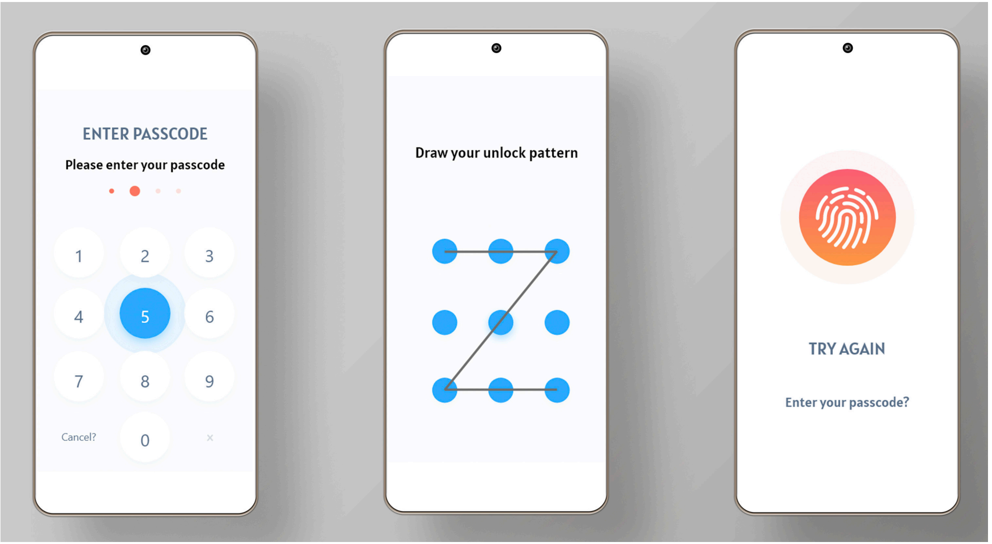
# Using a Blocklist to Improve the Security of User Selection of Android Patterns

Collins W. Munyendo, Miles Grant, Philipp Markert, Timothy J. Forman, and Adam J. Aviv

*USENIX Symposium on Usable Security and Privacy (SOUPS)*
*August 9th 2021*

# Mobile Authentication

- Access to smartphones can be secured in the following ways:

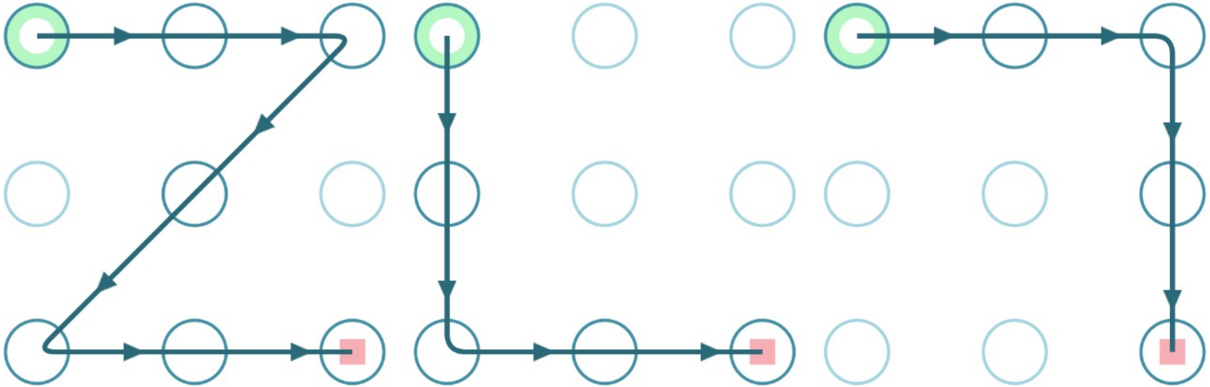



| Fingerprint | 4-digit PIN | Pattern | 6-digit PIN | Face | Password |
|---|---|---|---|---|---|
| 57% | 46% | 27% | 16% | 12% | 4% |


Collins W. Munyendo: cmunyendo@gwu.edu
Miles Grant: milesgrant@gwu.edu
Philipp Market: philipp.markert@rub.de
Timothy J. Forman: tforman37@gmail.com
Adam J. Aviv: aaviv@gwu.edu

# How Secure are Patterns?

- Despite 389,112 options, most users choose common, easily guessable patterns.



