How are you?

Great
How are you?

Great 😊 🦄

Great 😞
Happy Birthday Kate 🎉 🎈
Enjoy the 🎂
But please don't overdo it like last year 😞

Too late 😛
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

[Images of different unlocking methods]
There Are More ...

- Trusted Location
- Trusted Device
- Trusted Voice
- Trusted Face
- On-Body Detection
- Picture Password

[Img. 2] Lollipop Smart Lock, androidpolice.com
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. 2] Lydia Kraus et al.: Implications of the Use of Emojis in Mobile Authentication. (WAY ’16)
Outline

Motivation

Background

User Study

Results
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?”
Grid Size

Intelligent Environments[1]

Our Approach

Kraus et al.[2]

44 emoji

20 emoji

12 emoji


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

[Ref. 3] Sebastian Uellenbeck et al.: Quantifying the Security of Graphical Passwords: The Case of Android Unlock Patterns. (CCS '13)
Measure Position Bias

Emoji grid is randomized on a per user basis.

Fixed grid between enrollment and authentication.
Outline

Motivation

Background

User Study

Results
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

<table>
<thead>
<tr>
<th>Progress</th>
<th>Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enrollment</td>
<td>795</td>
</tr>
<tr>
<td>Dropout + Email Issues</td>
<td>141 + 22</td>
</tr>
<tr>
<td>Clicked Recall Link</td>
<td>632</td>
</tr>
<tr>
<td><strong>Authentication</strong></td>
<td><strong>623</strong></td>
</tr>
<tr>
<td>Success / Unsuccessful</td>
<td>🎉 😞</td>
</tr>
<tr>
<td>All</td>
<td>535</td>
</tr>
<tr>
<td>1&lt;sup&gt;st&lt;/sup&gt; try</td>
<td>464</td>
</tr>
<tr>
<td>2&lt;sup&gt;nd&lt;/sup&gt; try</td>
<td>58</td>
</tr>
<tr>
<td>3&lt;sup&gt;rd&lt;/sup&gt; try</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>88</td>
</tr>
</tbody>
</table>
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

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.
PictoPass: A New Graphical Passcode Scheme

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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.

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

---

Reset your choice if you clicked wrong or changed your mind.
Please select an emoji-passcode.

Options include:
- 🎵🎵
- 🎤🔫
- 🌸
- 💽
- 🏈
- 🍕
- 🍔
- 🎣
- 🤜️
- 🎸
- 👶
- 🚴
- 🤘
- 🍺
- 👹
- 🎮
- ⚡️

Clear selection or proceed to 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:
Age: 26

I identify my gender as:
Male

Where are you from (Country):
Germany

How did you choose your emoji-passcode:
- 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

How often do you use emoji:

Remembering a 4-digit PIN is:

Working with emoji was enjoyable:

How do you assess your technical understanding:

How much effort do you spend to protect your data:

NEXT
Feedback

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

Recall
Thank you very much for your help!

You are now taking part in the Amazon gift card raffle.

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

Facebook
Twitter
Google+
Pinterest
Selection Bias: Most Frequent Emoji
Selection Bias: Popular 2-grams
Selection Bias: Top 5 Passcodes

In our dataset 13 passcodes occurred more than once.

**Tendencies:**
- Cheerful emoji
- Single emoji passcodes

<table>
<thead>
<tr>
<th>Occ.</th>
<th>Passcode</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>🕶️😔😔😔</td>
<td>0.64%</td>
</tr>
<tr>
<td>3</td>
<td>😭🎵🌞❤️❤️</td>
<td>0.48%</td>
</tr>
<tr>
<td>2</td>
<td>❤️😢🎵🌞❤️❤️</td>
<td>0.32%</td>
</tr>
<tr>
<td>2</td>
<td>❤️❤️❤️❤️❤️</td>
<td>0.32%</td>
</tr>
<tr>
<td>2</td>
<td>☀️☀️☀️☀️</td>
<td>0.32%</td>
</tr>
</tbody>
</table>
### Selection Bias: Position

<table>
<thead>
<tr>
<th>Entry Bias</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>7.52</td>
<td>7.15</td>
<td>7.03</td>
<td>4.07</td>
<td>6.29</td>
</tr>
<tr>
<td>2</td>
<td>4.56</td>
<td>4.81</td>
<td>5.06</td>
<td>3.45</td>
<td>3.95</td>
</tr>
<tr>
<td>3</td>
<td>5.43</td>
<td>5.06</td>
<td>4.07</td>
<td>3.82</td>
<td>3.82</td>
</tr>
<tr>
<td>4</td>
<td>5.06</td>
<td>5.80</td>
<td>4.07</td>
<td>4.07</td>
<td>4.93</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Exit Bias</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6.17</td>
<td>4.07</td>
<td>3.95</td>
<td>4.32</td>
<td>5.06</td>
</tr>
<tr>
<td>2</td>
<td>3.82</td>
<td>4.69</td>
<td>3.70</td>
<td>5.55</td>
<td>5.55</td>
</tr>
<tr>
<td>3</td>
<td>4.19</td>
<td>3.95</td>
<td>5.06</td>
<td>5.30</td>
<td>5.18</td>
</tr>
<tr>
<td>4</td>
<td>6.29</td>
<td>5.80</td>
<td>4.56</td>
<td>5.55</td>
<td>7.27</td>
</tr>
</tbody>
</table>
Selection Bias: Position

