


Exploring decision making with Android's runtime permission dialogs using in-context surveys

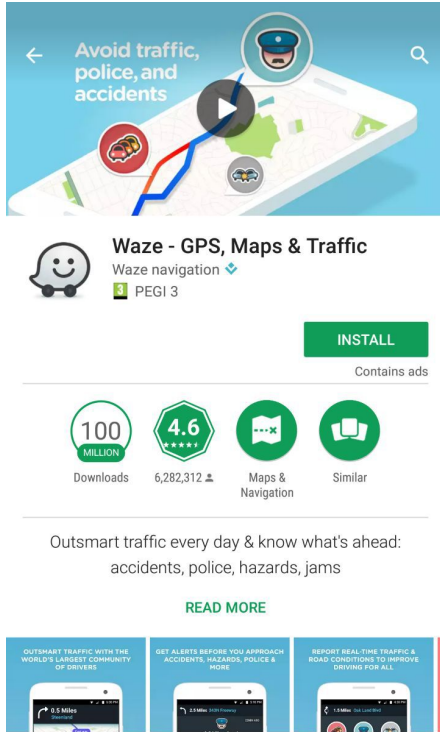


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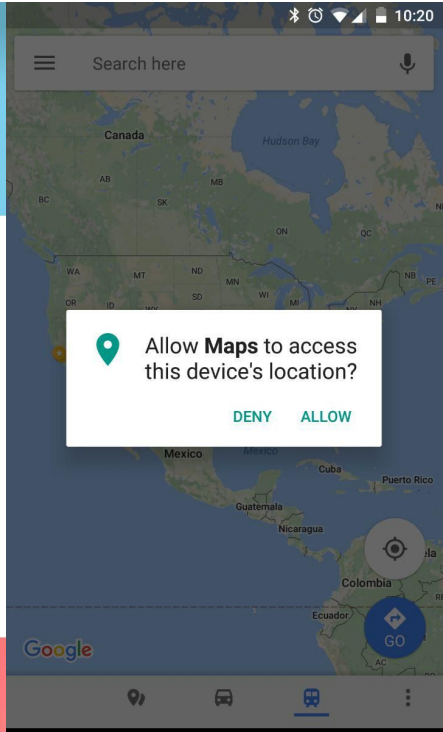
¹ Hasselt University

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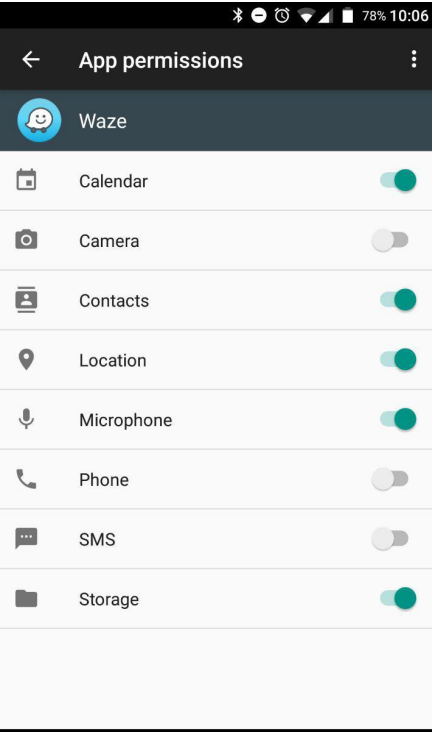
App lifecycle decisions



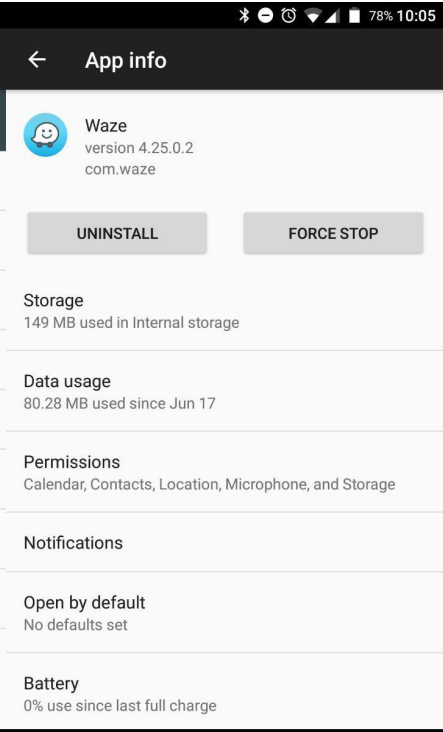
App installation



Permission request



Altering permission



App removal

Research questions

What are users' **rationales** when making these decisions?

Do they vary across:

- Permission groups?
- Demographics?

Are users **comfortable** with their decisions?

Context

- **Lack of user comprehension** and attention [*Felt 2012a, Kelley 2012*], unpleasant surprises due to **user expectation mismatch** [*Jung 2012, Thompson 2013*], and **user discomfort** [*Felt 2012b*].
- **Developers lack knowledge** [*Stevens 2013*], make mistakes [*Shklovski 2014, Smith 2016*], and are overzealous [*Wei 2012*].
- High rates for users wanting to **deny permissions** [*Wijesekera 2015, Wijesekera 2017*]
- And much more... (over 50 publications on Android permissions!).

