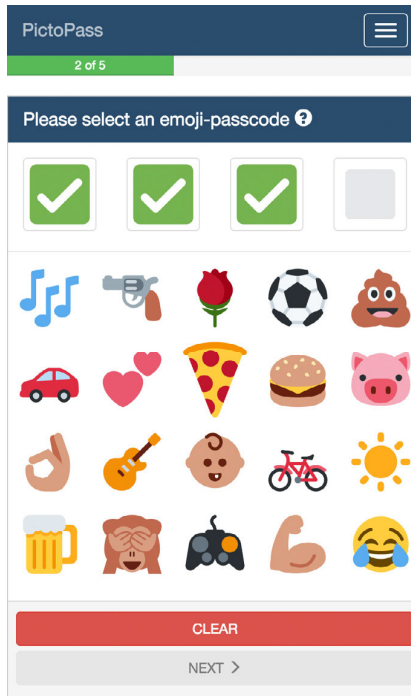
Grid Size

Intelligent Environments^[1]



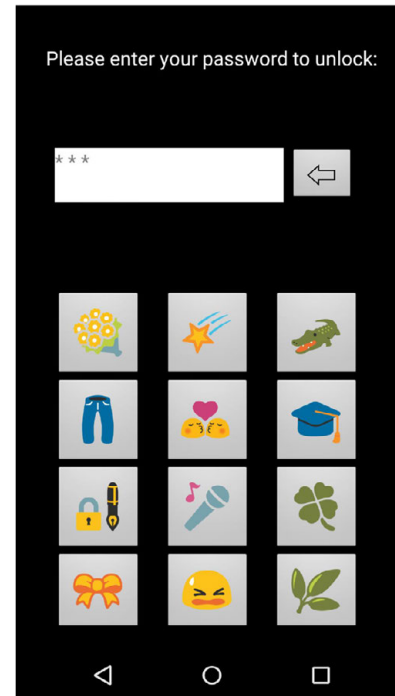
44 emoji

Our Approach



20 emoji

Kraus et al.^[2]



12 emoji

Attacker

Comparison: Guesser + methodology similar to Uellenbeck et al. [6]

Markov Model-Based Guesser:

- Model probability of the next emoji, based on the previous emoji in passcode

- 1) Model for content
- 2) Model for position
- 3) Fusion of both: Content + position model

Methodology:

- 5-fold cross-validation

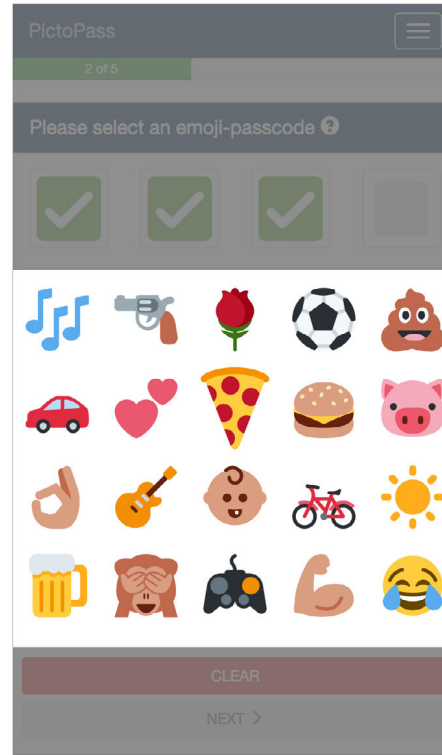


Measure Position Bias

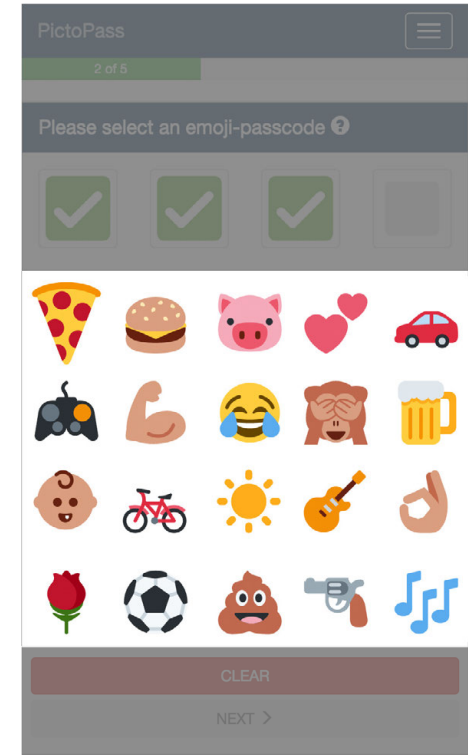
Emoji grid is randomized on a per user basis.

Fixed grid between enrollment and authentication.

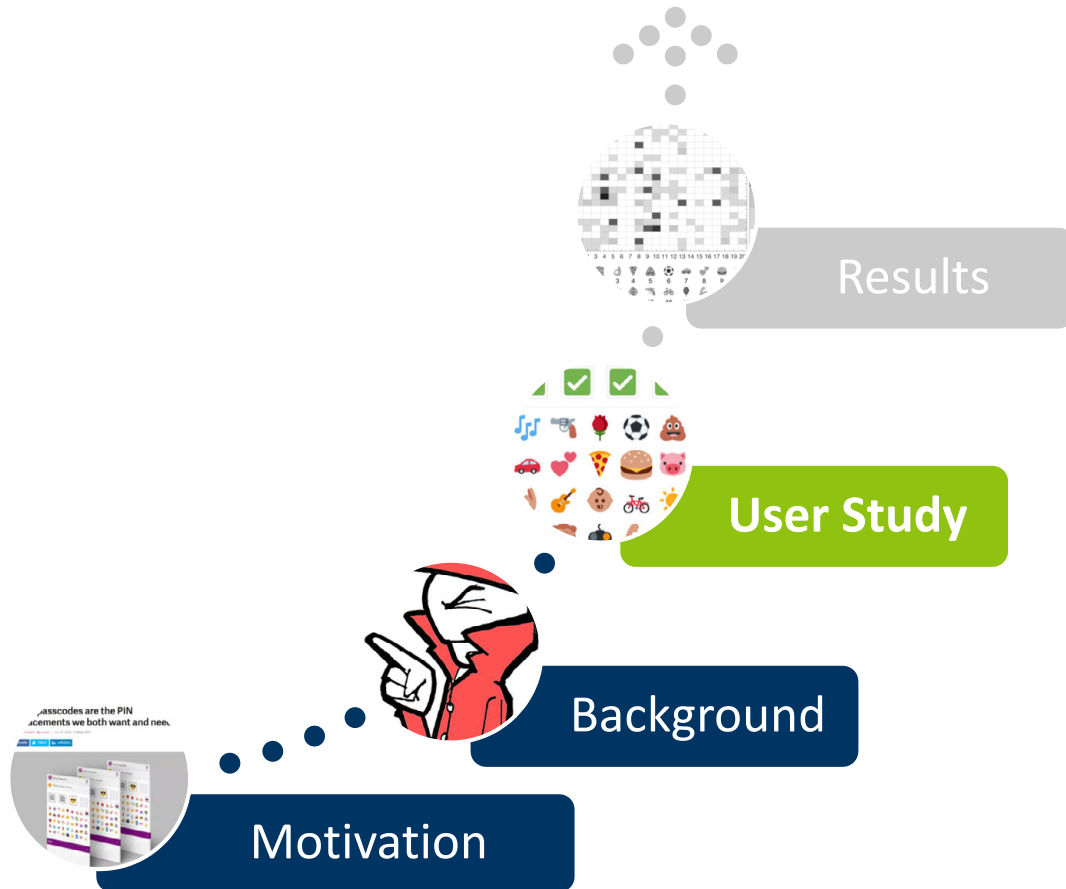
User A



User B



Outline



User Study



- Online user study
- Lasted: 21 days
- Recall after 2 days, reminder after 4 days

Limitations:

Snowball sampling bias

- 37% female
- Young participants (20 - 30 years)
- More than average technical background

→ Protects the study from overestimating the offered security level

Progress	Participants		
Enrollment	795		
Dropout + Email Issues	141 + 22		
Clicked Recall Link	632		
Authentication	623		
Success / Unsuccessful			
	All	535	88
	1 st try	464	8
	2 nd try	58	14
	3 rd try	13	66



PictoPass: A New Graphical Passcode Scheme

Passcodes and PINs are commonly used to authenticate users, but they can be hard to remember and they are often not secure. In this survey we are testing a potential replacement for 4-digit passcodes, which claims to be easier to remember and more secure. Your help to test this new scheme is greatly appreciated. We will raffle 3x Amazon gift cards (10 Euros each) among all participants who completed both phases of the survey.



PictoPass: A New Graphical Passcode Scheme

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Enter your email address

I agree to the [privacy policy](#).

Start

Security

We care a lot about security! Your email address will be stored encrypted with strong, state of the art algorithms (AES-256 and SHA-512) and will only be used for the authentication phase and to inform the winners of the gift cards.



