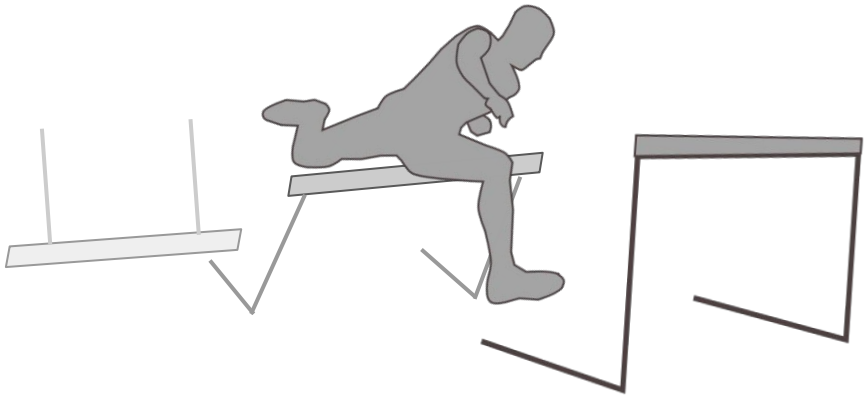
Evaluating In-Workflow Messages for Improving Mental Models of End-to-End Encryption

Omer Akgul • Wei Bai • Shruti Das • Michelle L. Mazurek

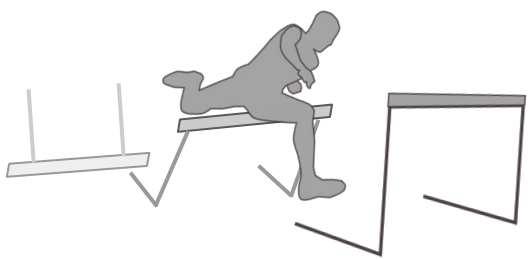
Adoption of E2EE By **General Users**?

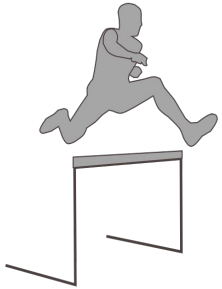
Many hurdles impede adoption!



Icons from https://freesvg.org/vector-silhouette-of-an-athlete with modification

Many Hurdles Impede Adoption





UI Design

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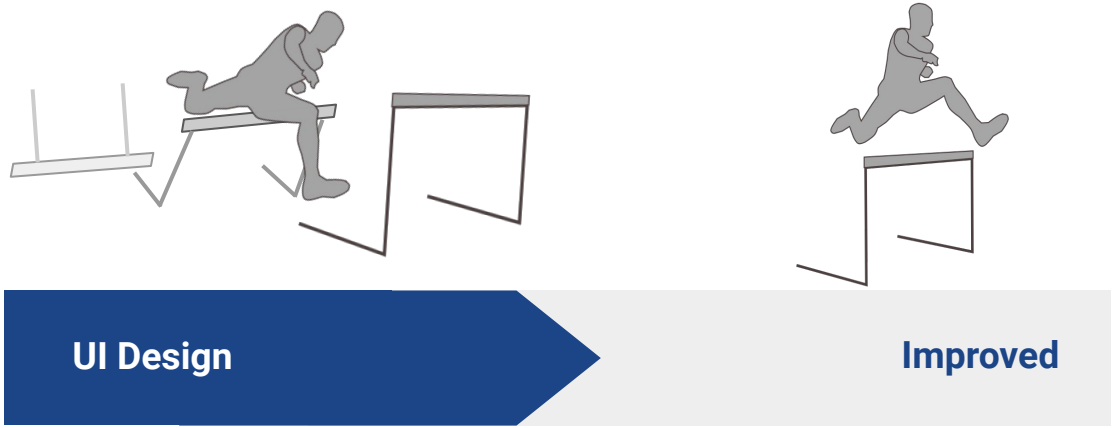

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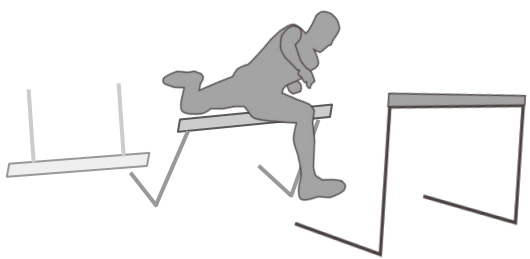

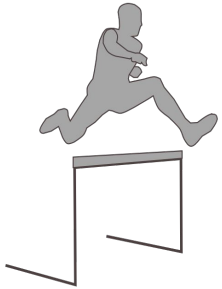

UI Design → **Improved**

Key Management

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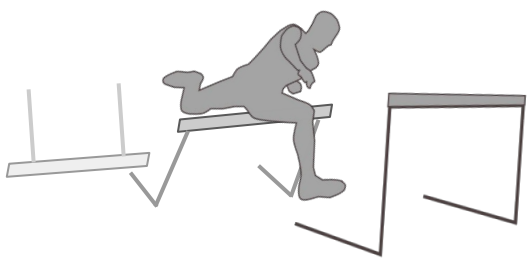

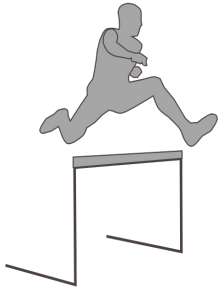

UI Design	Improved
Key Management	Key-Directory Based Model

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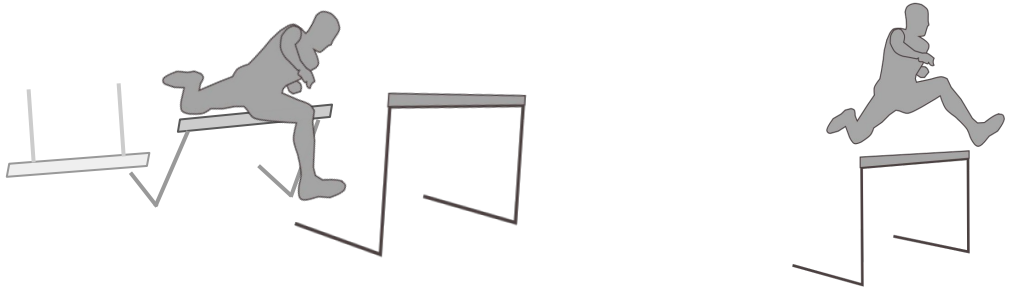

UI Design	Improved
Key Management	Key-Directory Based Model
Social Norms	

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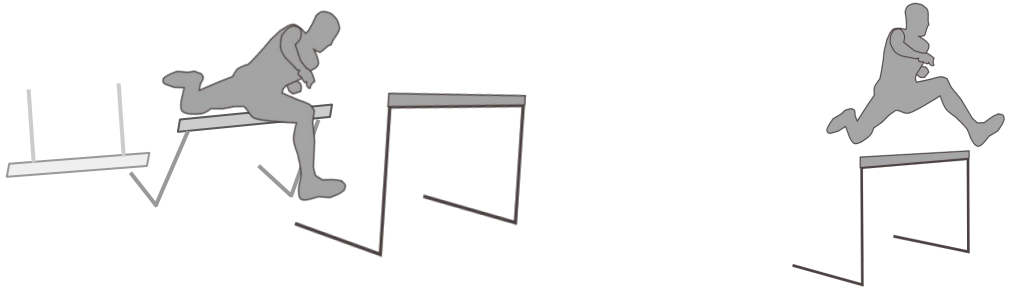

UI Design	Improved
Key Management	Key-Directory Based Model
Social Norms	Large Deployment

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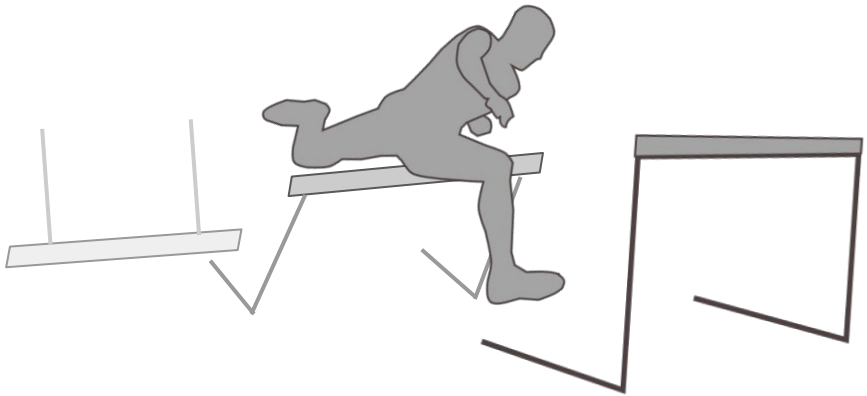
But... Mental Models still a problem!