GWUSEC
Collins W. Munyendo: cmunyendo@gwu.edu
Miles Grant: milesgrant@gwu.edu
Philipp Market: philipp.markert@rub.de
Timothy J. Forman: tforman37@gmail.com
Adam J. Aviv: aaviv@gwu.edu



RUB

# Study Objective

- Interested in the security and usability impact of blocking common patterns.
- We ask two questions:
  - What is the security and usability impact of blocklists on patterns?
  - What is the right-sized blocklist that balances security and usability of patterns?

# Study Design

- Online study on Amazon Mturk (n = 1006).
- Participants selected patterns under 6 treatments:
  - Control: No blocklist intervention.
  - BL-32: 12 patterns blocked.
  - BL-16: 54 patterns blocked.
  - BL-8: 105 patterns blocked.
  - BL-4: 172 patterns blocked.
  - BL-2: 581 patterns blocked.
- Each participant was assigned to one treatment.

GWUSEC
Collins W. Munyendo: cmunyendo@gwu.edu
Miles Grant: milesgrant@gwu.edu
Philipp Market: philipp.markert@rub.de
Timothy J. Forman: tforman37@gmail.com
Adam J. Aviv: aaviv@gwu.edu
RUB

# Primary Findings

- Blocklists, even small ones, improve the security of selected patterns.
- Blocklists prime users to consider security when selecting patterns.
- Blocklists do not significantly impact the usability of patterns.
- A blocklist size of 100 would well balance security and usability.


Collins W. Munyendo: cmunyendo@gwu.edu
Miles Grant: milesgrant@gwu.edu
Philipp Market: philipp.markert@rub.de
Timothy J. Forman: tforman37@gmail.com
Adam J. Aviv: aaviv@gwu.edu

# Security Analysis: Threat Models

**Perfect Knowledge Attacker**

- Has complete knowledge of the frequency order of patterns, from the most to the least frequent.

**Simulated Attacker**

- Knows a subset of the patterns and constructs a model based on that observed distribution.


Collins W. Munyendo: cmunyendo@gwu.edu
Miles Grant: milesgrant@gwu.edu
Philipp Market: philipp.markert@rub.de
Timothy J. Forman: tforman37@gmail.com
Adam J. Aviv: aaviv@gwu.edu

# Security Analysis: Perfect Knowledge Guessing

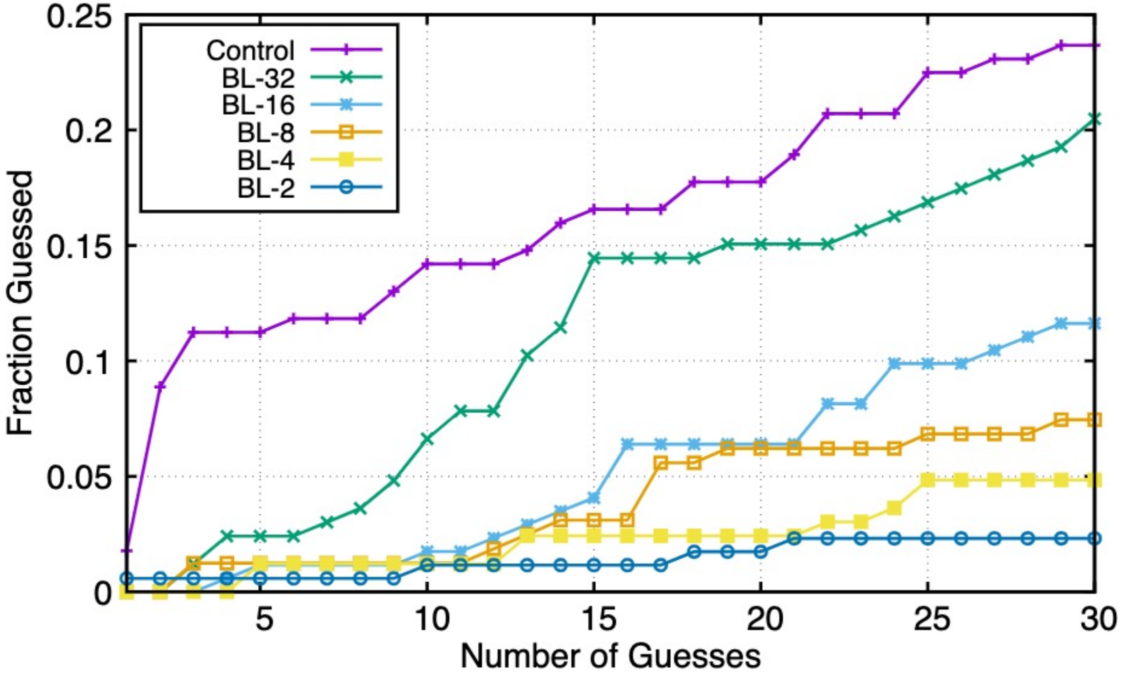
| Treatment | Throttled Attack (%) | | | Unthrottled Attack (Bits) | | | |
|---|---|---|---|---|---|---|---|
| | $\lambda_3$ | $\lambda_{10}$ | $\lambda_{30}$ | $H_\infty$ | $\tilde{G}_{0.1}$ | $\tilde{G}_{0.3}$ | $\tilde{G}_{0.5}$ |
| Control | 13.1 % | 22.9 % | 41.1 % | 3.75 | 4.66 | 6.00 | 6.93 |
| BL-32 | 9.0 % | 18.0 % | 33.1 % | 5.01 | 5.82 | 6.65 | 7.26 |
| BL-16 | 7.3 % | 15.6 % | 29.9 % | 5.33 | 6.04 | 7.00 | 7.45 |
| BL-8 | 8.0 % | 17.1 % | 31.9 % | 5.33 | 5.89 | 6.81 | 7.33 |
| BL-4 | 4.6 % | 10.9 % | 22.3 % | 6.33 | 6.64 | 7.34 | 7.61 |
| BL-2 | 5.1 % | 13.1 % | 27.9 % | 5.75 | 6.31 | 7.00 | 7.43 |