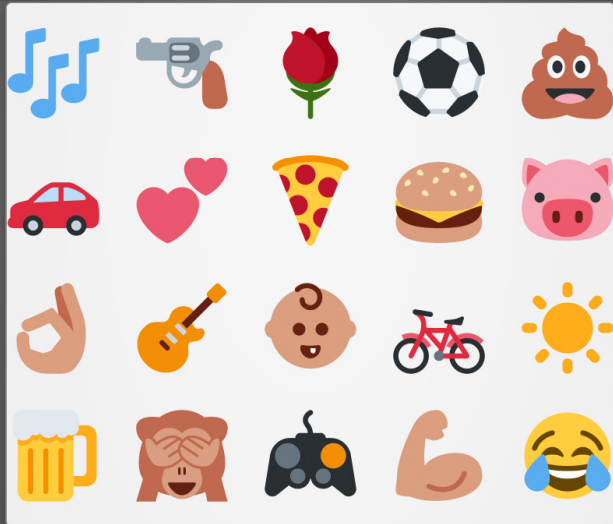
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Got it!



Please select an emoji-passcode ?



Select the first emoji for your emoji-passcode.
skip back next

Enter your email address
participant@email.com
 I agree to the [privacy policy](#).
Start

Security
We care a lot about security! Your email address will be stored encrypted with strong, state of the art algorithms (AES-256 and SHA-512) and will only be used for the authentication phase and to inform the winners of the gift cards.



2 of 5

Please select an emoji-passcode ?

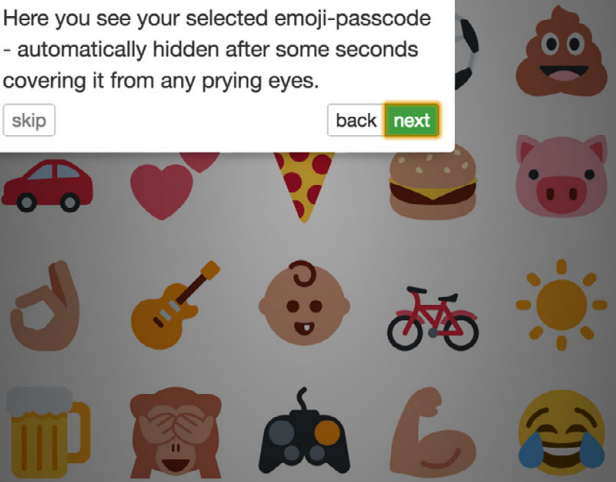


Here you see your selected emoji-passcode - automatically hidden after some seconds covering it from any prying eyes.

skip

back

next



CLEAR

NEXT >



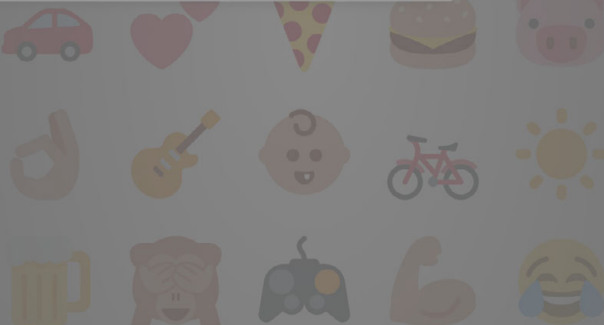
Please select an emoji-passcode ?



Here you see your selected emoji-passcode - automatically hidden after some seconds covering it from any prying eyes.

skip

back next

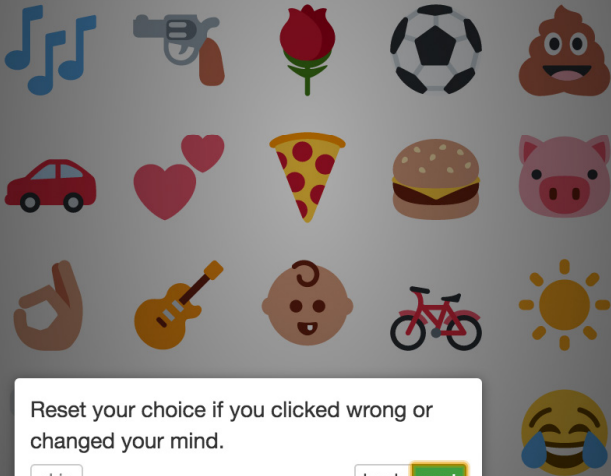


CLEAR

NEXT >



Please select an emoji-passcode ?



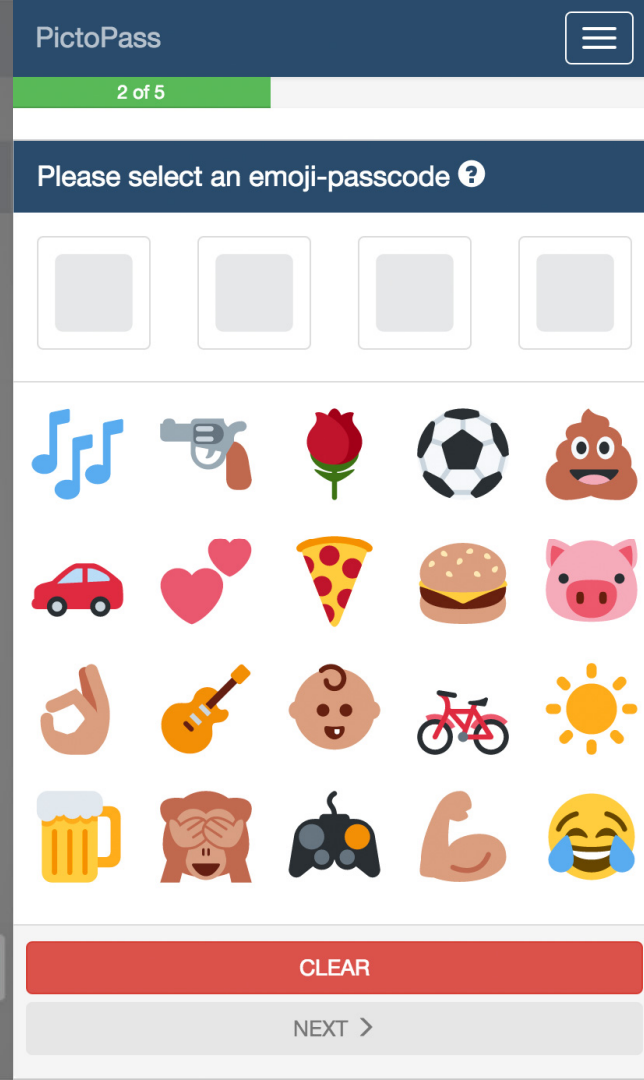
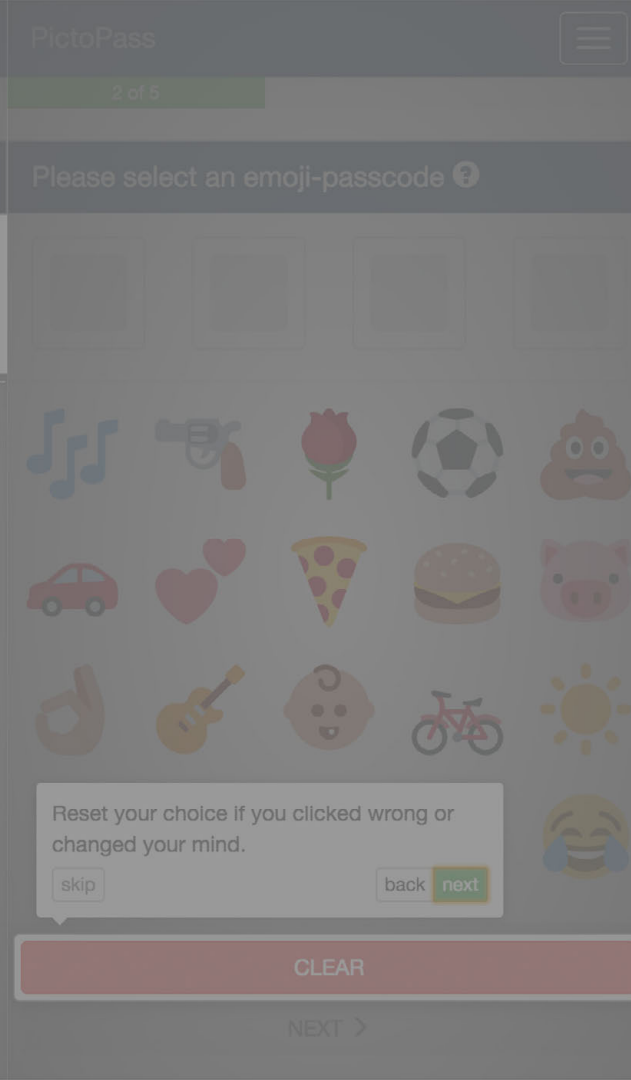
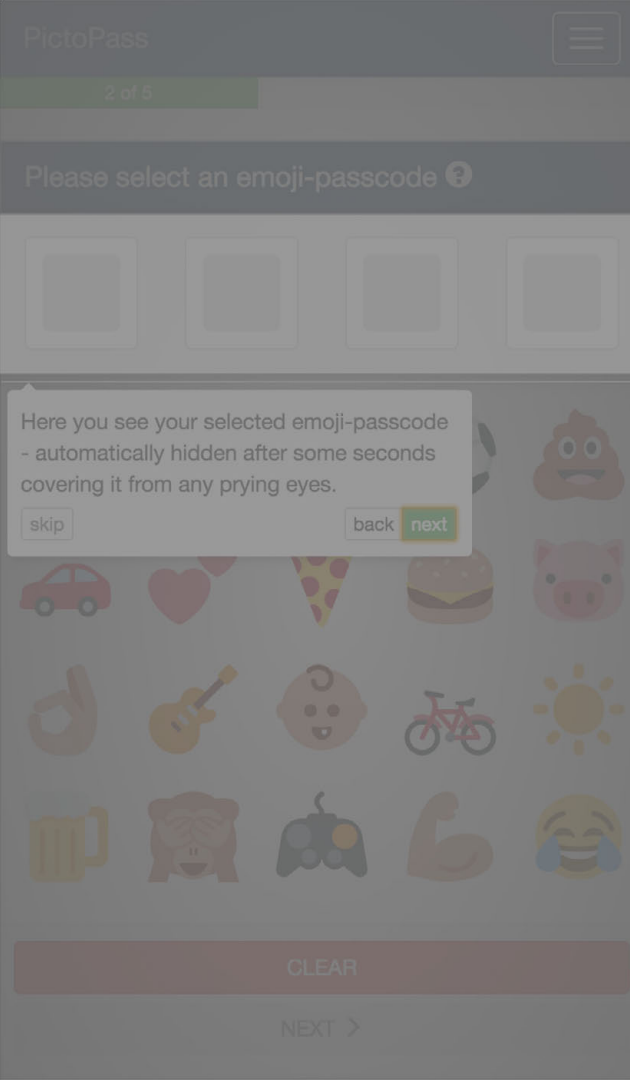
Reset your choice if you clicked wrong or changed your mind.