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Why do (incorrect) mental models matter?

People perceive E2EE incorrectly in both directions [1-2]:

- Encryption protects from anything
- Encryption can be trivially broken by anyone who works in IT

[1] Abu-Salma et al. Obstacles to the adoption of secure communication tools. In IEEE Security & Privacy, 2017
[2] Wu et al. When is a Tree Really a Truck? Exploring Mental Models of Encryption. In SOUPS 2018

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Difficult for users to make thoughtful decisions:

- “SMS is the most secure messaging service.” [1]

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Difficult for users to make thoughtful decisions:

- "SMS is the most secure messaging service." [1]

Because they inhibit

Confident, Proactive, and Correct usage

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Improve mental models **Naturally**

Goal: **Help people grok basic understanding and threats**

- **Enough** to make judgments about how to communicate
- **Without** turning everyone into crypto experts
- **Without** requiring people to sign up for training modules

Solution: **Place educational messages in a messaging app, where people see them.**

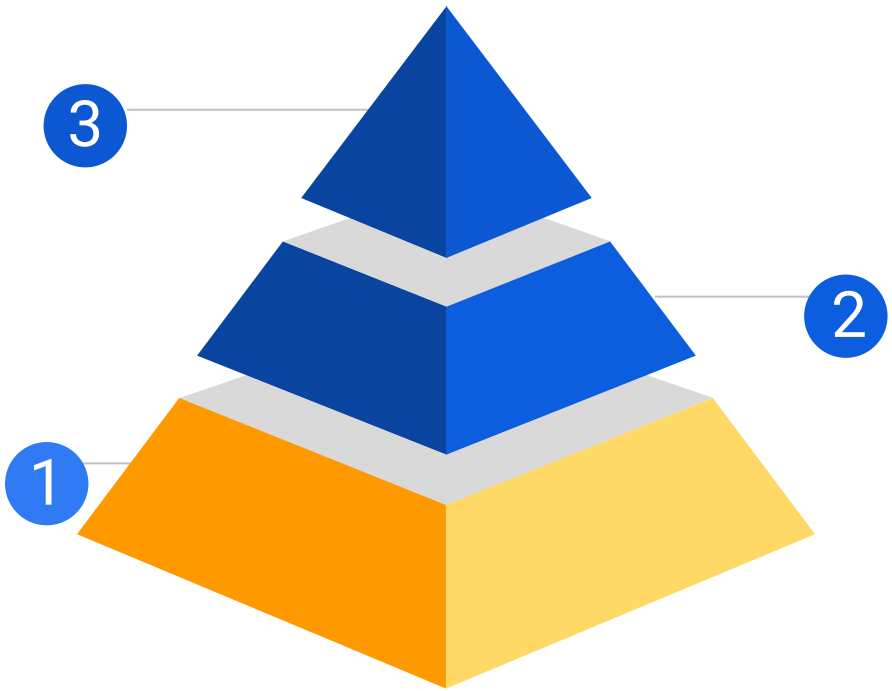
Multi-Stage Efforts: From Lab to Field

Field(ish) Study

- Fit messages to an app
- Daily use for 3 weeks

Lab Study

- In-depth tutorial
- What's important, difficult?



Online Survey

- Test different messages varying in length and contents

Bai et al. Improving Non-Experts' Understanding of End-to-End Encryption: An Exploratory Study. In EuroUSEC, 2020

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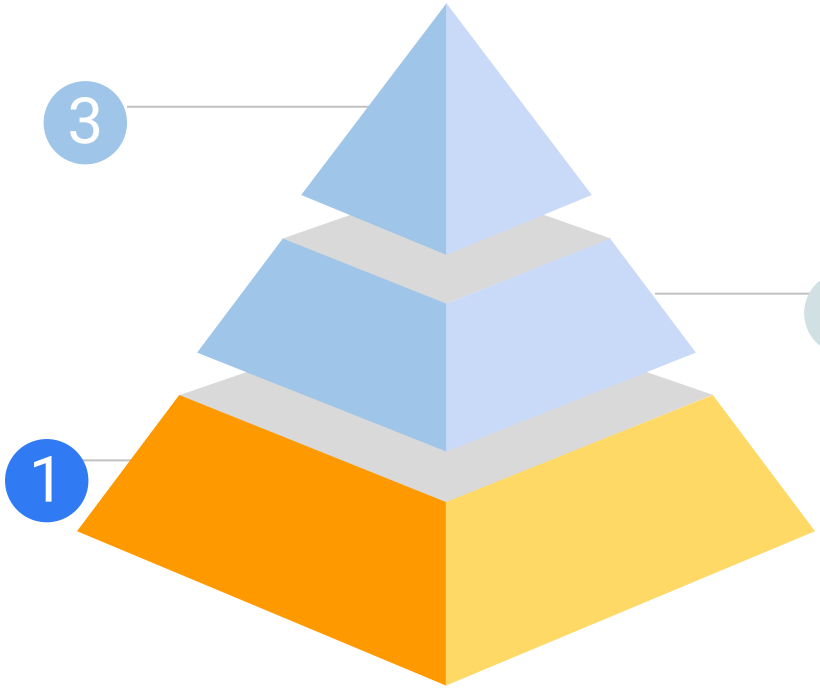

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Study 1 - Takeaways

- Confidentiality: Most significant

- Explaining risks clearly is useful
  - Comparing E2EE vs Non-E2EE
  - Weakness

- Some pieces may not worth mentioning
  - Integrity & authenticity
  - How E2EE works

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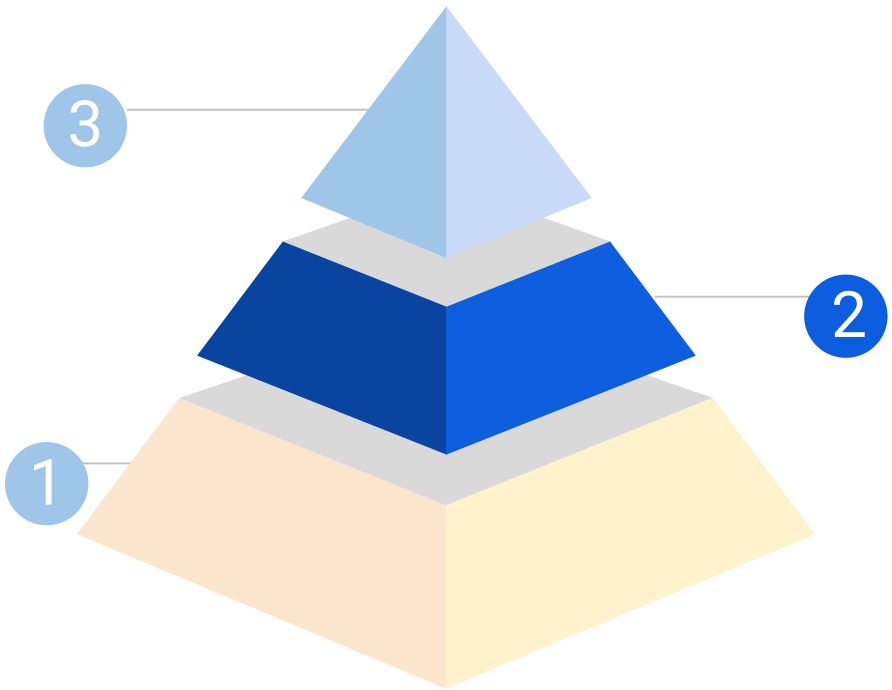

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Testing educational messages

- Can we **shift** user mental models with short messages in text?
  - In isolation
- How much is lost in **short**, **medium** vs. **long** messages?
  - Appropriate for various UIs.
- Which short, medium messages are most effective (for what)?
- Don’t want to **oversell** security

Study 2: Setup

- Online study via a crowdsourcing platform (Prolific, n=461)
- 1 Long, 5 short, 2 medium, 1 control message
  - Hypothetical app called TextLight (to remove brand bias)
- One message per participant.