Context

All of the previous studies:

- **Install-time permissions** model (pre-Android Marshmallow), or
- **Runtime request models**
 - Hypothetical scenarios
 - Ask questions some time after decisions had been made
 - Using modified Android devices

Our approach:

- **Runtime permissions** model
- Use participants' **personal Android devices**
- Ask **in-situ**, at the moment participants are making their decision

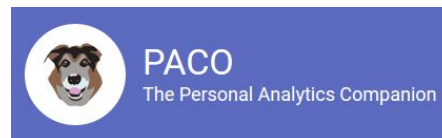
Methodology

Experience Sampling Method: Survey participants right at the moment they made their choice.

Extended open-source Android app called “**Paco**”.

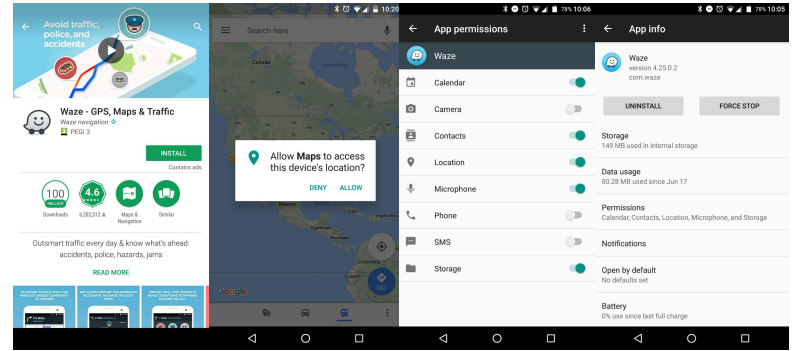
- To launch **in-situ** surveys when apps are installed/removed and when permission decisions are made
- To collect information about installed apps and their permissions
- To provide E2E encryption
- Open source extensions available on <https://github.com/google/paco>

Users install it on their personal phones.

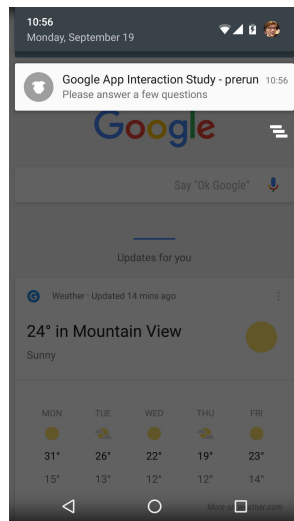
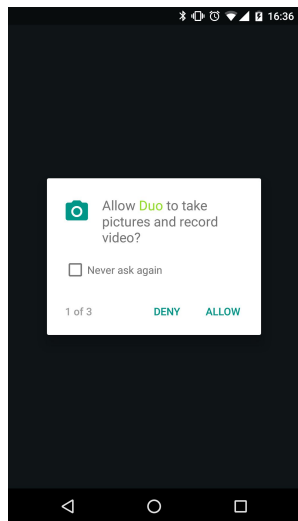


In-situ survey

- Asked on specific **events**
 - App installation
 - App removal
 - Granting / denying permission via dialog
 - Granting / denying permission via settings
- Asks about **rationale** (“Why did you allow ...?”)
- **Multiple choice** (randomized order), including “other” option
 - Options are based on a **pre-study** using Google Surveys with 4000 participants
 - Coded responses, grouped by topic, consolidated to 10 rationales per event
- Also measures **reluctance**: is the participant comfortable with their decision?
- Limited to 5 questions per day



Paco User Experience

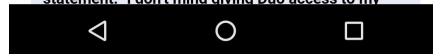


Why did you choose to allow Duo to access your Camera? (select all that apply) [required]

- I want to use a specific feature that requires this permission
- I won't be able to grant this permission later
- Nothing bad will happen
- I wanted the permission screen to go away
- The app developer already has this information about me
- Because the app is popular
- I have nothing to hide
- I trust the app developer
- I didn't know I did that
- I think the app won't work otherwise

Other

To what extent do you agree with the following statement: "I don't mind giving Duo access to my



- I have nothing to hide
- I trust the app developer
- I didn't know I did that
- I think the app won't work otherwise
- Other

To what extent do you agree with the following statement: "I don't mind giving Duo access to my Camera?"

- Strongly disagree
- Disagree
- Neither agree or disagree
- Agree
- Strongly agree

Save Response



Exit survey

- Identify participants' **privacy stance & technology adoption**
- Revisit **comfort level** with permissions granted in the past
“How comfortable would you be with <app> knowing your home and work address?”
 - Worded as hypothetical scenarios
 - Permission access made explicit
 - Knowing your home and work address (Location)
 - Knowing the phone numbers of your friends and family (Contacts)
 - Knowing who is calling you (Phone)
 - Seeing the pictures taken with your camera (Storage)
 - Includes pre-study permission grants

Participants

- 157 remote participants across the U.S., from different job categories
- 6 weeks
- No interaction with researchers after set-up
- Experiment labeled as “study on app interactions”
- Incentives: \$10 per week, \$20 for exit survey

Age		Gender	
18 - 23	29	Male	79
24 - 30	44	Female	78
31 - 40	35		
41 - 50	23		
51 or over	26		

Education	
Up to High School	15
Some college (1-4 years, no degree)	40
Associate's degree	28
Professional school degree	5
Bachelor's degree	51
Graduate degree	18