skip

back next

CLEAR

NEXT >



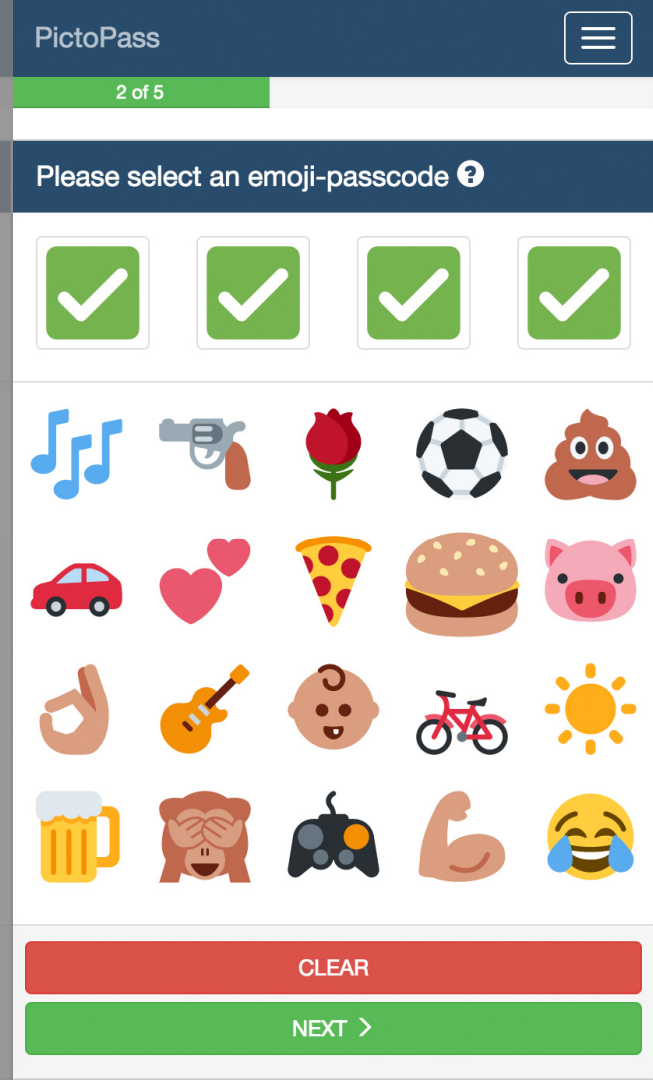
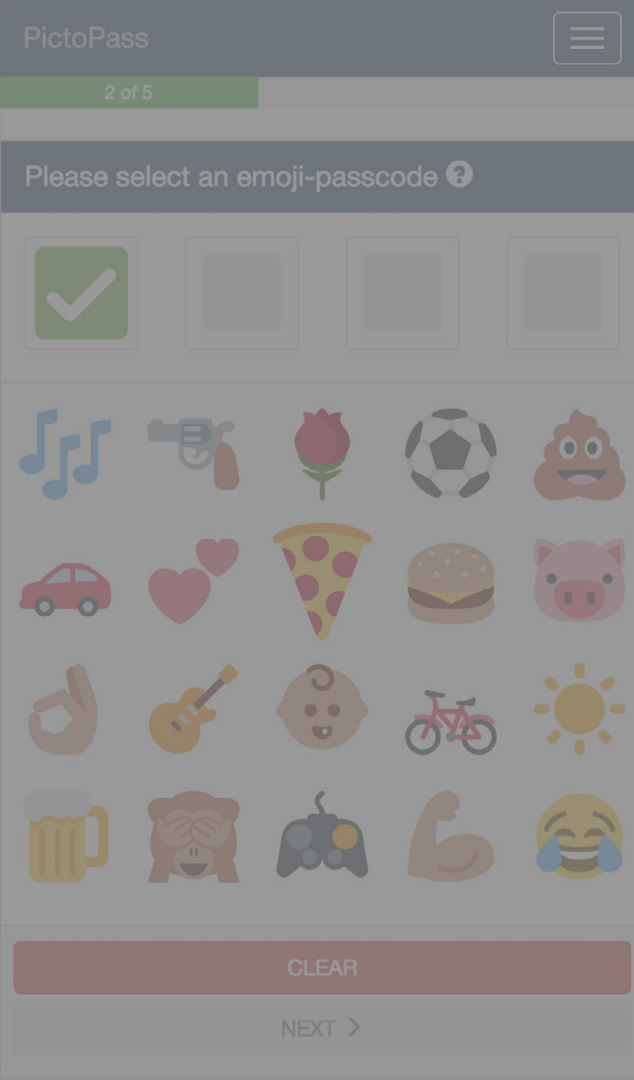


Please select an emoji-passcode ?



CLEAR

NEXT >



PictoPass

2 of 5

Please select an emoji-passcode ?

CLEAR

NEXT >

PictoPass

2 of 5

Please select an emoji-passcode ?

CLEAR

NEXT >

PictoPass

3 of 5

Repeat your emoji-passcode

CLEAR

NEXT >



Age:

26

+

-

I identify my gender as:

Male

Where are you from (Country):

Germany



How did you choose your emoji-passcode:

✓ -- Please choose --

Created a story

Repeating event of my life

Emoji I use the most while texting

Selection as random as possible

Important things of my life

Via the position within the grid

Via a visual pattern

Other

Working with emoji was enjoyable:

PictoPass

4 of 5

Age:

26

I identify my gender as:

Male

Where are you from (Country):

Germany

How did you choose your emoji-passcode:

- ✓ -- Please choose --
- Created a story
- Repeating event of my life
- Emoji I use the most while texting
- Selection as random as possible
- Important things of my life
- Via the position within the grid
- Via a visual pattern
- Other

Working with emoji was enjoyable:

PictoPass

4 of 5

-- Please choose --

How often do you use emoji:

-- Please choose --

Rembering a 4-digit PIN is:

-- Please choose --

Working with emoji was enjoyable:

-- Please choose --

How do you assess your technical understanding:

-- Please choose --

How much effort do you spend to protect your data:

-- Please choose --

NEXT >

Age:

26

+

-

I identify my gender as:

Male

Where are you from (Country):

Germany



How did you choose your emoji-passcode:

✓ -- Please choose --

Created a story

Repeating event of my life

Emoji I use the most while texting

Selection as random as possible

Important things of my life

Via the position within the grid

Via a visual pattern

Other

Working with emoji was enjoyable:

-- Please choose --

How often do you use emoji:

-- Please choose --

Remembering a 4-digit PIN is:

-- Please choose --

Working with emoji was enjoyable:

-- Please choose --

How do you assess your technical understanding:

-- Please choose --

How much effort do you spend to protect your data:

-- Please choose --

NEXT >

Feedback

If you have any further feedback, questions, impressions or anything else you want to let us know - please leave a comment below!

FINISH



Thank you!

Thank you very much for participating in this survey.

You will receive an email in the next 2 days with further instructions for your authentication phase.

After that you will automatically take part in the raffle for the Amazon voucher.

If you liked it, please share PictoPass with your friends:

 **On Facebook**

 **On Twitter**

 **On Google+**

 **On Pinterest**





Thank you!

Thank you very much for participating in this survey. You will receive an email in the next 2 days with further instructions for your authentication phase. After that you will automatically take part in the raffle for the Amazon voucher.

If you liked it, please share PictoPass with your friends:

 On Facebook

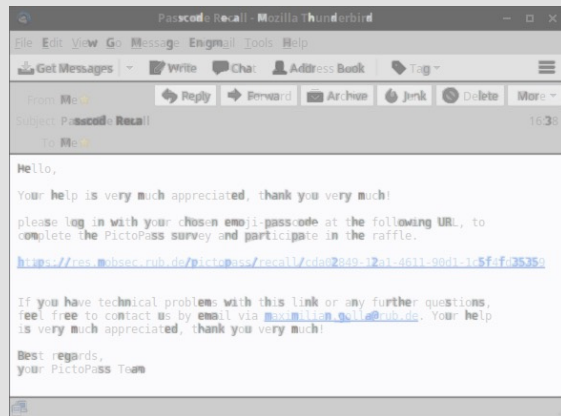
 On Twitter

 On Google+

 On Pinterest



2 Days later



Recall



Thank you!

