



Jacqueline Bermudez, Alaa Abdulaal,  
Liwen Xu, Benson Quach  
University of Toronto  
Department of Computer Science  
{jbermudez, alaa84, xuliwenx, benson}@cs.toronto.edu

# Innovative Spiral Lock Design for Smartphone Security

## Abstract

One aspect that have yet to significantly change is the unlocking gestures amongst the variety of smartphones. After performing the following experimental research we believe that the Spiral design holds significant potential and is indeed a step forward towards efficient mobile lock design.

**Goal:** determine a lead towards a more convenient and secure unlocking gesture that may in hopes alleviate the current setbacks of the two mentioned locks.

## Literature review

A few lock applications commonly used for touchscreen mobile devices are pattern, text, PINs, and image-based passwords.

In a study by Clarke et al., 41% of their respondents expressed concerns with respect to PINs and alphanumeric passwords, supporting the need for alternative authentication techniques and thus, shape-based authentication better supports the way the brain remembers and stores information. Shapes can be remembered as an image, hence exploiting the pictorial superiority effect.

Since the pattern is drawn manually in exactly the same way every time and repeated regularly within the Pattern lock, the user's motor memory further improves the memorability. This point encourages and supports our choice of modelling our lock after the form of the Pattern lock.

## Hypothesis

**Question:** Amongst the mentioned respective locks, which of them provided more efficiency to the user in terms of the mentioned dependent variables as well as providing a preferable experience overall

### We hypothesized

- Error rate: PIN lock > Spiral lock > Pattern lock
- Speed: PIN lock > Spiral lock > Pattern lock
- Users would prefer the Pattern lock overall due to the users natural instinct of preferring to resist change.

## Apparatus



## Participants

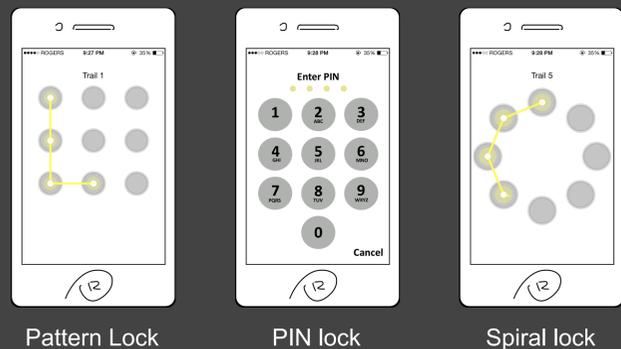
- 20+ years old,
  - At least a high school level education,
  - Either female or male
  - Familiar at least with the Pattern & PIN
- X 27

## Experimental Design

- **Purpose:** Studying efficiency and accuracy between the different lock types
- Three level design within participants

## Independent variables

### Lock Type:



## Dependent variables



## Measures

- Unlocking Speed
- Failed Unlocks
- Lock combination presentation
- Lock Usability and Overall Preference

## Data collection process

For each measure this is how the data was collected:

### Unlocking Speed

- the data was programmatically collected and stored in a log file on the used phone

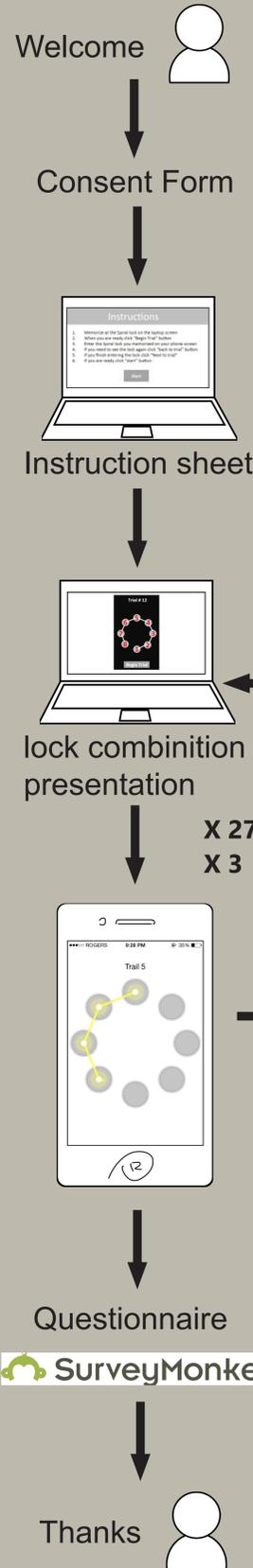
### Failed Unlocks

- the data was programmatically collected and stored in a log file on the used phone

### Lock Usability and Likeability Variable

- The data was collected using an electronic questionnaire (survey monkey) filled by each participant after finishing all three lock type trials.

## Task & Procedures



## Results - Quantitative measures

One-way - repeated measures - three level ANOVA test.