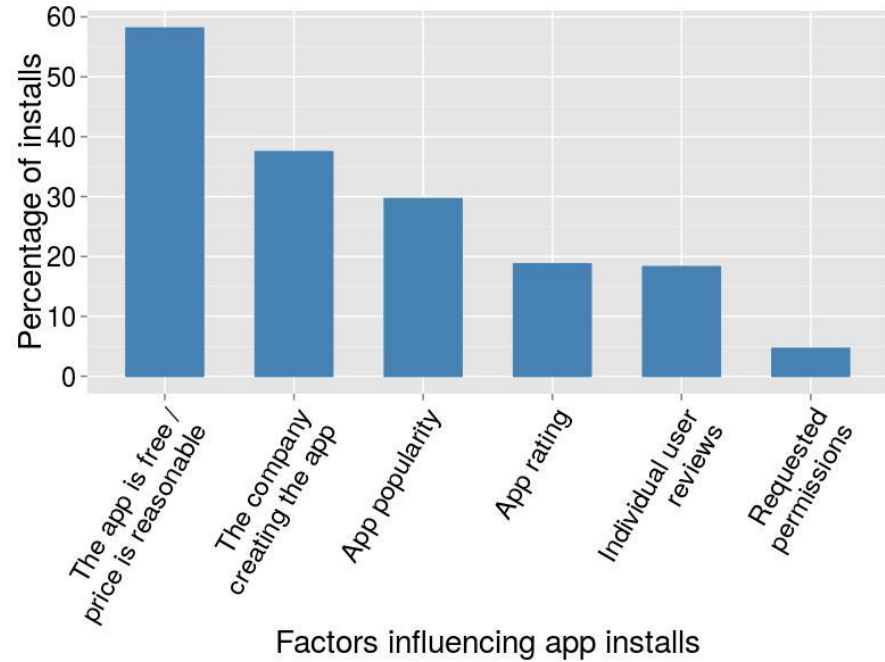
Results



Results

Event Type	Occurrences	Surveyed
App Installs	3118	1913
App Removals	1944	775
Permission Grants	2239	1605
Permission Denials	437	272
Total	7738	4565

Factors influencing app installs

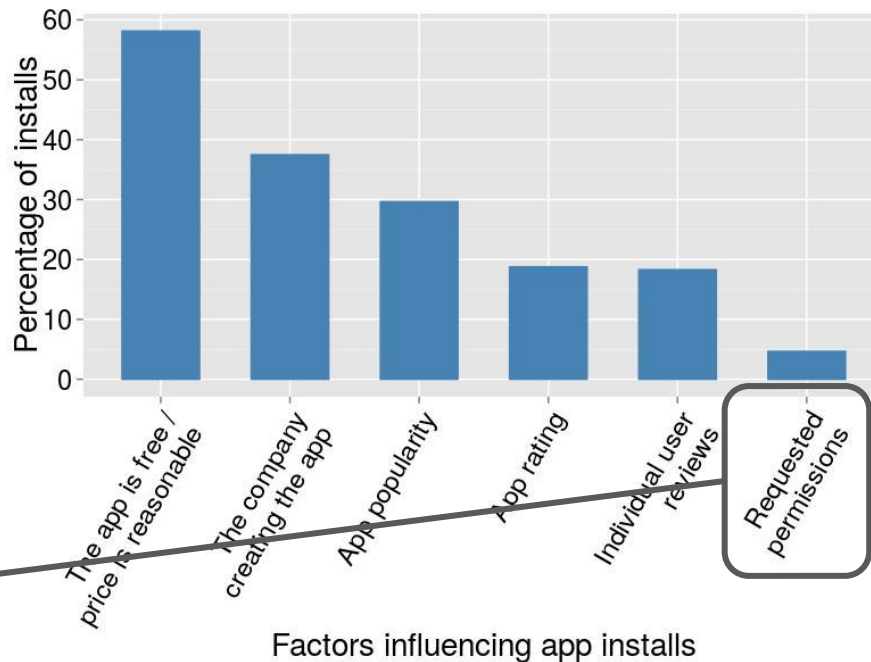


(multiple responses per event are possible)

Factors influencing app installs

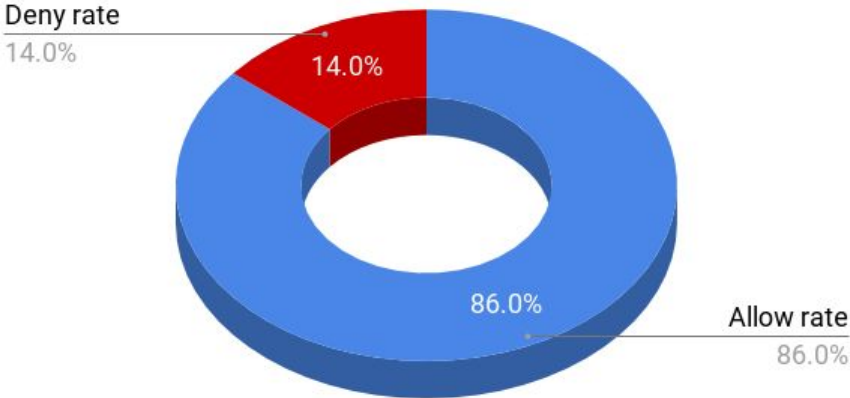
Runtime permissions model: no permissions shown during installation

5% of install events, but from 33% of participants.