Thank you very much for participating in this survey. You will receive an email in the next 2 days with further instructions for your authentication phase. After that you will automatically take part in the raffle for the Amazon voucher.

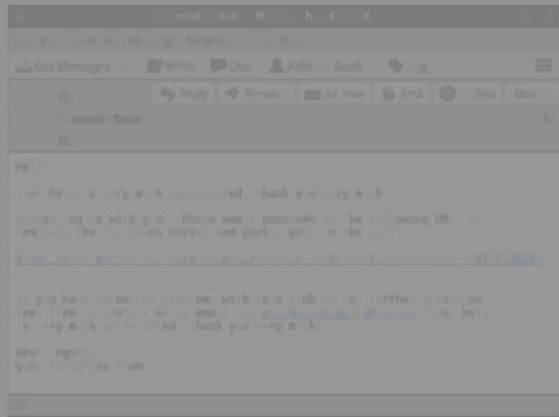
If you liked it, please share PictoPass with your friends:

On Facebook
 On Twitter

On Google+
 On Pinterest



2 Days later



Recall



Please enter your emoji-passcode

CLEAR

LOGIN >



Your emoji-passcodes do not match. Please try again!

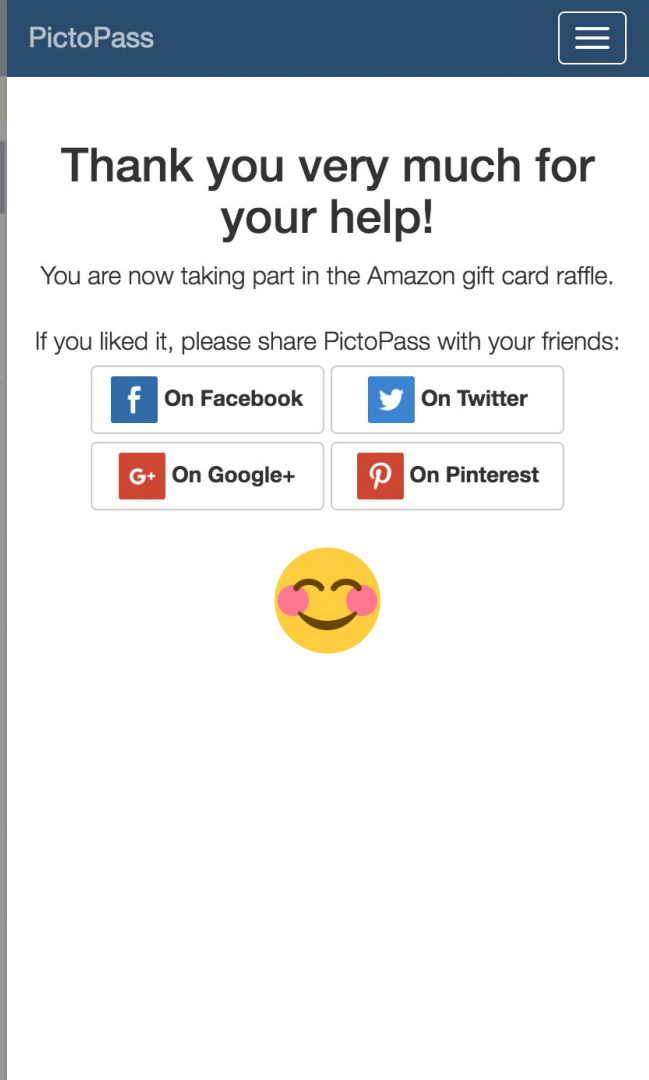
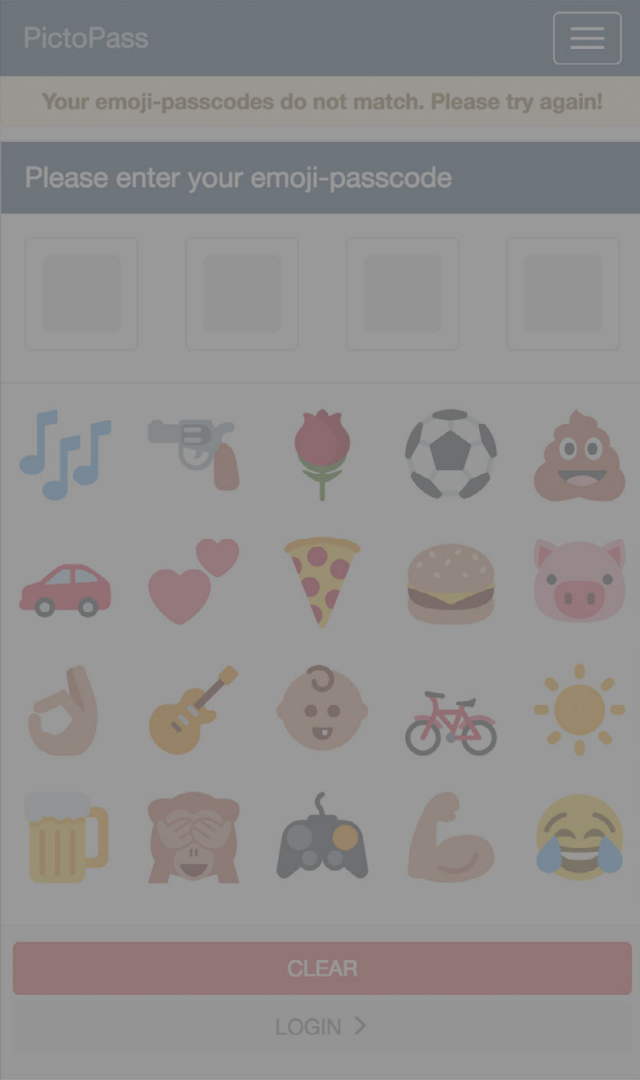
Please enter your emoji-passcode

Four empty square boxes for entering the emoji-passcode.