Message types

Short	

Message types

Short	(1) Nobody but you and recipient

Message types

Short	(1) Nobody but you and recipient (2) Metadata risks

Message types

Short	(1) Nobody but you and recipient (2) Metadata risks (3) Endpoint risks

Message types

Short	(1) Nobody but you and recipient (2) Metadata risks (3) Endpoint risks (4) Lock/key metaphor

Message types

Short	(1) Nobody but you and recipient (2) Metadata risks (3) Endpoint risks (4) Lock/key metaphor (5) E2EE vs. other

Message types

Short	(1) Nobody but you and recipient (2) Metadata risks (3) Endpoint risks (4) Lock/key metaphor (5) E2EE vs. other
Medium	

Message types

Short	(1) Nobody but you and recipient (2) Metadata risks (3) Endpoint risks (4) Lock/key metaphor (5) E2EE vs. other
Medium	Two messages with various combinations of short messages.

Message types

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Medium	Two messages with various combinations of short messages.
Long	

Message types

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Medium	Two messages with various combinations of short messages.
Long	All key points, extra emphasis

Message types

Short	(1) Nobody but you and recipient (2) Metadata risks (3) Endpoint risks (4) Lock/key metaphor (5) E2EE vs. other
Medium	Two messages with various combinations of short messages.
Long	All key points, extra emphasis
Control	

Message types

Short	(1) Nobody but you and recipient (2) Metadata risks (3) Endpoint risks (4) Lock/key metaphor (5) E2EE vs. other
Medium	Two messages with various combinations of short messages.
Long	All key points, extra emphasis
Control	Describes non-security/privacy features

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Based on your understanding of end-to-end encryption, please indicate whether you agree or disagree that **hackers who have compromised the TextLight servers** have the following abilities, regardless of their motivation to do so.

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
Can see that you have sent a message on TextLight, regardless of knowing the content of the message.	○	○	●	○	○
Can see what is in the	○	○	●	○	○

Pre survey → Read Message → Exit survey

“Messages in TextLight are end-to-end encrypted. Before a message ever leaves your device, it’s secured with a lock, and only you and your recipients have the keys to open the message and read it.”