**Note:** A perfect knowledge attacker has complete knowledge of the frequency order of the patterns, from the most frequent to the least frequent.

GWUSEC
Collins W. Munyendo: cmunyendo@gwu.edu
Miles Grant: milesgrant@gwu.edu
Philipp Market: philipp.markert@rub.de
Timothy J. Forman: tforman37@gmail.com
Adam J. Aviv: aaviv@gwu.edu

RUB

# Security Analysis: Simulated Guessing



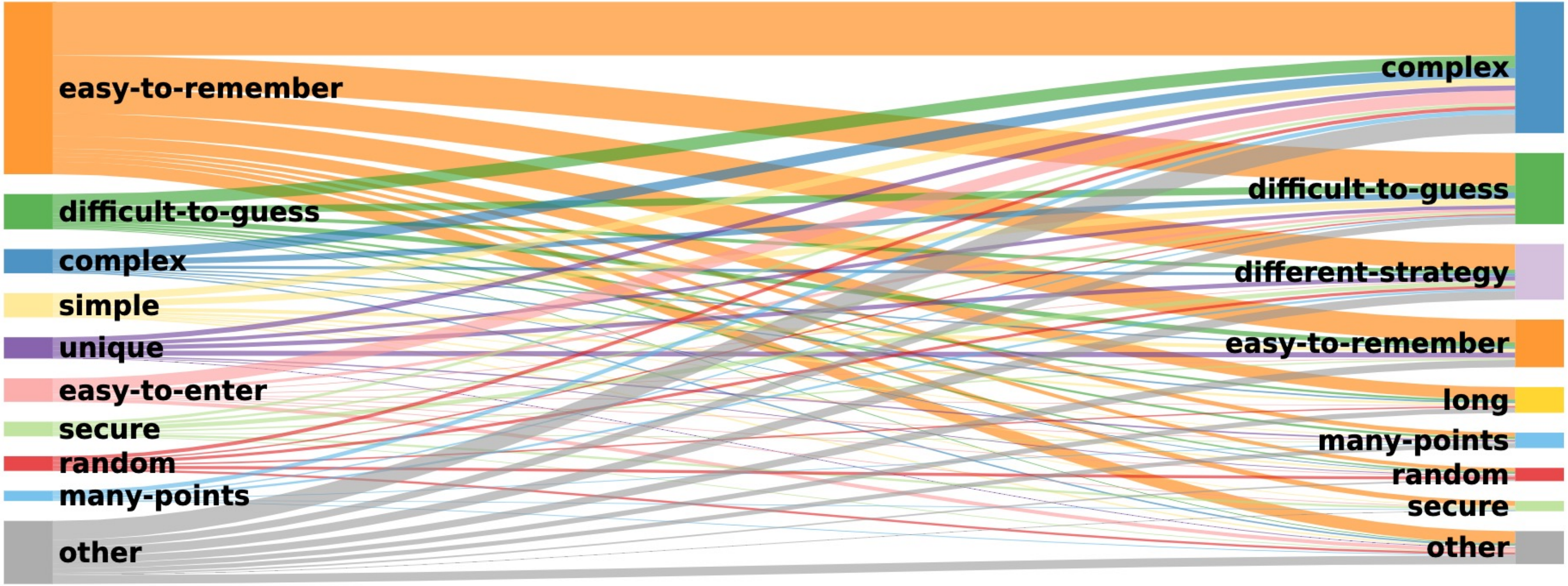

**Note:** A simulated guesser knows a subset of the patterns and constructs a model based on that distribution. We used a Markov Model to break ties.