### Unlocking Speed

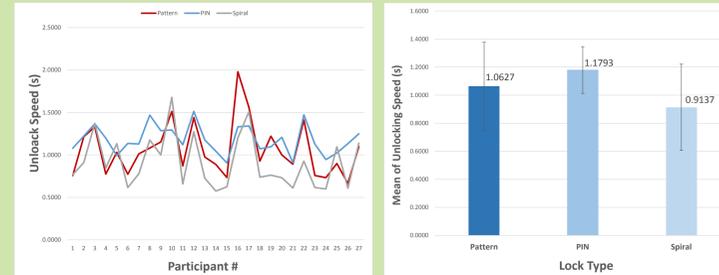


Fig 1. speed time (s) of unlocking

Fig 2. Mean +/- SD of unlocking time

- $F = 18.076, p < 0.05$
- All pairwise comparisons were statistically significant,  $p < 0.05$ .

### Failed Unlocks

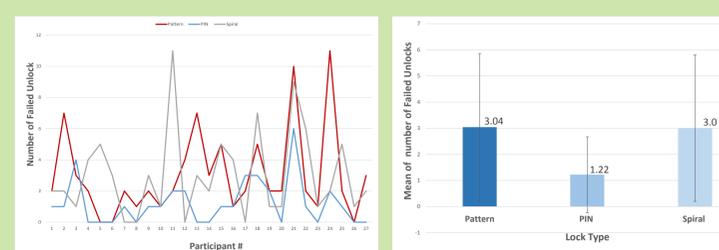


Fig 3. number of failed unlockings

Fig 4. Mean +/- SD of number of failed unlockings

- $F = 6.932, p < 0.05$
- All pairwise comparisons were statistically not significant except for PIN vs. Pattern and PIN vs. Spiral,  $p < 0.05$ .
- Failed in unlocking the phone:
  1. Spiral lock > PIN lock (mean difference of 1.778)
  2. Pattern lock > PIN lock (mean difference of 1.815)

## Discussion - Quantitative measures

### Spiral lock vs. Pattern lock



- Unlocking speed:
- Circle design
  - smaller distance between neighbored dots than Pattern
  - unlocking gesture faster
  - more natural and fluent

- Failed unlockings:
- Designed based on Pattern lock
  - similar unlocking gestures
  - Training
  - Insufficient to support our hypothesis

### PIN lock vs. Spiral/Pattern lock

Pattern lock and Spiral lock > faster > PIN lock

- Length of passwords:
  - Pattern lock is 4 ~ 9 (average is 5.7), Spiral lock is 4 ~ 10 (average is 5.8)
  - Pattern lock and Spiral lock > longer > PIN lock
  - Pattern and Spiral locks > outperform > PIN lock.

PIN lock < failed < Spiral and Pattern lock

- Inline with our hypothesis
- There are two main possible reasons:
  - Length of passwords
  - Frictional force

## Results - Qualitative measures

Due to all result were not significant, the mean was used for analysing and comparing.

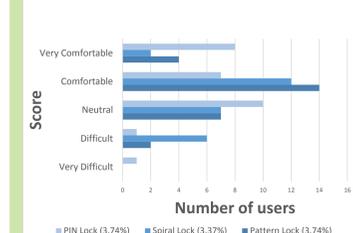


Fig 5 User conformity evaluation when performing their unlocking action using the three different lock types

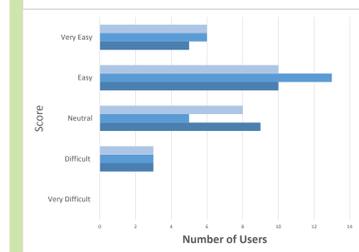


Fig 6 Ease of a one-handed unlocking.

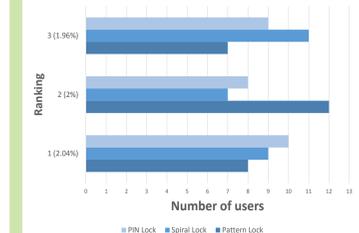


Fig 7. Ranking score of the three lock types in order of preference. It was ranked 1 to 3, where 1 represents the most preferred.

Spiral lock is more natural and has more accessibility, the PIN is more popular and familiar, and no written feedback on the Pattern lock was given

## Discussion - Qualitative measures

LEAST Preferred

PIN

**Why is PIN the most comfortable?**

- PIN lock had the fewest failed unlockings.

**Why is Pattern the most preferred?**

- Numeric passwords harder to memorize

MOST Preferred

Pattern

**Why is Spiral the 2nd preferred?**

- Shape-based easier to memorize
- New
- Familiarity is required

## Conclusion

🕒 Spiral (Avg. 0.9137s) < Pattern lock < PIN (Avg. 1.1793s)

🚫 PIN lock (Avg. 1.22) < Spiral/Pattern (not significant)

👤 Pattern > Spiral > PIN lock

**Limitation:** 1. different length of password of the 3 locks  
2. Memory 3. Number of participants (27)

**Future work:** Having in account the mentioned limitations Spiral lock design hold significant potential in enhancing and improving upon the limitations of common lock designs such as Pattern and PIN and is a potential step forward in regards to speed and error rate efficiency.