Pre survey | Read Message | Exit survey

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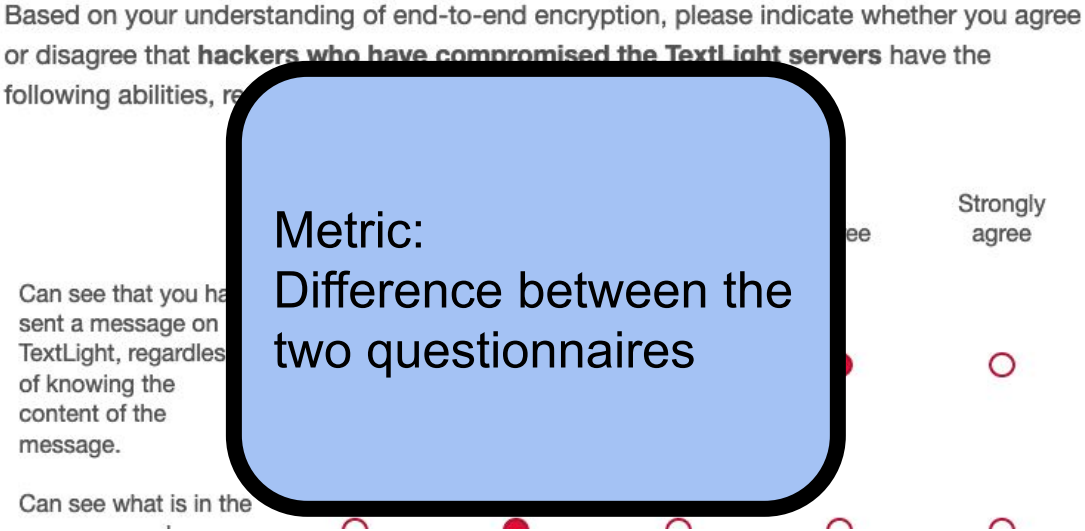
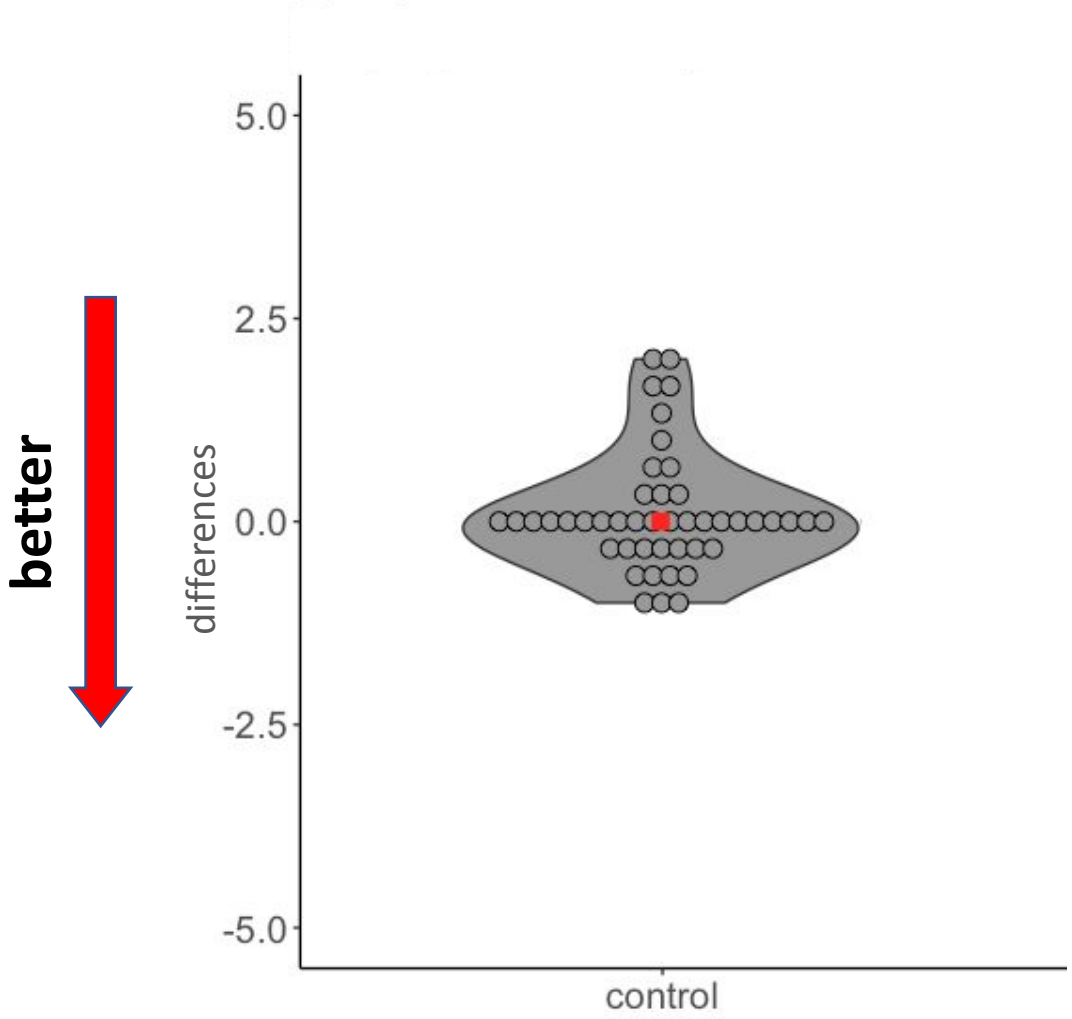
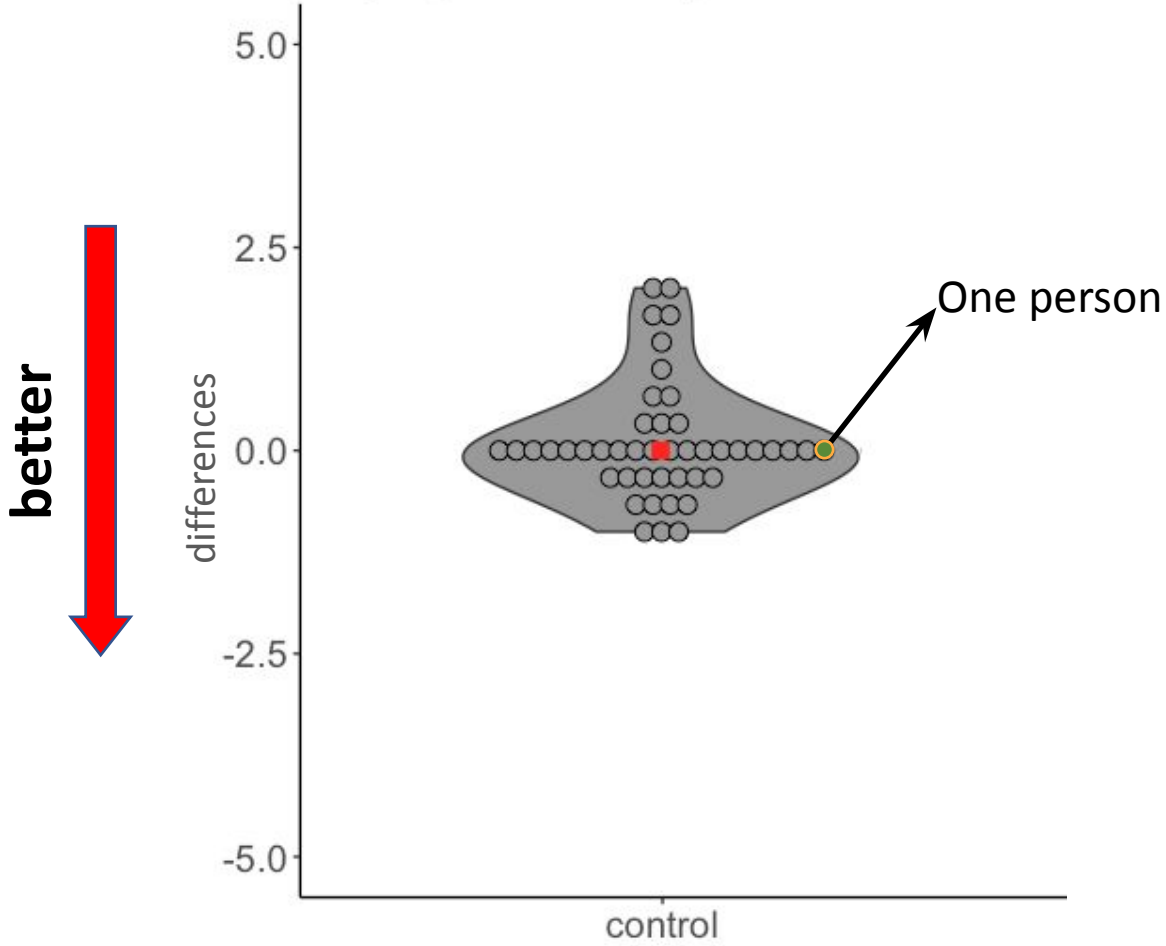
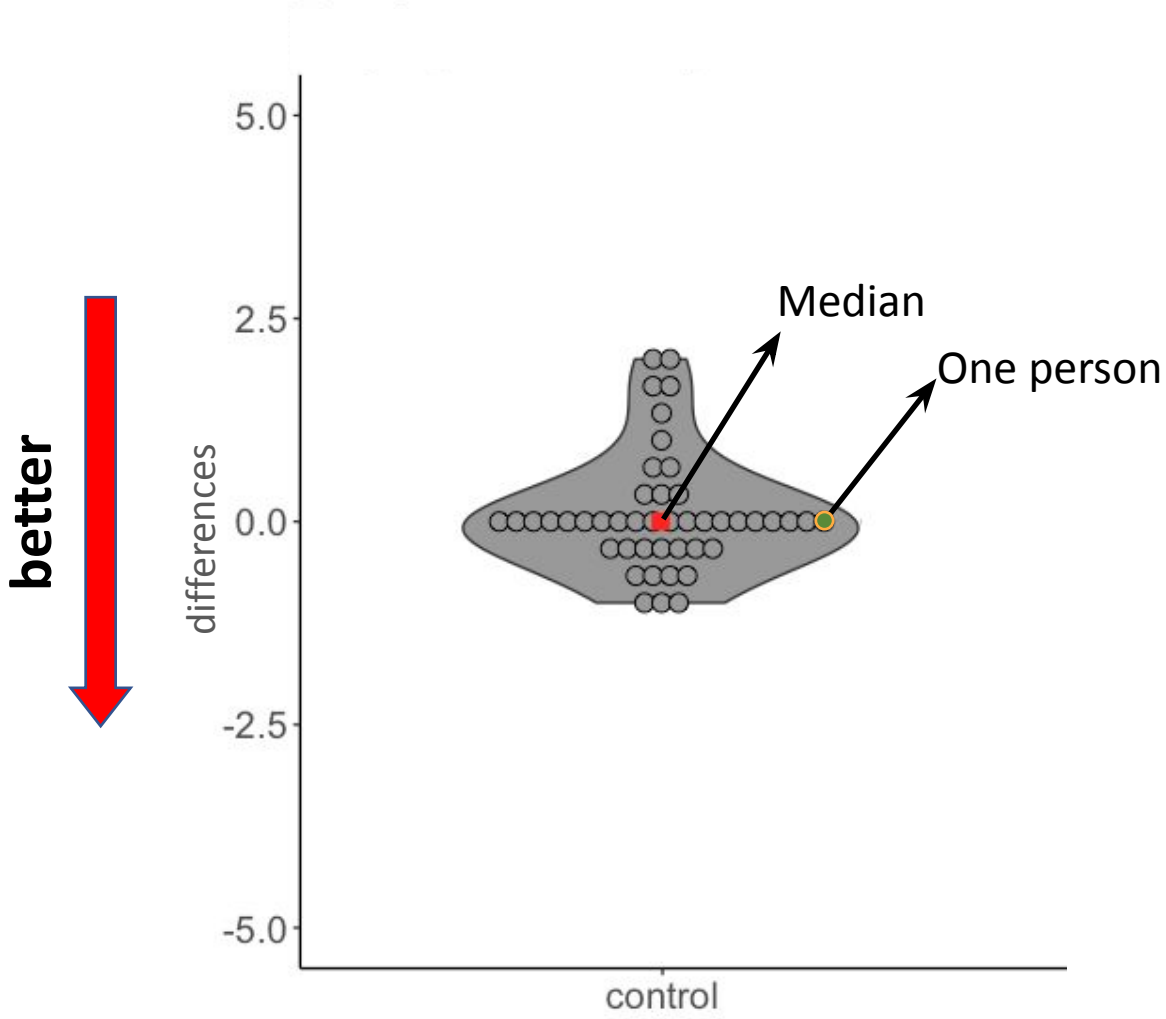