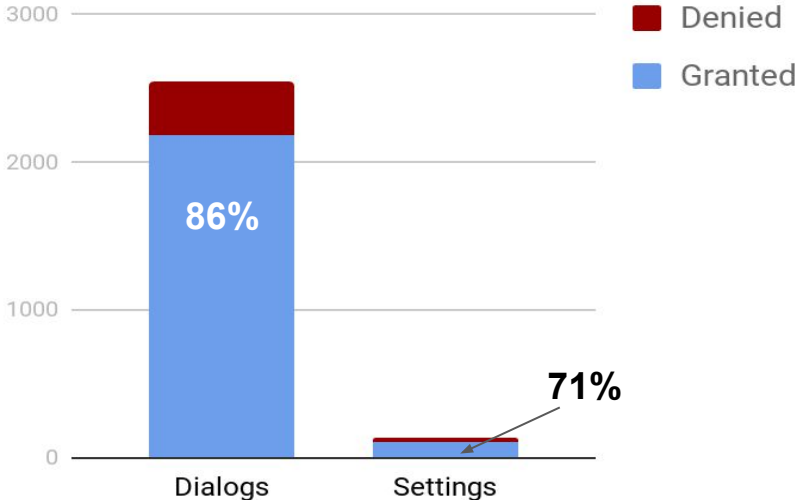
(multiple responses per event are possible)

Permission decisions



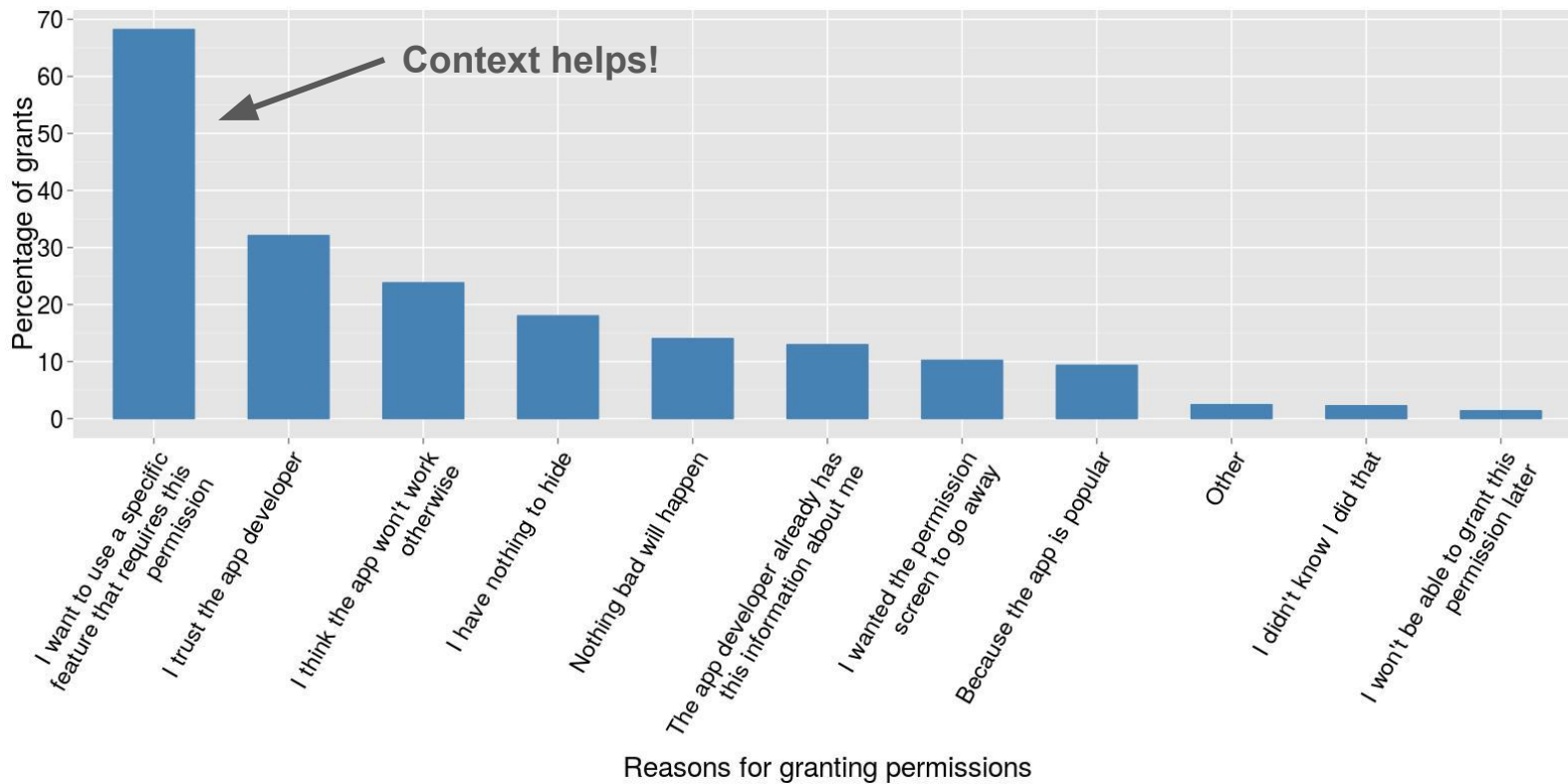
49% of users deny permissions at least once.