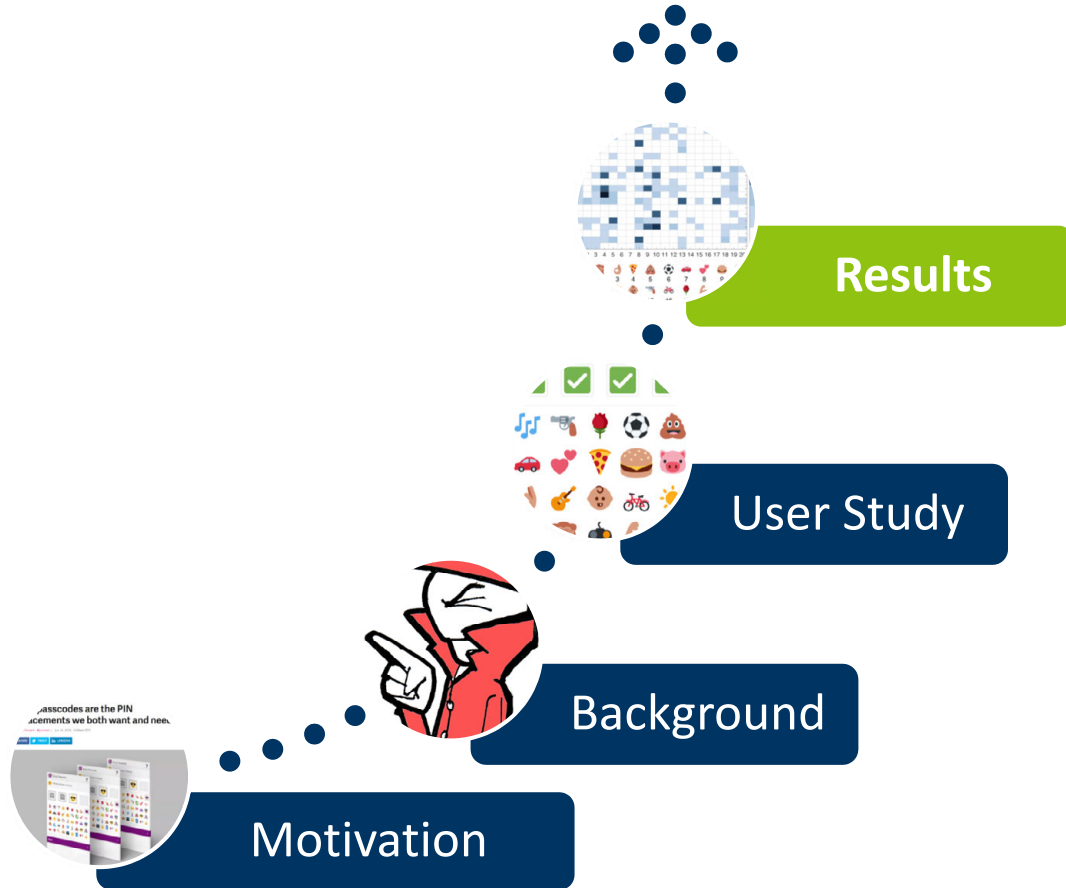


CLEAR

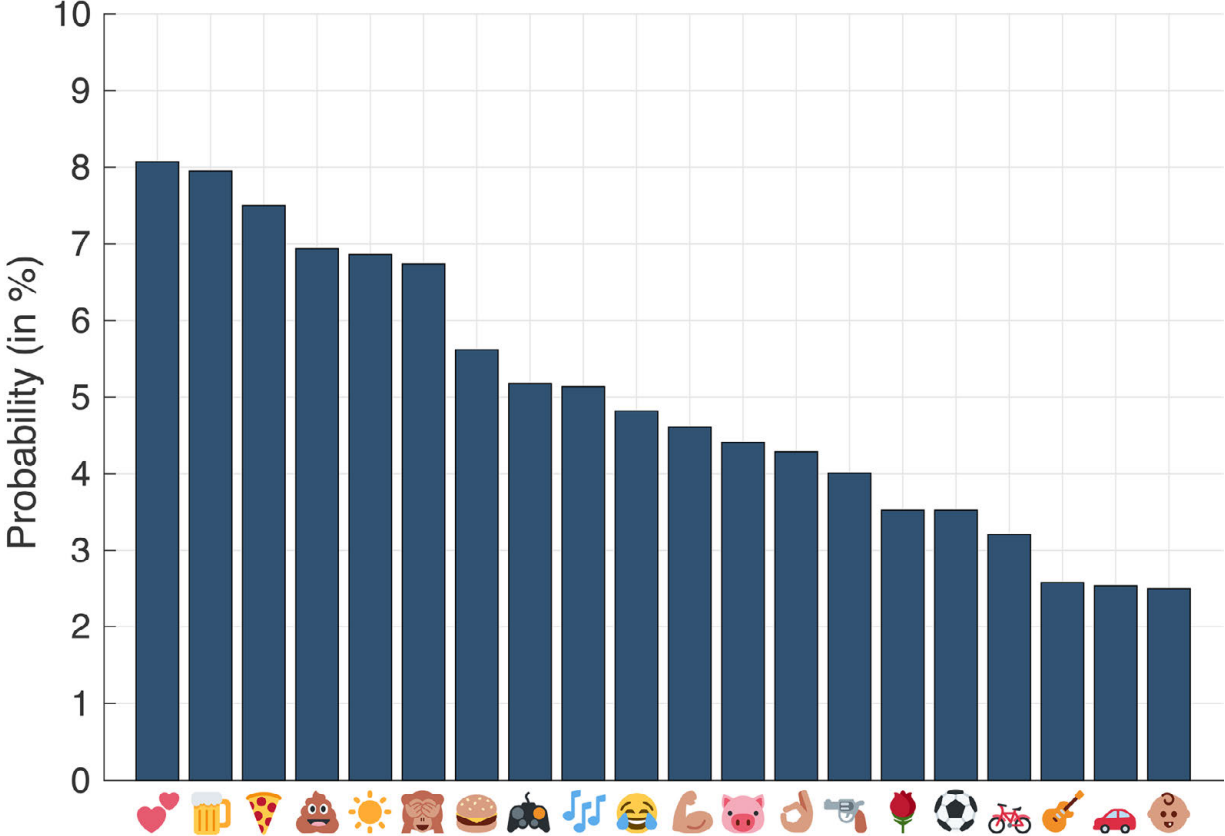
LOGIN >



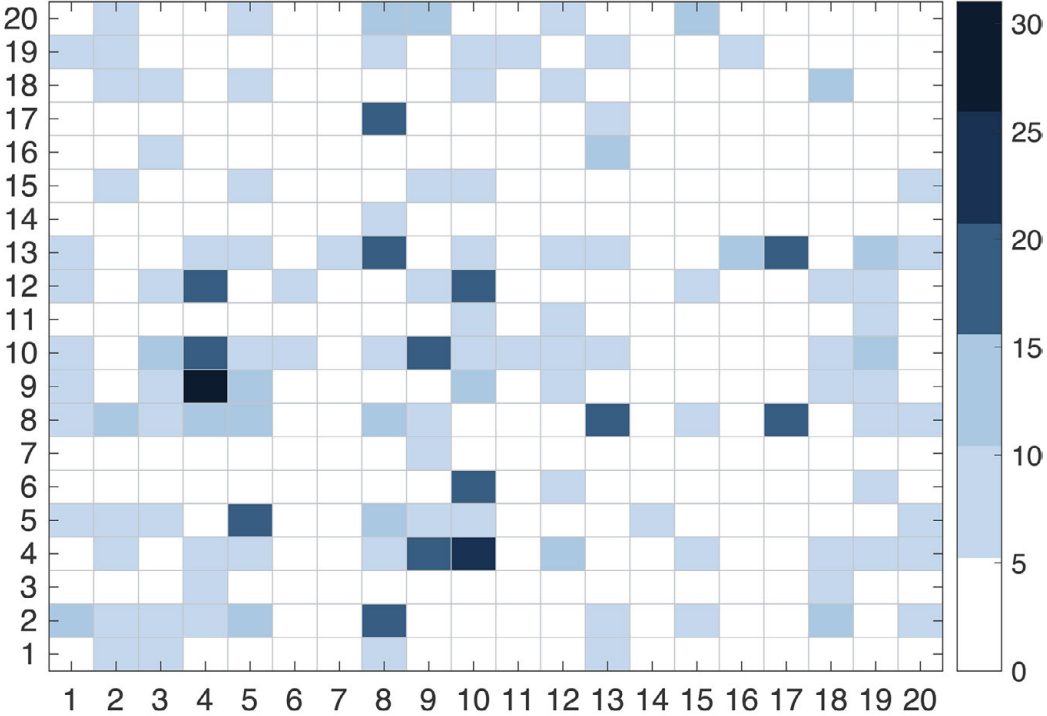
Outline



Selection Bias: Most Frequent Emoji



Selection Bias: Popular 2-grams





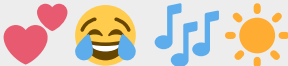


- 1 🤔
- 2 🙈
- 3 🤞
- 4 🍕
- 5 💩
- 6 ⚽
- 7 🚗
- 8 ❤️
- 9 🍔
- 10 🍺
- 11 🎸
- 12 🎮
- 13 ☀️
- 14 🙄
- 15 🔫
- 16 🚲
- 17 🌹
- 18 💪
- 19 🎵
- 20 🐷

Selection Bias: Top 5 Passcodes

In our dataset 13 passcodes occurred more than once.

Tendencies:

- Cheerful emoji
- Single emoji passcodes

Occ.	Passcode	Prob.
4		0.64%
3		0.48%
2		0.32%
2		0.32%
2		0.32%

Selection Bias: Position












Selection Bias: Position

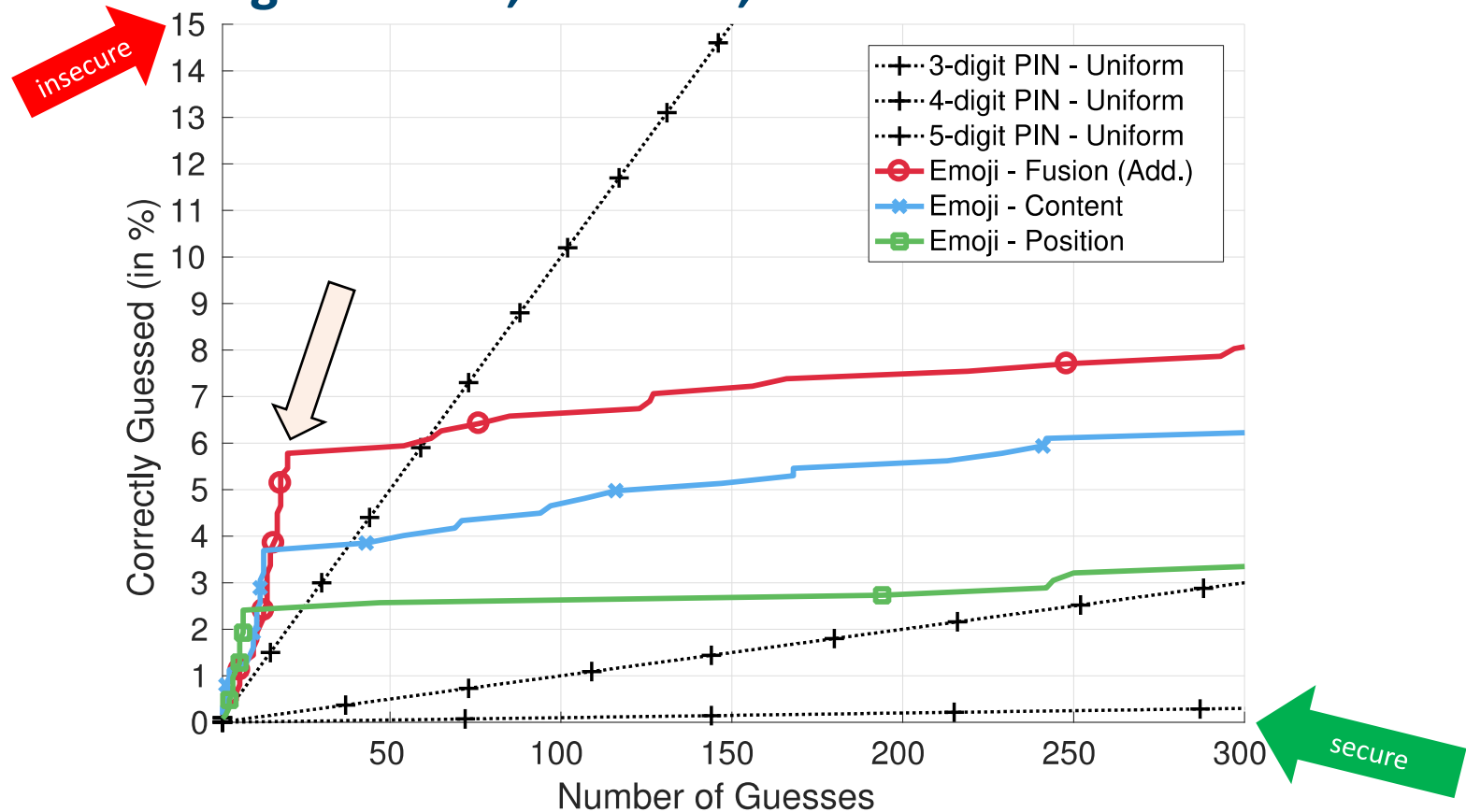
The image displays eight mobile app screens, each titled 'Position 1' through 'Position 8'. Each screen has a dark header with the text 'Please enter your emoji-passcode'. Below the header is a row of four empty square emoji slots. The main area is a 4x4 grid. The passcode digits are shown in the first row of the grid. The positions of the digits are as follows:

- Position 1:** Row 1: 1, 2, 3, 4
- Position 2:** Row 1: 1, 2, 3/4
- Position 3:** Row 1: 1, 2, 3; Row 2: 4
- Position 4:** Row 1: 1, 2, 3, 4
- Position 5:** Row 1: 1, 2, 3, 4
- Position 6:** Row 1: 1, 2, 3; Row 2: 4
- Position 7:** Row 1: 2, 3, 4; Row 2: 1
- Position 8:** Row 1: 1, 2/3, 4

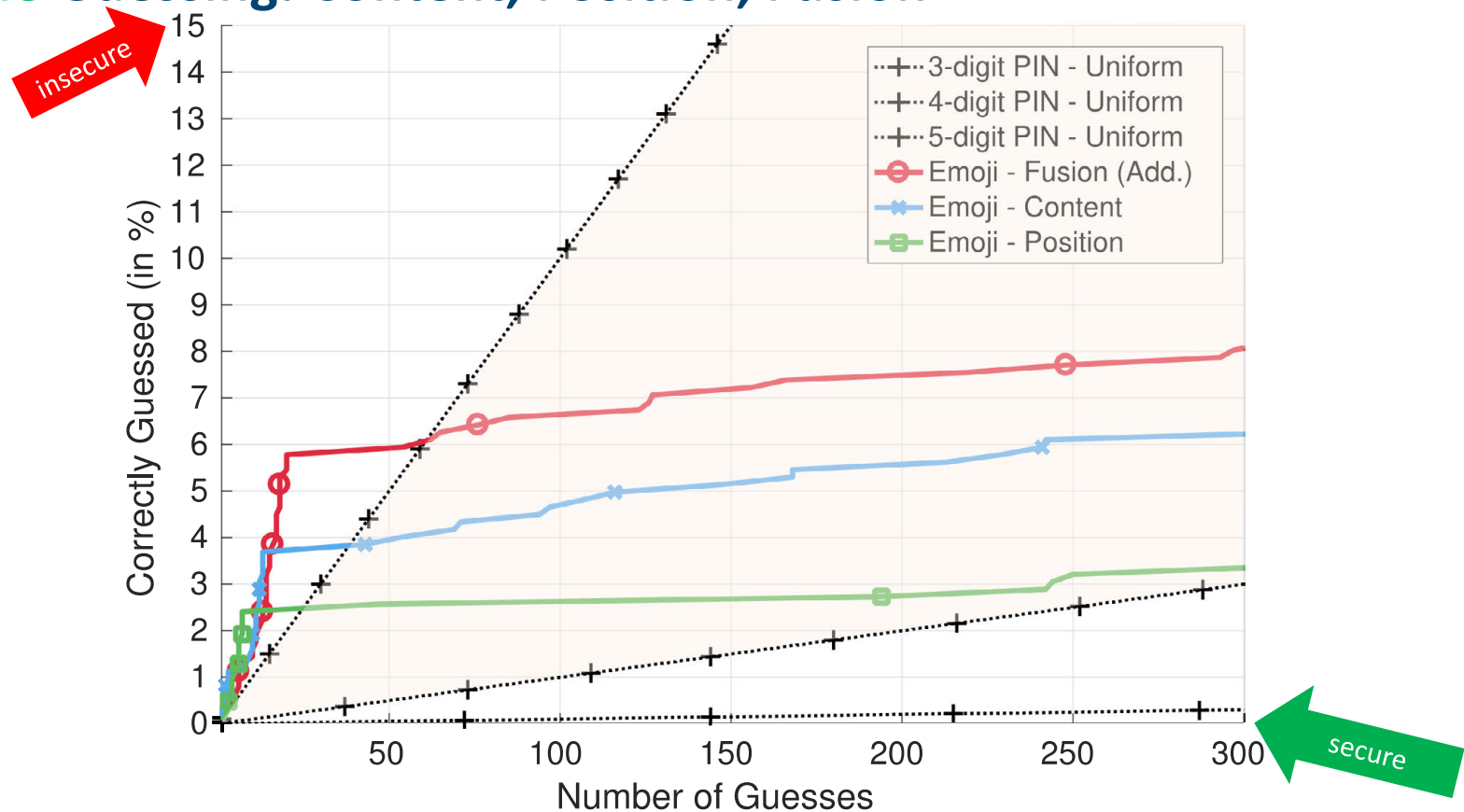
At the bottom of each screen is a grey bar with a 'CLEAR' button and a 'LOGIN >' button.

No.	Strategy	Users	Example
1	Created a story	268	
2	Used important things of their lives	234	
3	Tried to select a random passcode	83	
4	Repeating event of my life	54	
5	Emoji frequently used while texting	44	
6	Visual pattern: "A-B-A-B"	31	
7	Positions within the grid	19	
8	Emoji I like the most	17	
9	Emoji I find hilarious and funny	6	
10	Emoji of the same color	3	
11	Constructed a passphrase: "Super-Baby-Pig-Poo"	3	
12	Emoji related to the same category: "food"	3	

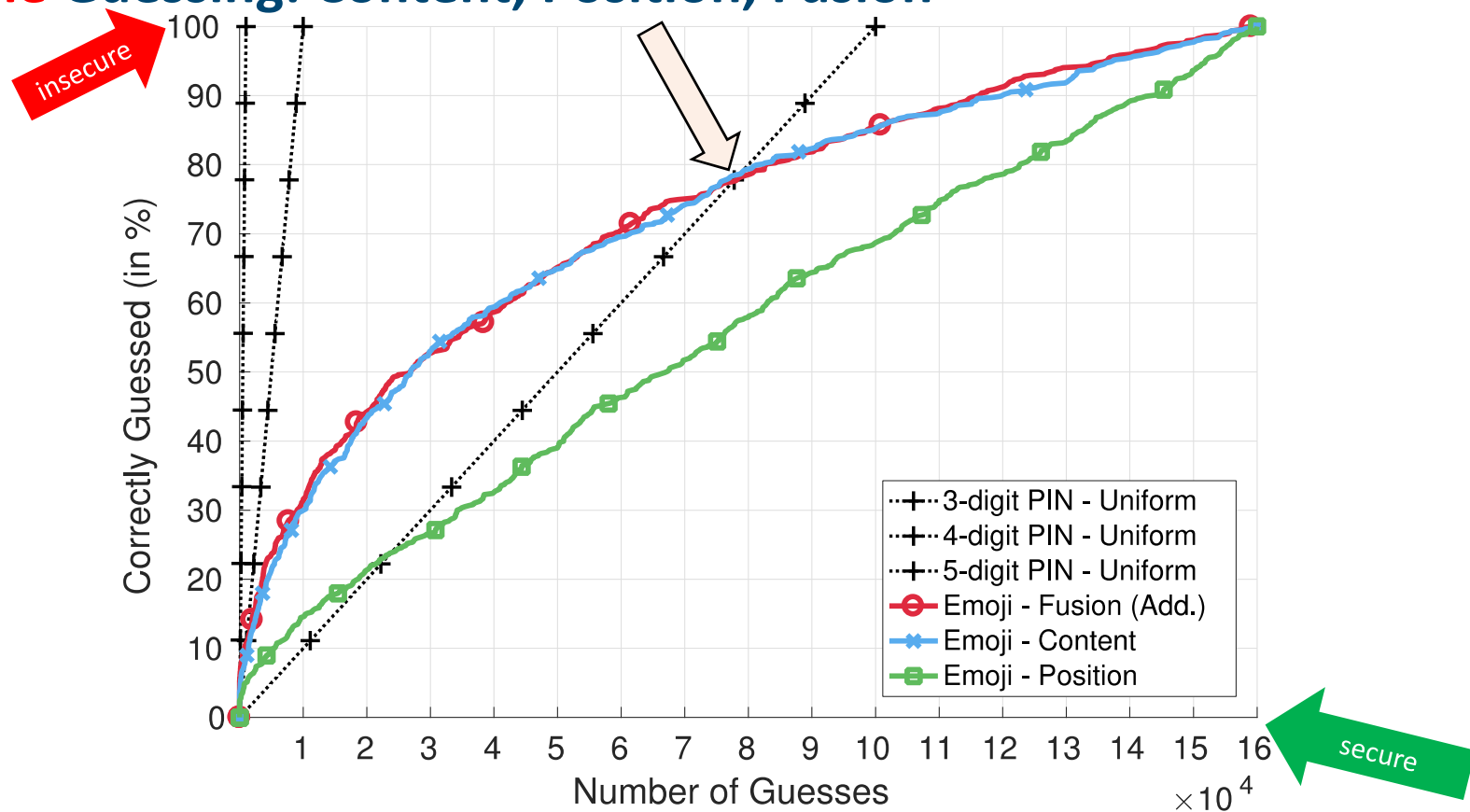
Online Guessing: Content, Position, Fusion



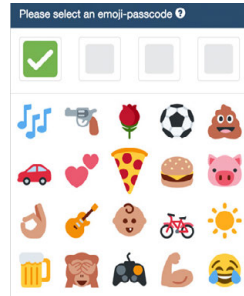
Online Guessing: Content, Position, Fusion



Offline Guessing: Content, Position, Fusion

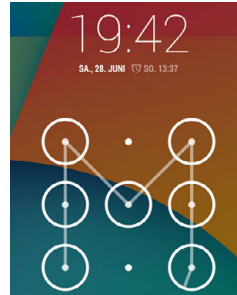


Comparison with Existing Solutions

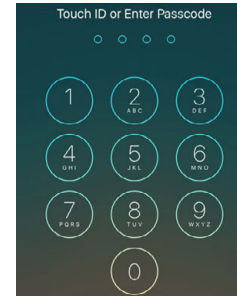


EmojiAuth

IV.?