Metric:
Difference between the two questionnaires

Pre survey → Read Message → Exit survey


better
differences
5.0
2.5
0.0
-2.5
-5.0
control


better
differences
5.0
2.5
0.0
-2.5
-5.0
control
One person


better
differences
5.0
2.5
0.0
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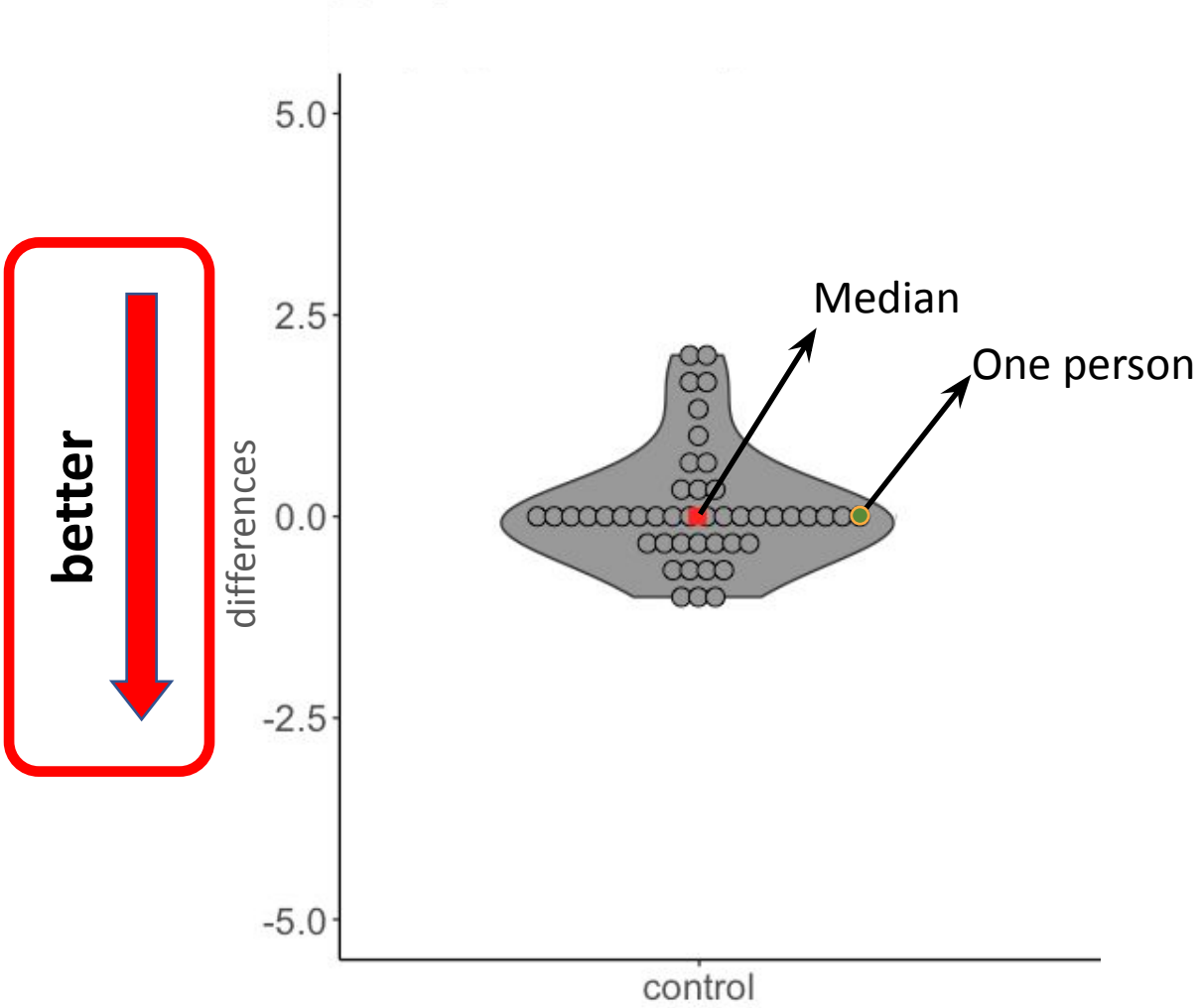
control
Median
One person


better
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5.0
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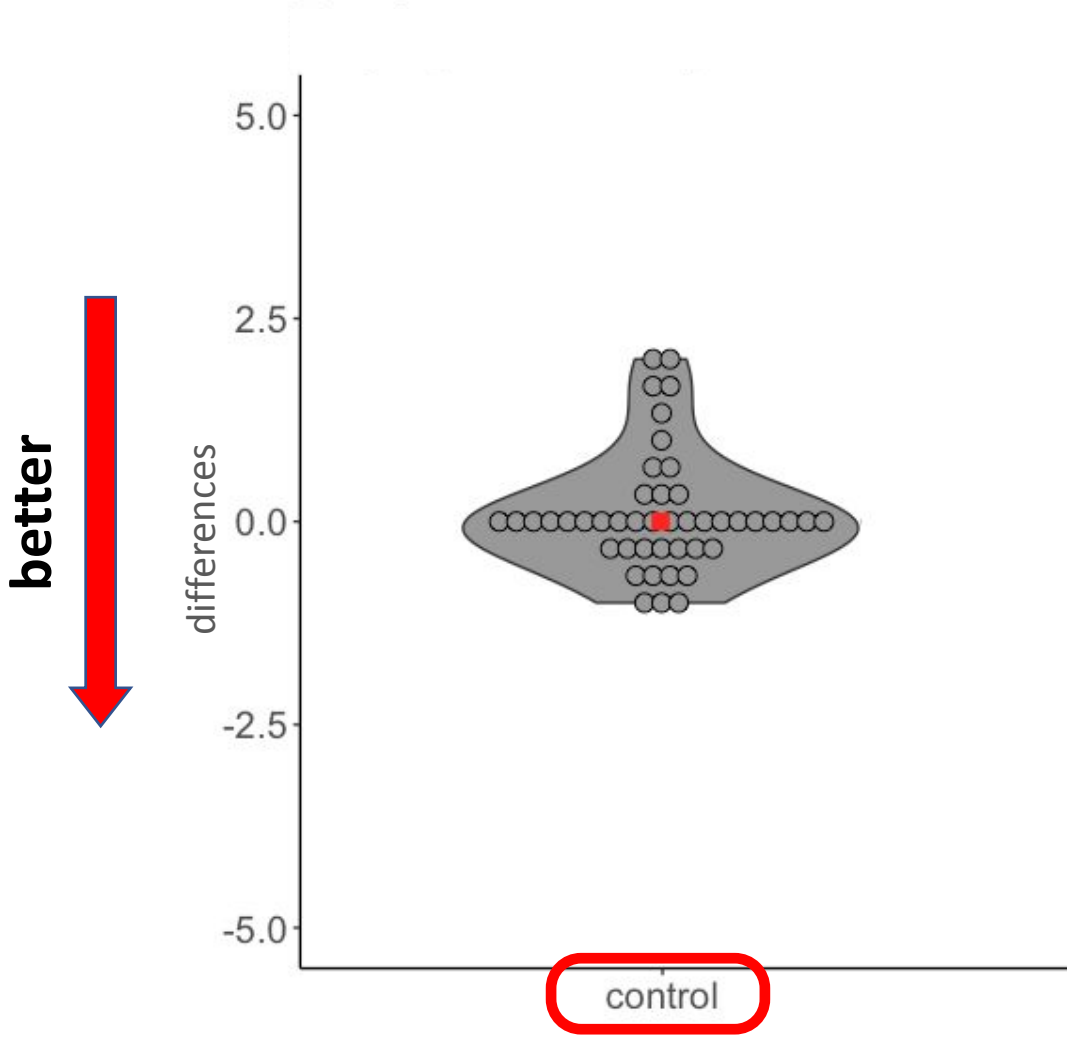
better
differences
5.0
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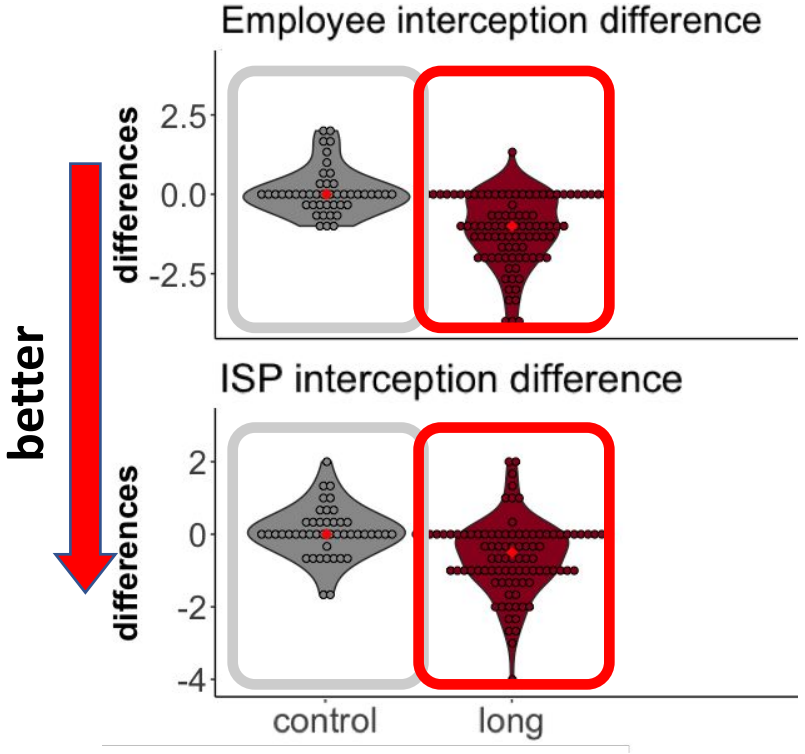
-5.0
control