Position 1

Position 2

Position 3

Position 4

Position 5

Position 6

Position 7

Position 8
<table>
<thead>
<tr>
<th>No.</th>
<th>Strategy</th>
<th>Users</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Created a story</td>
<td>268</td>
<td>🚴‍♂️ 🏀 ⚽️ 🌞 🍕</td>
</tr>
<tr>
<td>2</td>
<td>Used important things of their lives</td>
<td>234</td>
<td>⚽️ ❤️ 🌸 ❤️ ❤️</td>
</tr>
<tr>
<td>3</td>
<td>Tried to select a random passcode</td>
<td>83</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Repeating event of my life</td>
<td>54</td>
<td>🍺 😂 🍔 🍩 🎉</td>
</tr>
<tr>
<td>5</td>
<td>Emoji frequently used while texting</td>
<td>44</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Positions within the grid</td>
<td>19</td>
<td>📅 📅 📅 📅 📅 📅 📅</td>
</tr>
<tr>
<td>8</td>
<td>Emoji I like the most</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Emoji I find hilarious and funny</td>
<td>6</td>
<td>😢 😢 😢 😢 😢 😢 😢 😢 😢</td>
</tr>
<tr>
<td>10</td>
<td>Emoji of the same color</td>
<td>3</td>
<td>🚘 ❤️ 🌸 🍷 🐷</td>
</tr>
<tr>
<td>11</td>
<td>Constructed a passphrase: “Super-Baby-Pig-Poo”</td>
<td>3</td>
<td>🏋️‍♂️ 🍔 🐷 🐷 🐷 🐷 🐷</td>
</tr>
<tr>
<td>12</td>
<td>Emoji related to the same category: “food”</td>
<td>3</td>
<td>🍕 🍔 🍺 🍕 🍕 🍕</td>
</tr>
</tbody>
</table>
Online Guessing: Content, Position, Fusion

- 3-digit PIN - Uniform
- 4-digit PIN - Uniform
- 5-digit PIN - Uniform
- Emoji - Fusion (Add.)
- Emoji - Content
- Emoji - Position

Correctly Guessed (in %)

Number of Guesses

San Diego, February 26., 2017 | USEC’17
Online Guessing: Content, Position, Fusion

- 3-digit PIN - Uniform
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- Emoji - Content
- Emoji - Position

Correctly Guessed (in %) vs Number of Guesses

insecure
secure
Offline Guessing: Content, Position, Fusion

Correctly Guessed (in %)

Number of Guesses

3-digit PIN - Uniform
4-digit PIN - Uniform
5-digit PIN - Uniform
Emoji - Fusion (Add.)
Emoji - Content
Emoji - Position

Insecure
Secure
Comparison with Existing Solutions

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

<table>
<thead>
<tr>
<th>Scheme</th>
<th>$\lambda_1$</th>
<th>$\lambda_{10}$</th>
<th>$\lambda_{100}$</th>
<th>$\lambda_{1000}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emoji – Position</td>
<td>0.2%</td>
<td>2.4%</td>
<td>2.6%</td>
<td>5.0%</td>
</tr>
<tr>
<td>Emoji – Content</td>
<td>0.3%</td>
<td>1.9%</td>
<td>4.7%</td>
<td>8.5%</td>
</tr>
<tr>
<td>Emoji – Fusion</td>
<td>0.2%</td>
<td>1.6%</td>
<td>6.6%</td>
<td>10.8%</td>
</tr>
<tr>
<td>4-digit PIN (user)</td>
<td>2.6%</td>
<td>9.2%</td>
<td>17.7%</td>
<td>38.0%</td>
</tr>
<tr>
<td>3-digit PIN (uniform)</td>
<td>0.1%</td>
<td>1.0%</td>
<td>10.0%</td>
<td>100.0%</td>
</tr>
<tr>
<td>Unlock Pattern</td>
<td>0.9%</td>
<td>3.8%</td>
<td>17.0%</td>
<td>50.0%</td>
</tr>
</tbody>
</table>

$\lambda = \text{guesses}$
## Guessing Success

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<td>38.0%</td>
</tr>
<tr>
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$\lambda = \text{guesses}$
Online Guessing: Comparison with PIN and Pattern

Insecure

Secure

San Diego, February 26, 2017 | USEC’17
Offline Guessing: Comparison with PIN and Pattern

Correctly Guessed (in %)

Number of Guesses

- 3-digit PIN - Uniform
- 4-digit PIN - Uniform
- 5-digit PIN - Uniform
- 4-digit PIN - Subset
- 4-digit PIN - All
- Android Unlock Pattern
- Emoji - Fusion (Add.)
Takeaway

Unlock Issues

Emoji-based Authentication

Emoji ≥ PIN > Pattern Security Level
Online Guessing: Fusion Comparison

Correctly Guessed (in %)

Number of Guesses

- 3-digit PIN - Uniform
- 4-digit PIN - Uniform
- 5-digit PIN - Uniform
- Emoji - Fusion (Add.)
- Emoji - Fusion (Pro.)
- Emoji - Fusion (Max.)
- Emoji - Fusion (Min.)
- Emoji - Content
- Emoji - Position

insecure

secure
**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.

[^4]: Pierre Laperdrix et al.: Beauty and the Beast: Diverting Modern Web Browsers to Build Unique Browser Fingerprints. (SP '16)
[^5]: Hannah Miller et al.: "Blissfully Happy" or "Ready to Fight": Varying Interpretations of Emoji. (ICWSM '16)