Unlock Patterns

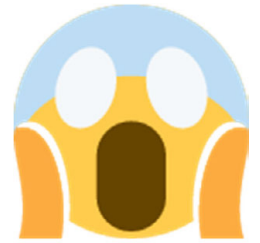


4-digit PINs

Limitations:

- Data from different studies and circumstances.
- Samples may be influenced by demographic bias.
- Guessing success depends on algorithm used and quantity of samples.
- Markov models seems like a sound approach, but better models may exist.

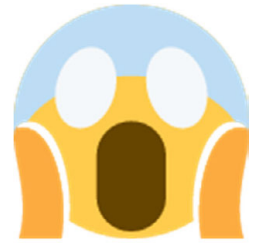
Guessing Success



Scheme	λ_1	λ_{10}	λ_{100}	λ_{1000}
Emoji – Position	0.2%	2.4%	2.6%	5.0%
Emoji – Content	0.3%	1.9%	4.7%	8.5%
Emoji – Fusion	0.2%	1.6%	6.6%	10.8%
4-digit PIN (user)	2.6%	9.2%	17.7%	38.0%
3-digit PIN (uniform)	0.1%	1.0%	10.0%	100.0%
Unlock Pattern	0.9%	3.8%	17.0%	50.0%

λ = guesses

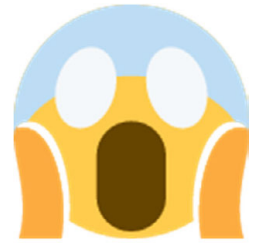
Guessing Success



Scheme	λ_1	λ_{10}	λ_{100}	λ_{1000}
Emoji – Position	0.2%	2.4%	2.6%	5.0%
Emoji – Content	0.3%	1.9%	4.7%	8.5%
Emoji – Fusion	0.2%	1.6%	6.6%	10.8%
4-digit PIN (user)	2.6%	9.2%	17.7%	38.0%
3-digit PIN (uniform)	0.1%	1.0%	10.0%	100.0%
Unlock Pattern	0.9%	3.8%	17.0%	50.0%

λ = guesses

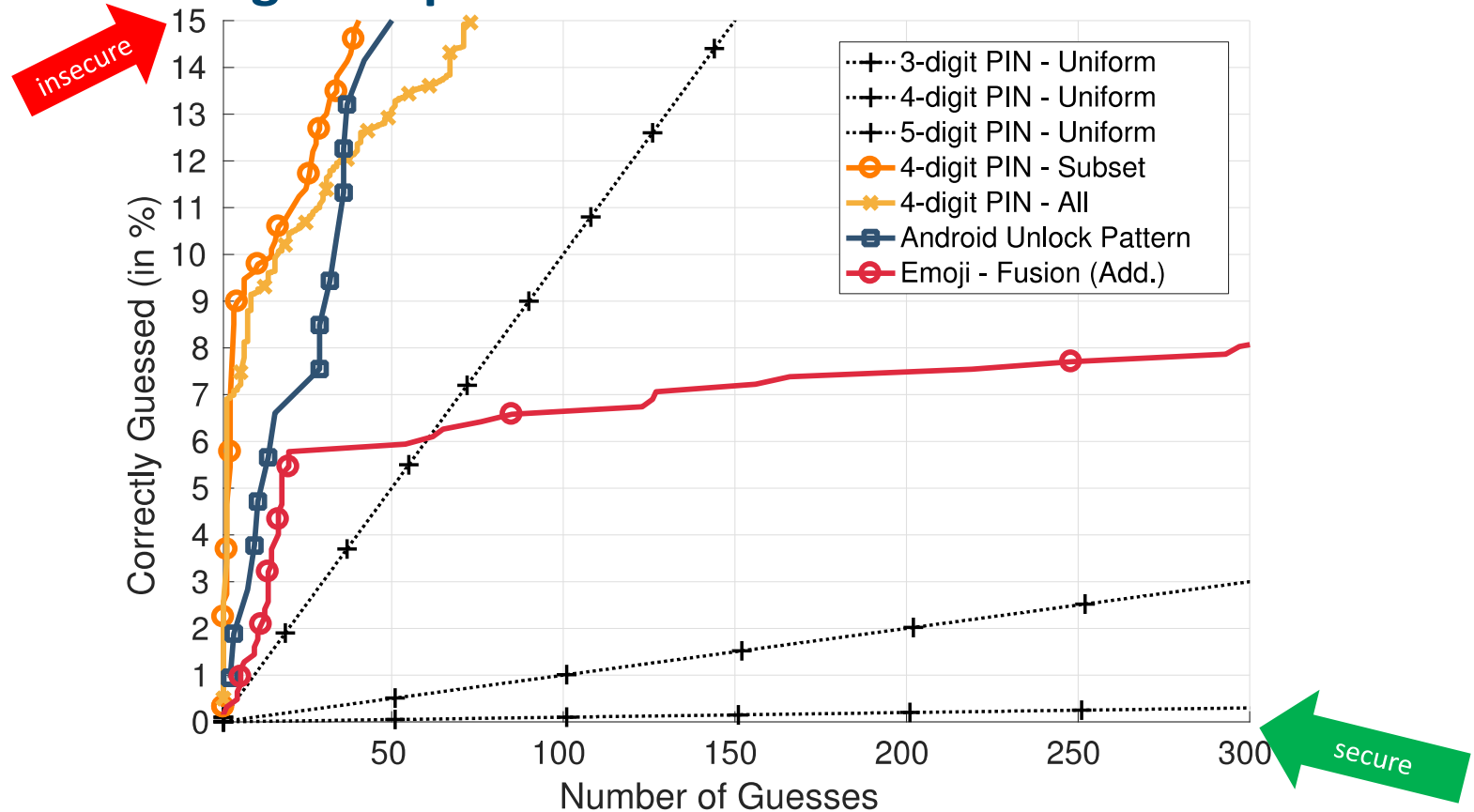
Guessing Success



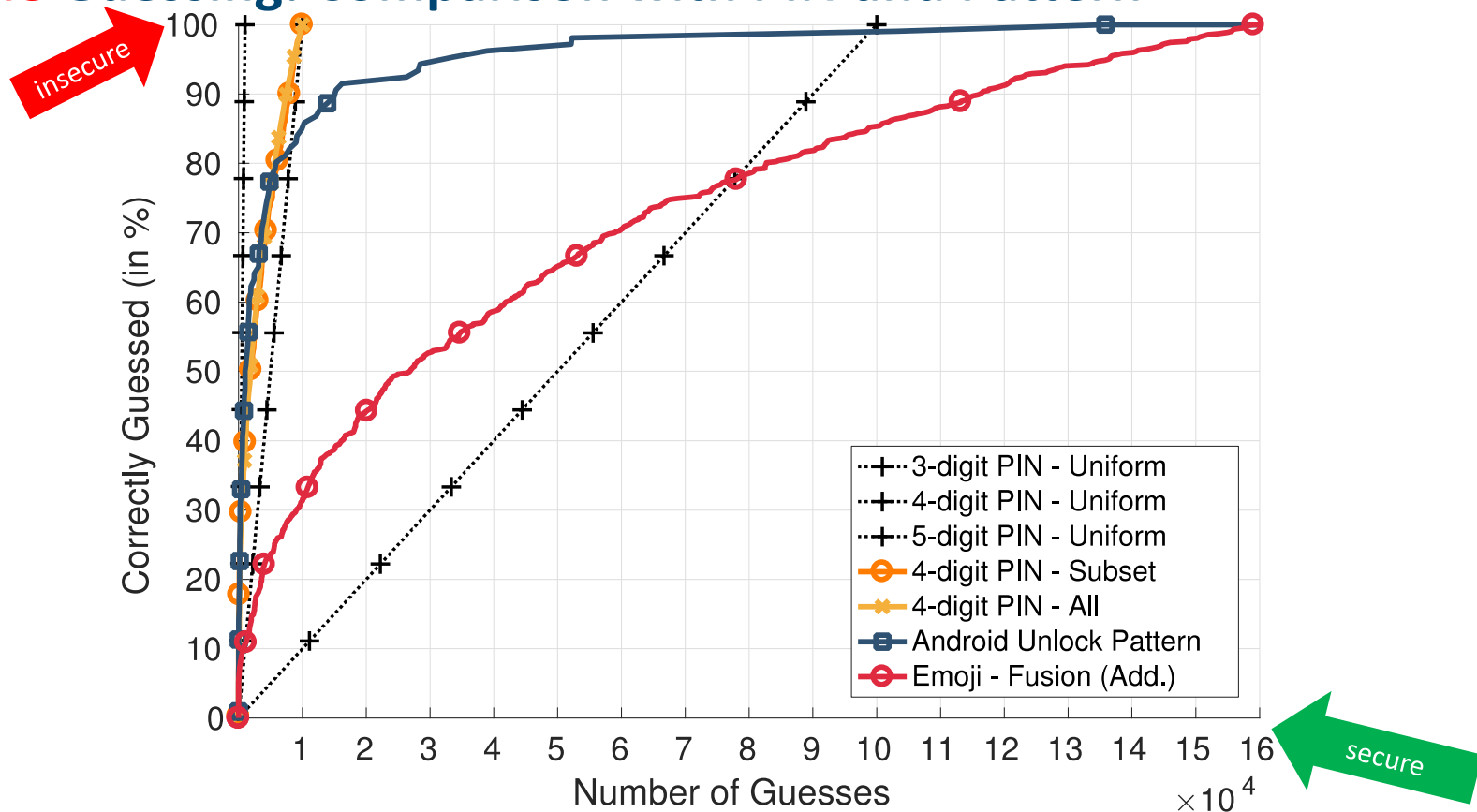
Scheme	λ_1	λ_{10}	λ_{100}	λ_{1000}
Emoji – Position	0.2%	2.4%	2.6%	5.0%
Emoji – Content	0.3%	1.9%	4.7%	8.5%
Emoji – Fusion	0.2%	1.6%	6.6%	10.8%
4-digit PIN (user)	2.6%	9.2%	17.7%	38.0%
3-digit PIN (uniform)	0.1%	1.0%	10.0%	100.0%
Unlock Pattern	0.9%	3.8%	17.0%	50.0%