Dialogs vs Settings

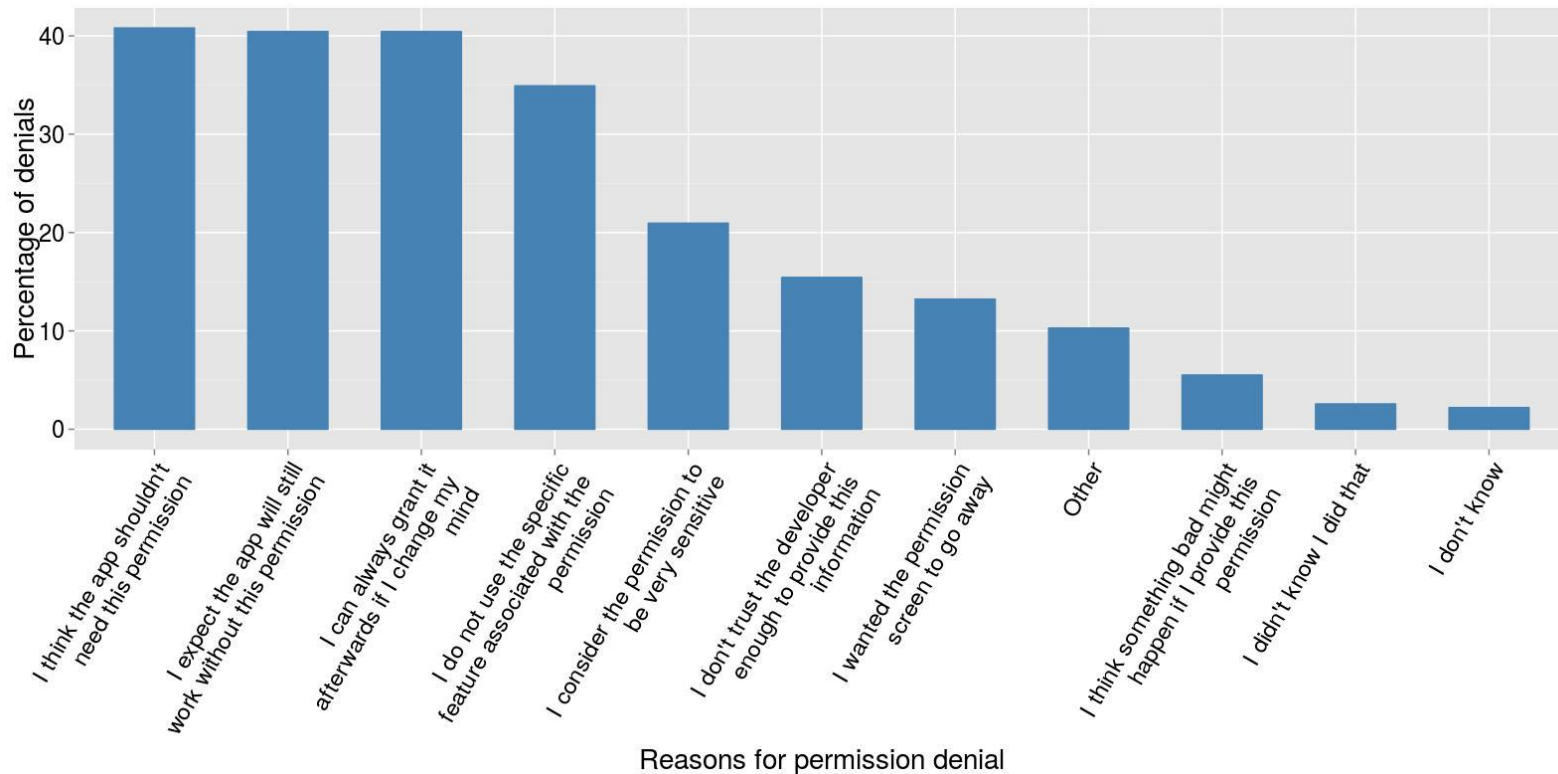


95% of decisions happen through dialogs.