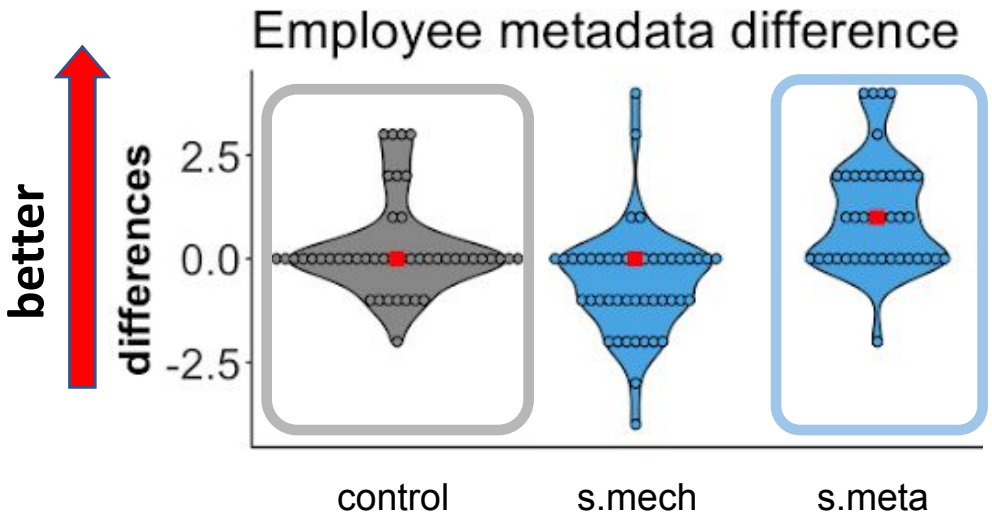
Long messages work!

- Long message is generally better than control
  - Our best effort



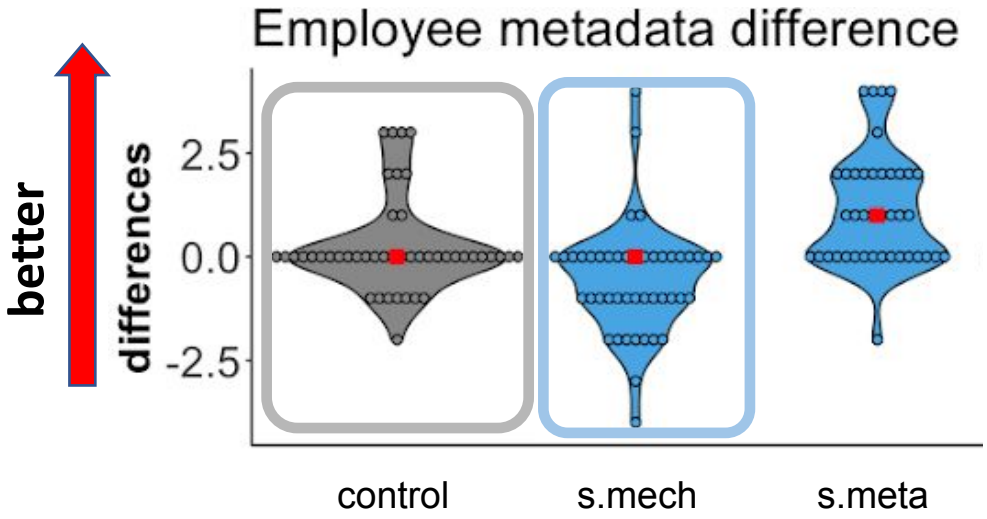
Shorts? Also work!

- When message is topical, mostly better than all messages



Shorts? Also work!

- When message is topical, mostly better than all messages
- But, some additional risk of overselling!



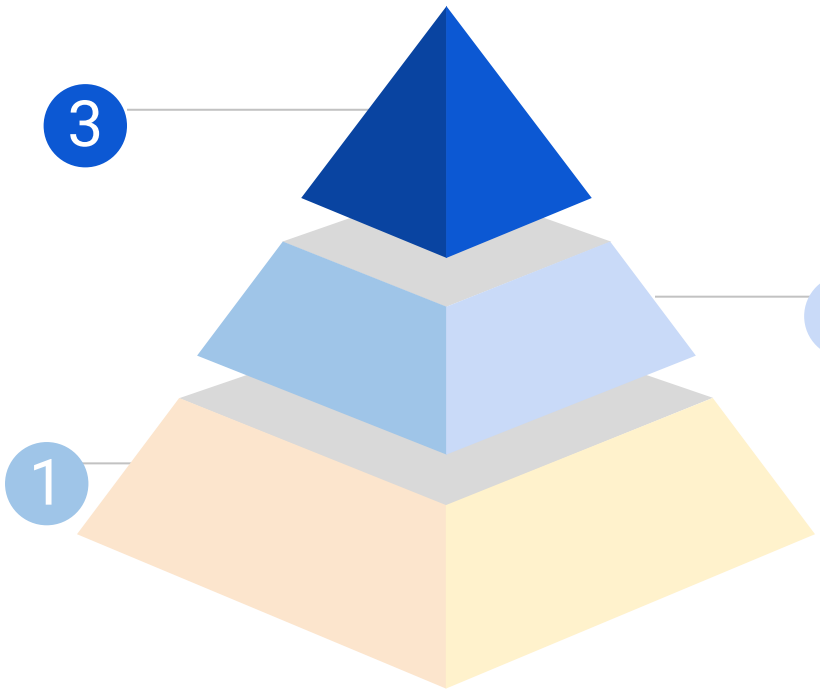
Study 2: Takeaways

- The messages work! (in a controlled environment)
- Short messages work surprisingly well
  - Chance of overselling, need all for a complete mental model

Multi-Stage Efforts: From Lab to Field

Field(ish) Study

- Fit messages to an app
- Daily use for 3 weeks



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- In-depth tutorial

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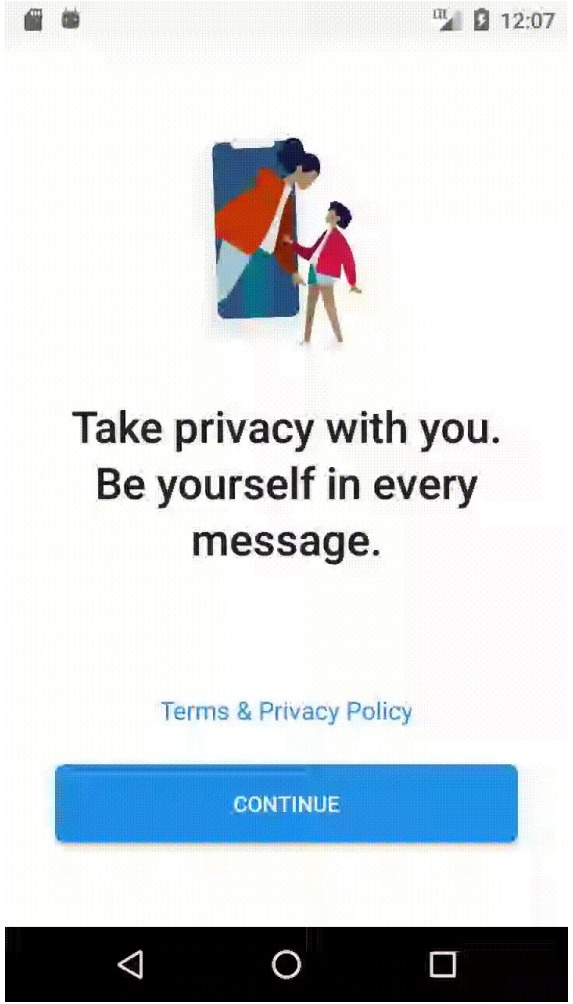
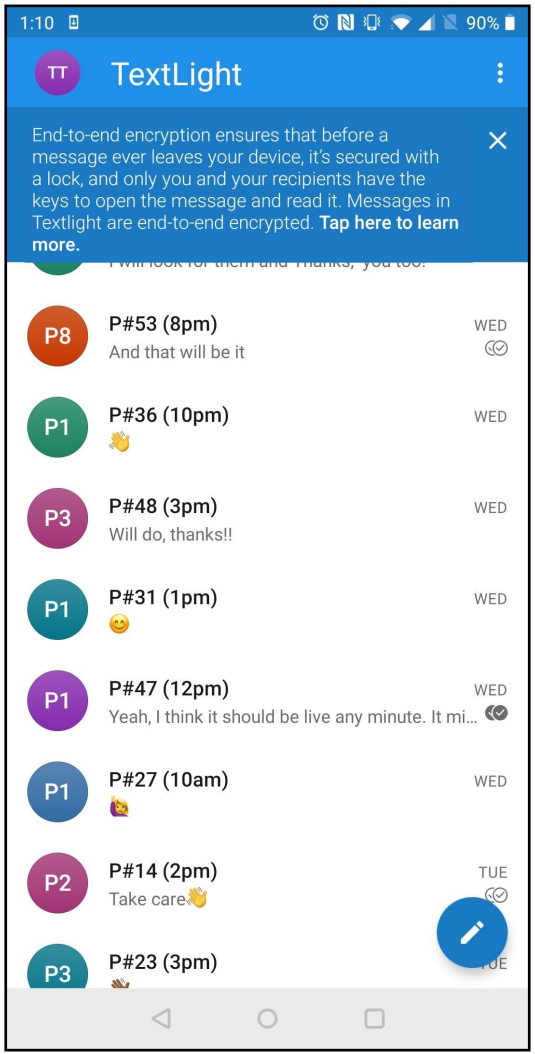
Feeds Into Study 3