Collins W. Munyendo: cmunyendo@gwu.edu
Miles Grant: milesgrant@gwu.edu
Philipp Market: philipp.markert@rub.de

Timothy J. Forman: tforman37@gmail.com
Adam J. Aviv: aaviv@gwu.edu

# Changes in Pattern Selection Strategies




Participants move from simple to complex pattern selection strategies after encountering blocklists.


Collins W. Munyendo: cmunyendo@gwu.edu
Miles Grant: milesgrant@gwu.edu
Philipp Market: philipp.markert@rub.de
Timothy J. Forman: tforman37@gmail.com
Adam J. Aviv: aaviv@gwu.edu

# Usability

| | Control | BL_32 | BL_16 | BL_8 | BL_4 | BL_2 |
|---|---|---|---|---|---|---|
| **Mean Selection Time** | 13.64s | 13.41s | 16.67s | 19.27s | 25.52s | 34.24s |
| Median | 7.38s | 9.12s | 12.34s | 13.88s | 17.48s | 26.70s |
| Standard Deviation | 26.91s | 12.17s | 15.98s | 17.04s | 25.25s | 29.23s |
| **Mean Entry Time** | 1.53s | 1.46s | 1.53s | 1.73s | 1.87s | 1.79s |
| Median | 1.27s | 1.19s | 1.33s | 1.46s | 1.53s | 1.62s |
| Standard Deviation | 1.10s | 0.94s | 0.83s | 1.00s | 1.35s | 0.91s |
| **Mean Recall Attempts** | 1.33 | 1.35 | 1.27 | 1.35 | 1.52 | 1.52 |
| Median | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Standard Deviation | 0.87 | 0.82 | 0.64 | 0.78 | 1.03 | 1.03 |
| **Recall Success Rate** | 100.00% | 99.55% | 100.00% | 99.54% | 100.00% | 99.62% |
| **Mean SUS Score** | 78.64 | 78.77 | 78.01 | 76.96 | 76.47 | 71.62 |
| Median | 82.5 | 80.0 | 80.0 | 80.0 | 77.5 | 75.0 |
| Standard Deviation | 17.37 | 16.51 | 16.47 | 16.84 | 16.80 | 17.82 |

Selection time increases due to interaction with blocklists; entry time and recall rates are unaffected.


Collins W. Munyendo: cmunyendo@gwu.edu
Miles Grant: milesgrant@gwu.edu
Philipp Market: philipp.markert@rub.de
Timothy J. Forman: tforman37@gmail.com
Adam J. Aviv: aaviv@gwu.edu

# Conclusion

- We studied the security and usability impact of blocklists on Android patterns.
- We find that even small blocklists improve security while minimally impacting usability.
- Our results indicate that blocking 100 most common patterns would well balance security and usability of patterns.

GWUSEC
Collins W. Munyendo: cmunyendo@gwu.edu
Miles Grant: milesgrant@gwu.edu
Philipp Market: philipp.markert@rub.de
Timothy J. Forman: tforman37@gmail.com
Adam J. Aviv: aaviv@gwu.edu



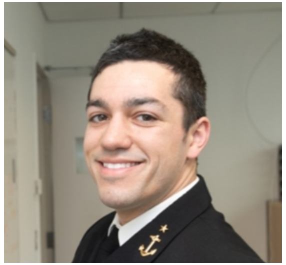
RUB

# Thank you! Ping us!


| Collins W. Munyendo | Miles Grant | Philipp Markert | Timothy J. Forman | Adam J. Aviv |
|---|---|---|---|---|
| cmunyendo@gwu.edu | milesgrant@gwu.edu | philipp.markert@rub.de | tforman37@gmail.com | aaviv@gwu.edu |








THE GEORGE WASHINGTON UNIVERSITY WASHINGTON, DC

THE GEORGE WASHINGTON UNIVERSITY WASHINGTON, DC

RUHR UNIVERSITÄT BOCHUM RUB

UNITED STATES NAVY

THE GEORGE WASHINGTON UNIVERSITY WASHINGTON, DC