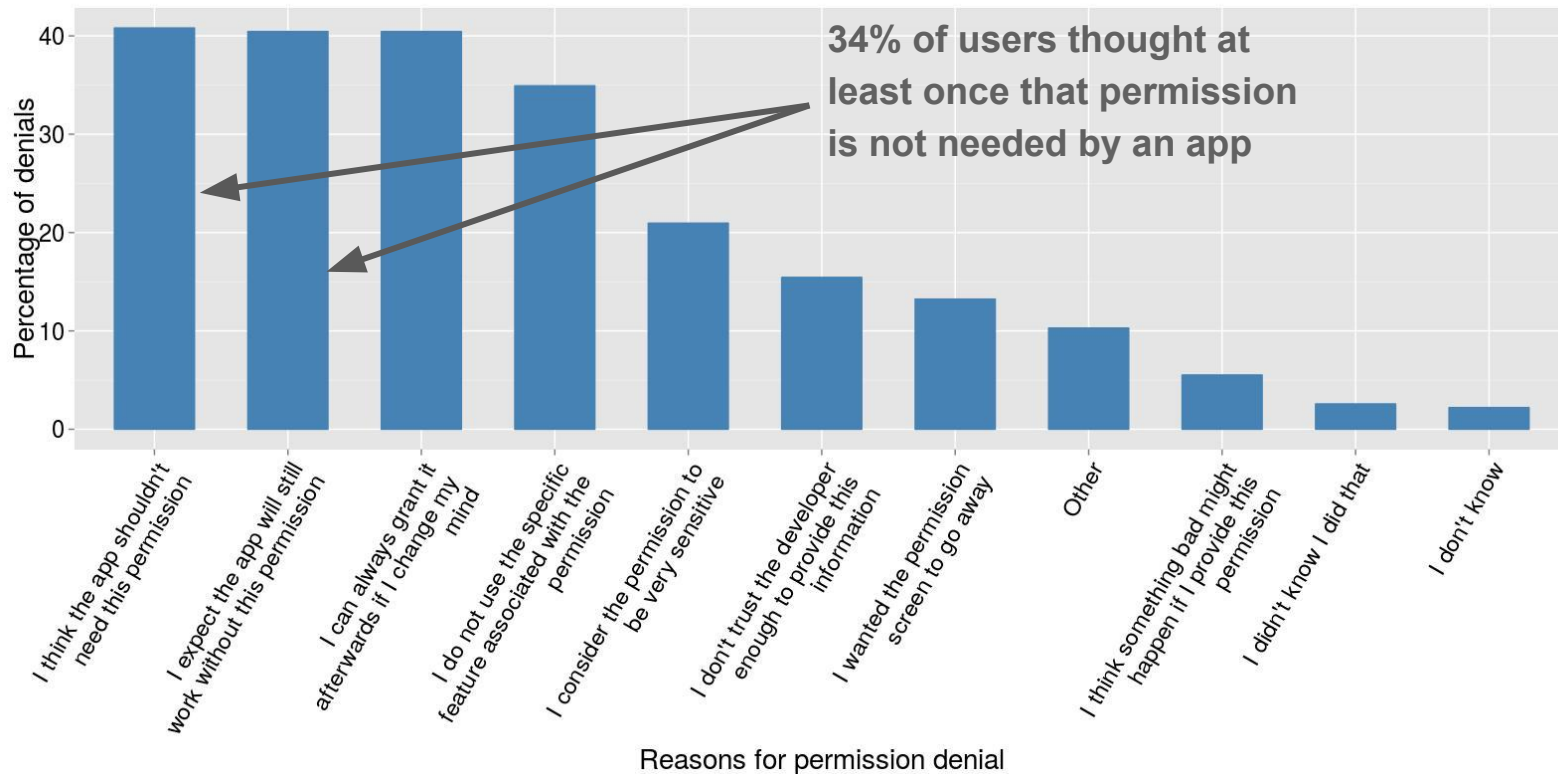
Why do users grant permissions?



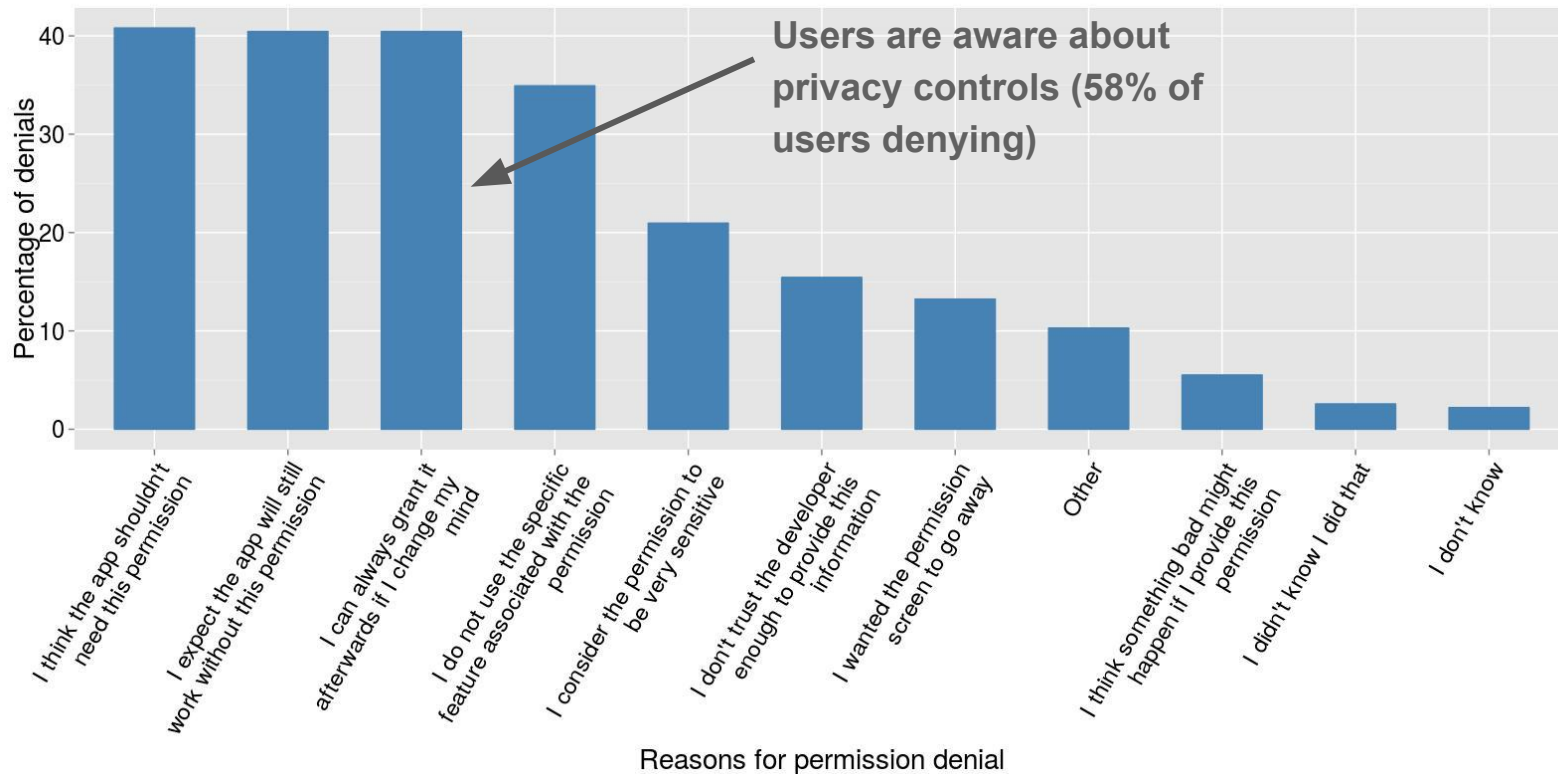
Why do users deny permissions?