- How well would messages from study 2 work in the real world?
  - (integrated in an app)
- Why does it or why doesn't it work?
  - How can we improve it further?



Study 3 Setup

- Incorporate successful messages from online study into an app (experimental)



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- Incorporate successful messages from online study into an app (experimental)
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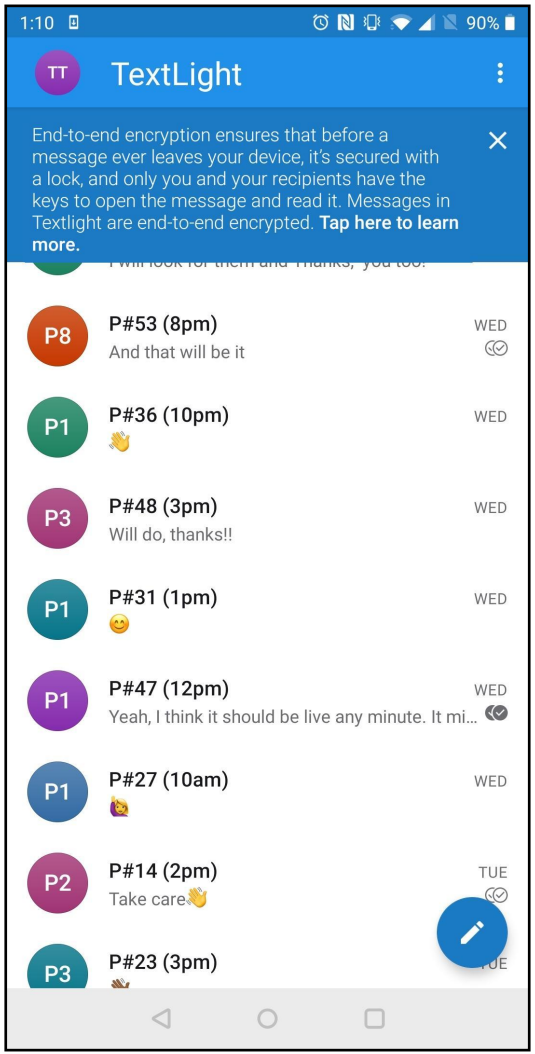

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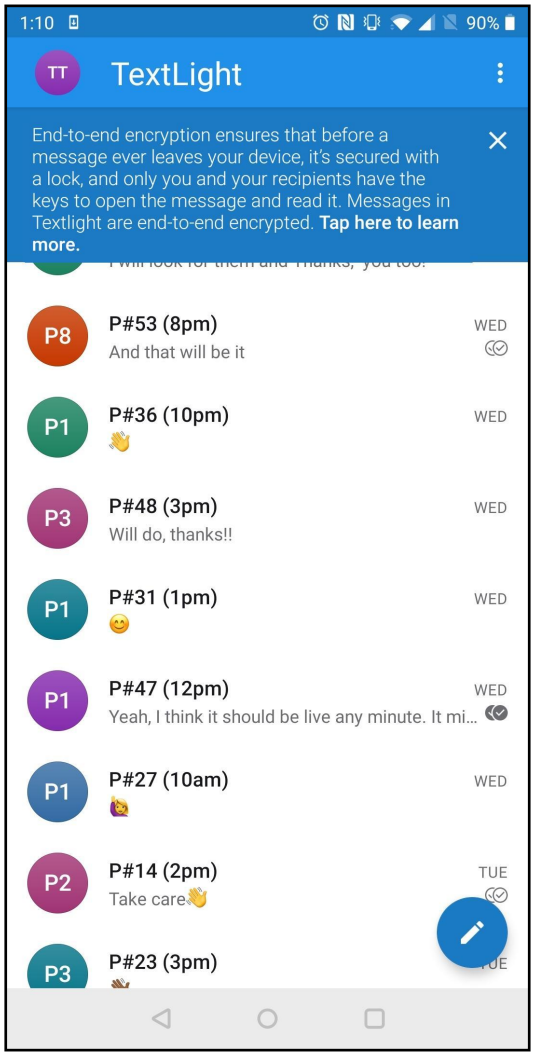
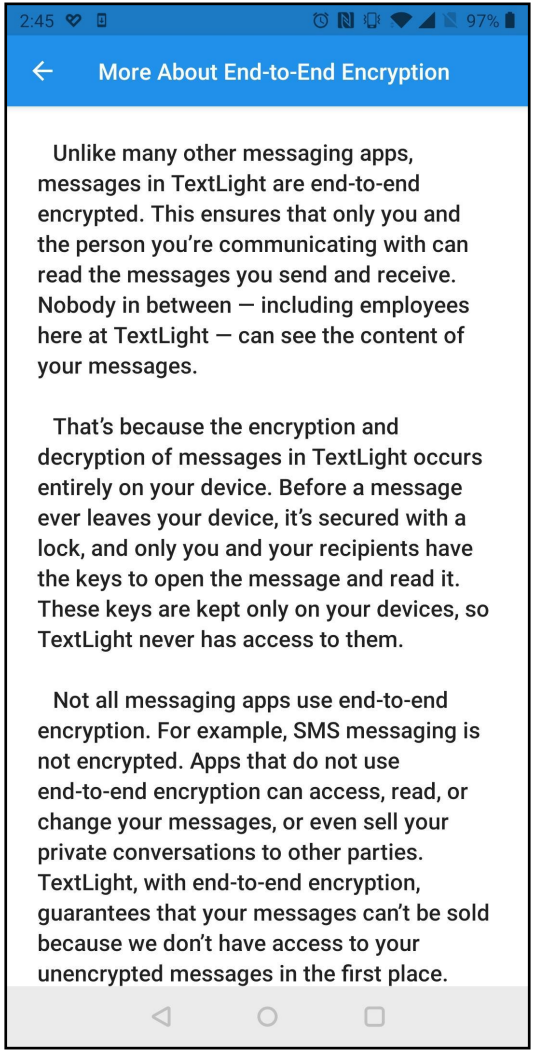
  - Show short messages



Study 3 Setup

- Incorporate successful messages from online study into an app (experimental)
  - Re-brand Signal to TextLight
  - Show short messages
  - Clickable to open long message