λ = guesses

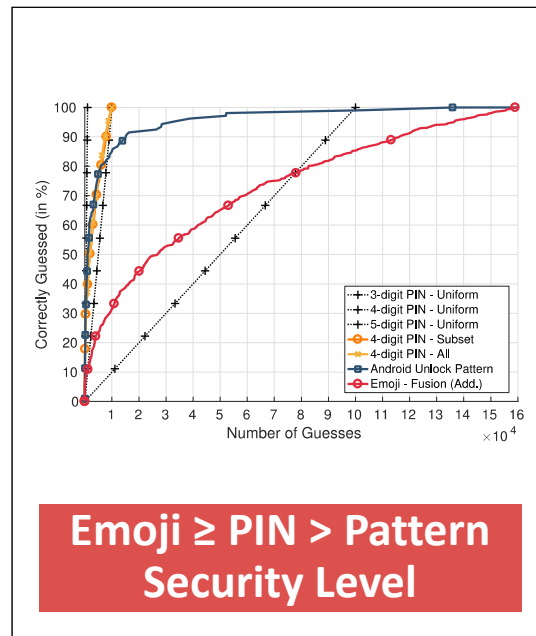
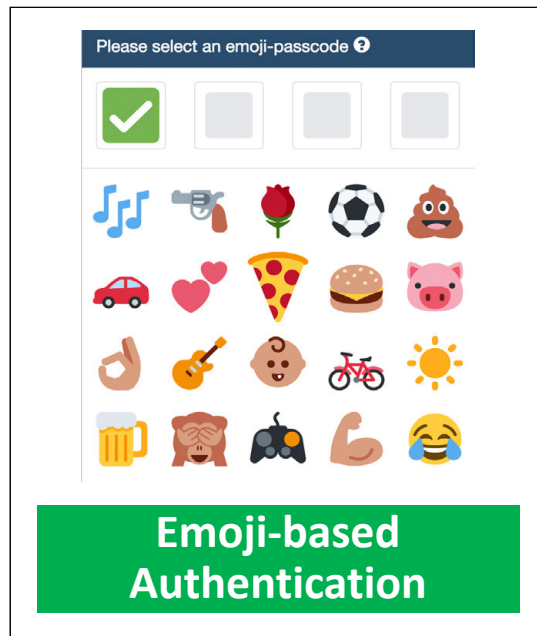
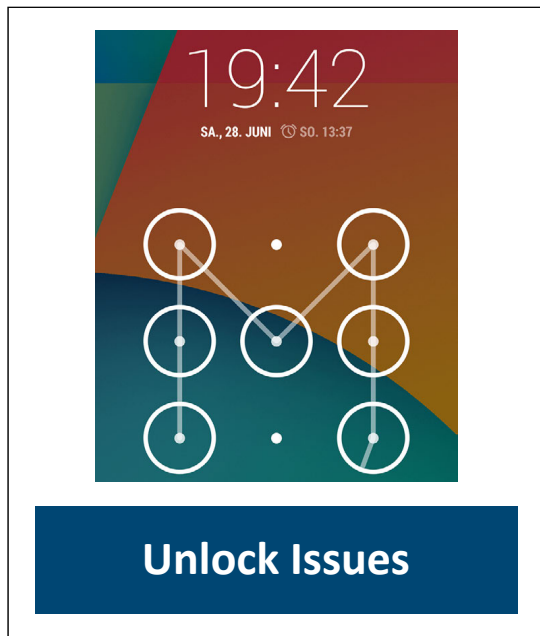
Online Guessing: Comparison with PIN and Pattern



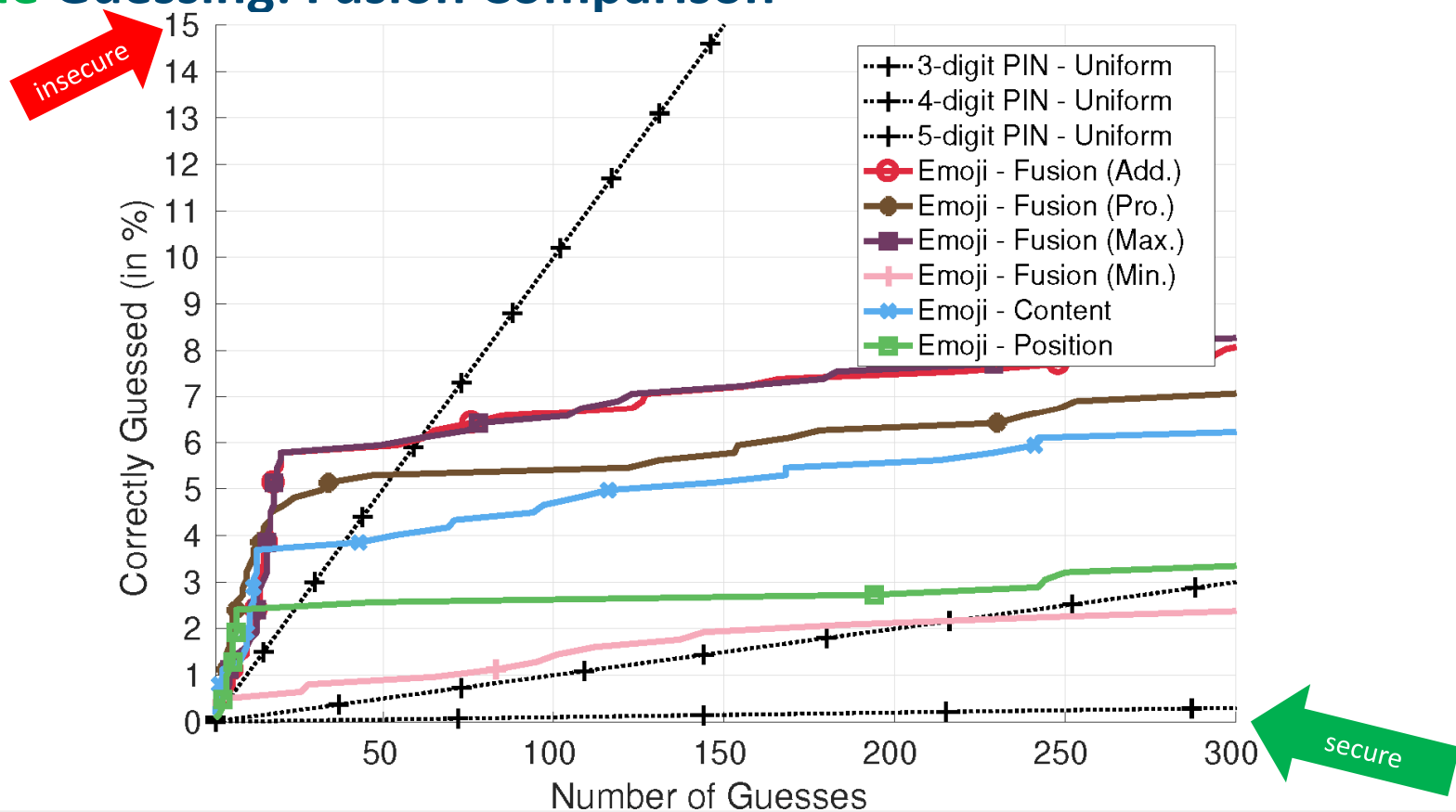
Offline Guessing: Comparison with PIN and Pattern



Takeaway



Online Guessing: Fusion Comparison



Practical Implications

Emoji are unicode characters, font developers provide their own implementation.

- Representations differ^[4] (Privacy)
- Can cause misleading interpretations^[5] (Usability)

EmojiAuth uses the vector graphics version of the "Twemoji" font to ensure same representation on all devices.

Apple



Google



Microsoft



Twitter



Facebook



Mozilla



U+1F606