Why do users deny permissions?



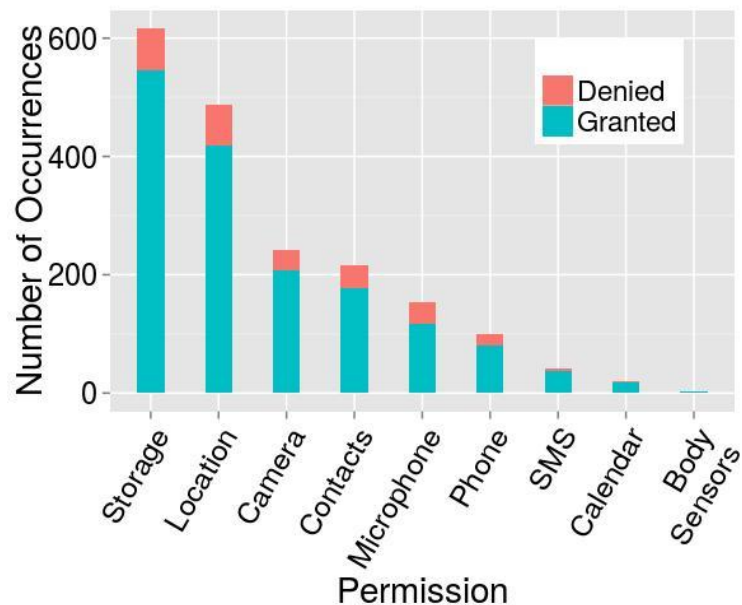
Why do users deny permissions?