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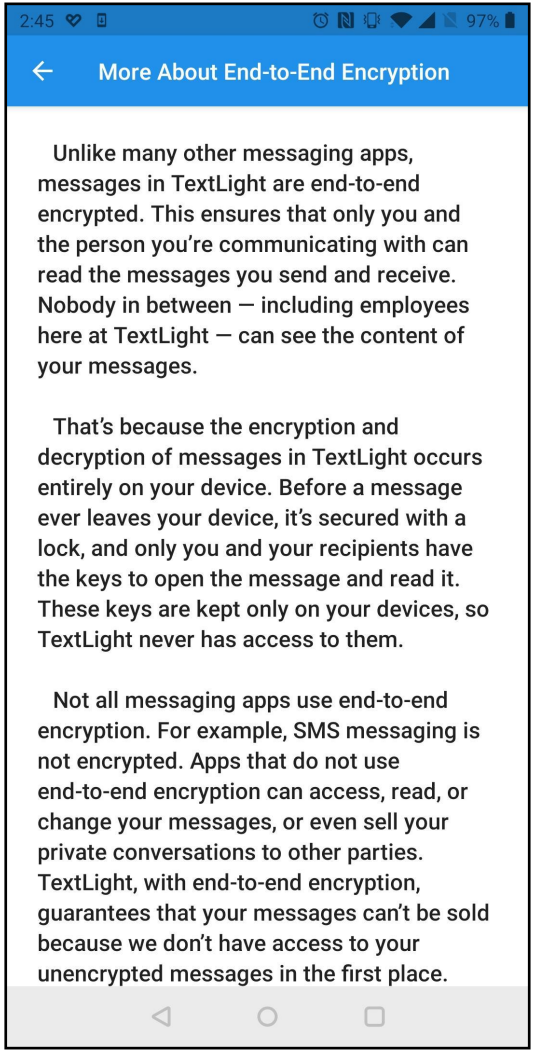
- Control version with no messages



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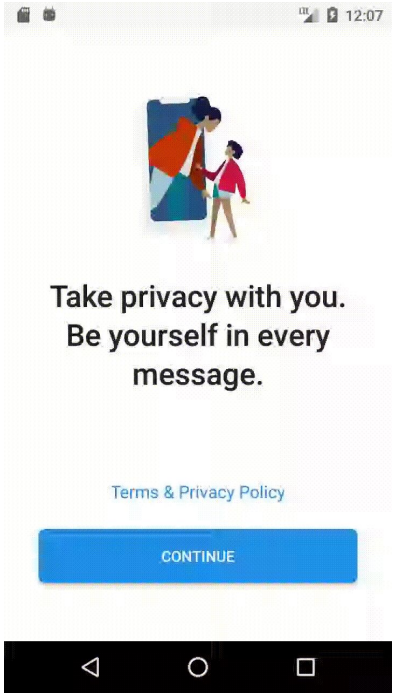
Pre survey | Remote install | Daily chat | Exit survey | Optional interview



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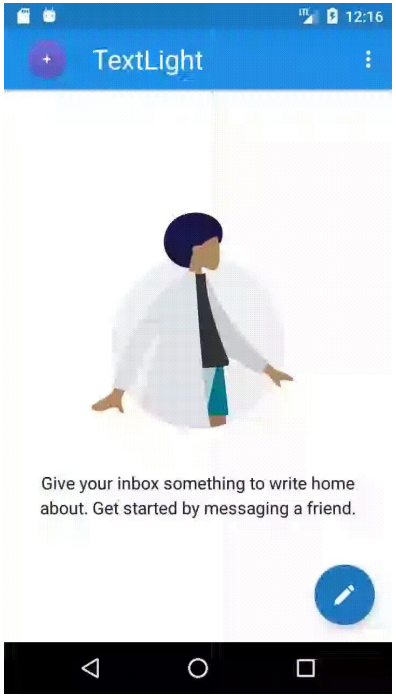

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Short texting sessions for 20 days.

Pre survey | Remote install | Daily chat | Exit survey | Optional interview

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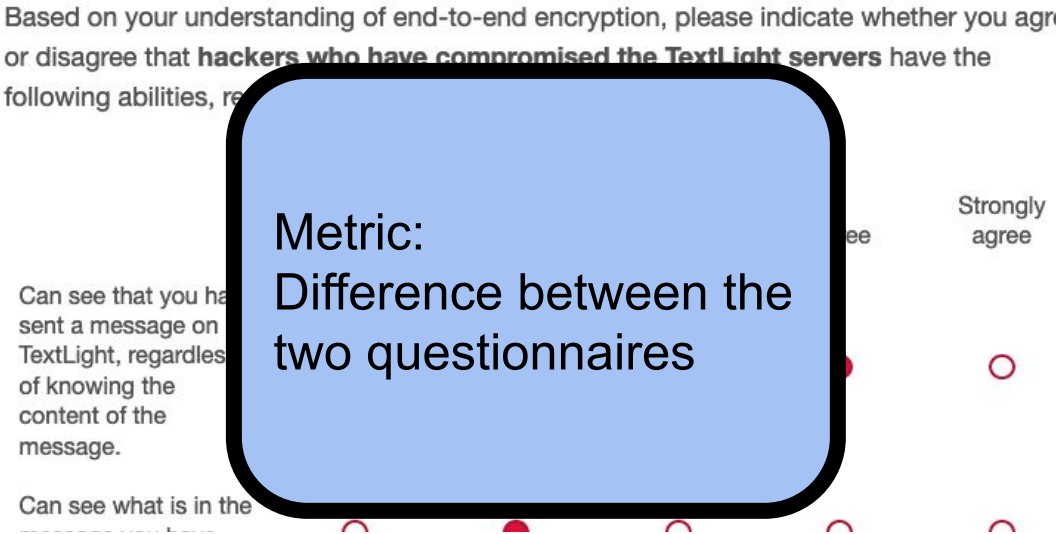

Metric:
Difference between the two questionnaires

Pre survey | Remote install | Daily chat | Exit survey | Optional interview

Pre survey | Remote install | Daily chat | Exit survey | Optional interview

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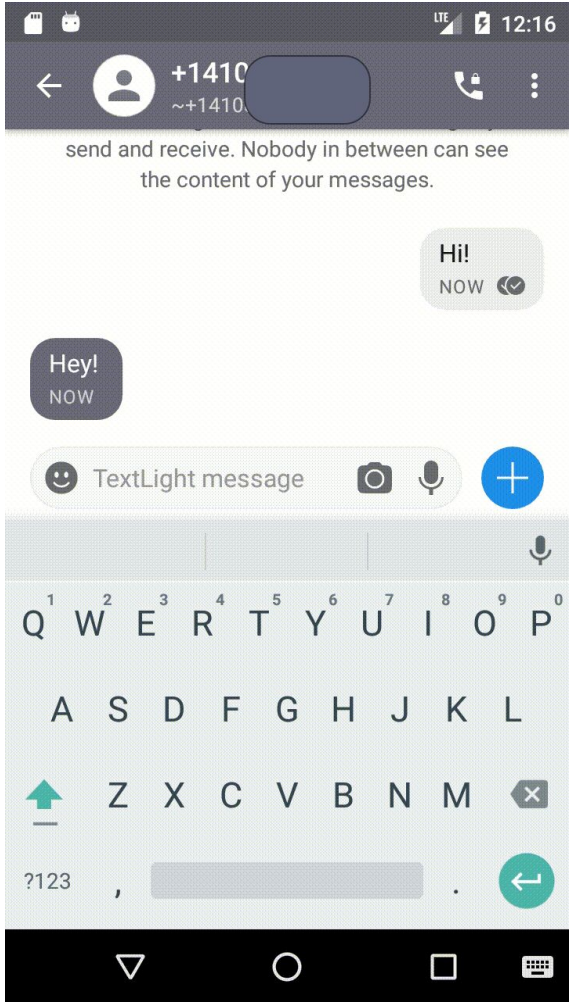
Study 3: Results

- Statistically, there is no improvement between experimental and control groups
  - People knew more than expected
  - In one question, we oversold E2EE (like in the survey study)

- Interviews tell us more



Interviews:

- 10/19 participants were able to generalize the concept
  - " [it protects from] *Probably anyone who would interrupt or interfere in between the messaging, in between where you sent it and someone else received it.*"
- 14/19 knew the unlocked phone adversary was powerful
- 9/19 got at least something wrong
  - " [it protects from] *people … hacking into your phone … from either reading the messages or altering the contents of the message.*"
- 9/19 said they didn't read messages or weren't interested in them.
  - "*I obviously didn't pay a lot of attention to it.*"

Summary

- Mental models of secure communication: not **functional** enough
- Can **small nudges** and user-centered design improve things?
  - Initial qualitative study to identify topics, messages
  - Online study to examine specific messages
  - Longitudinal study to measure real-world effectiveness

- They work well when we **control external factors**.
- **Integration** to applications might need to be more obvious.
  - Perhaps by sacrificing usability a little bit.

Summary

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