Denial rates across permission groups

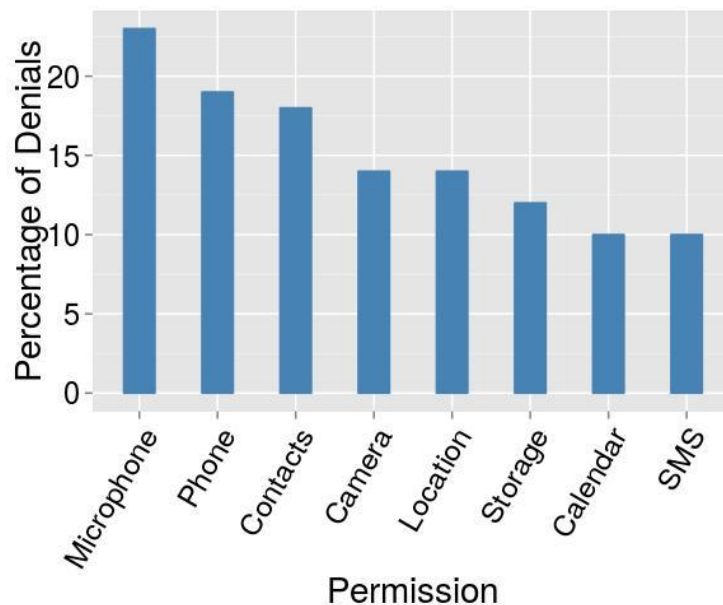
In absolute numbers

Storage and Location are most requested, most denied

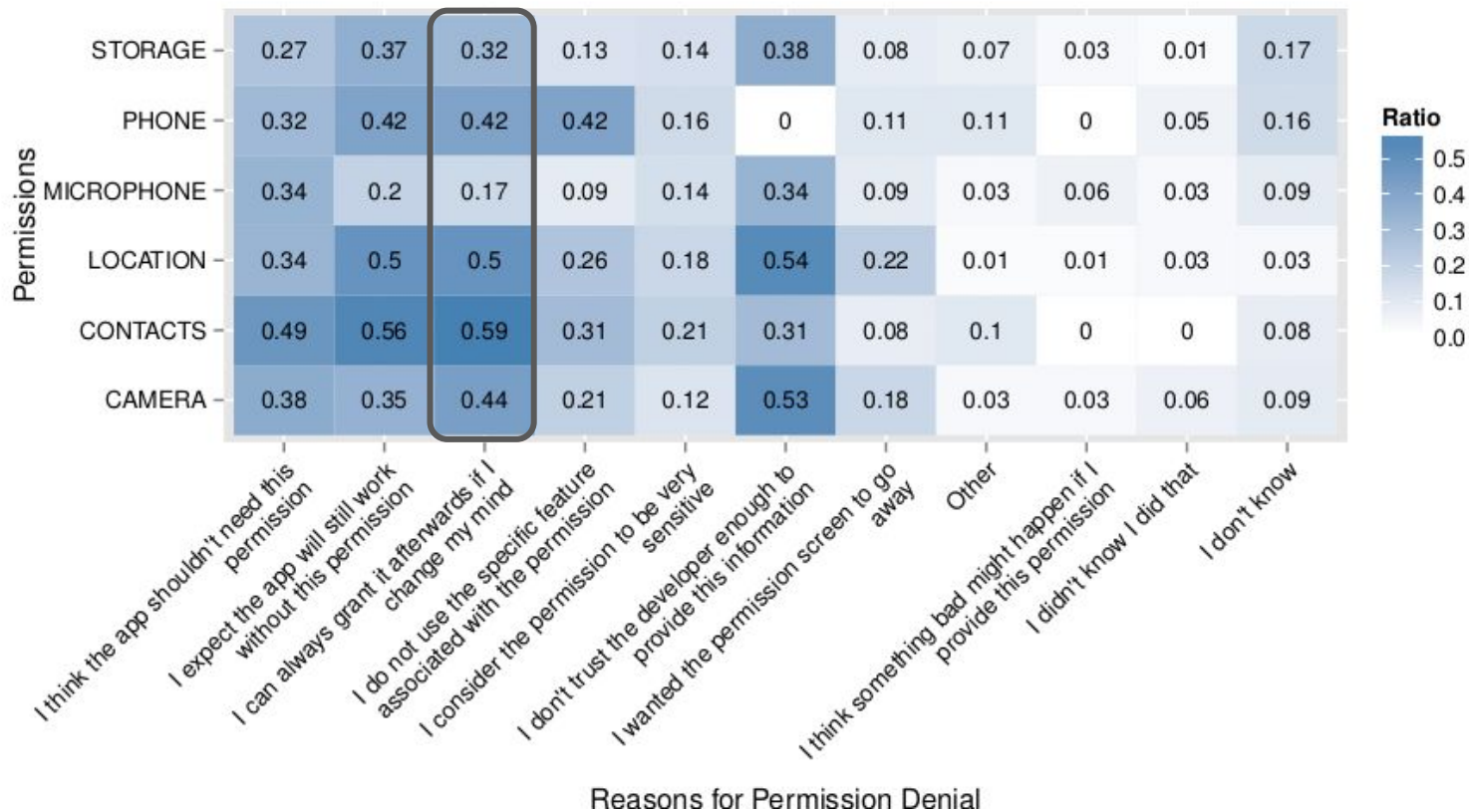


In relative numbers

Microphone has highest *denial rate*



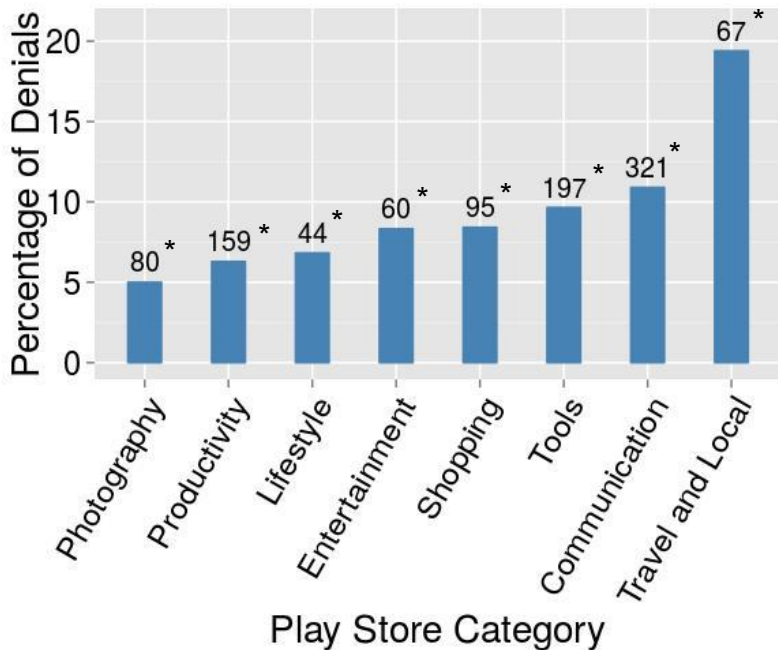
Reasons for denials across permission groups



Permission denials in categories

Difference in denial rate also per permission type

- E.g. Location permission
- 43% denial rate in Travel and Local
 - 11% denial rate in Communication



*numbers indicate total # decisions per category

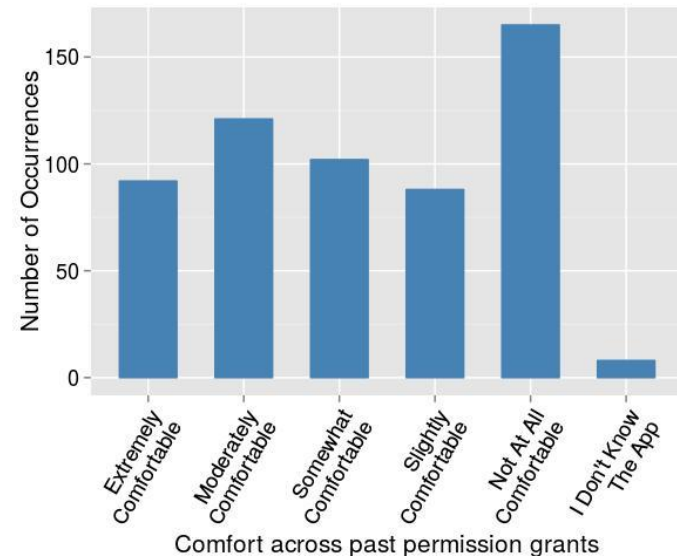
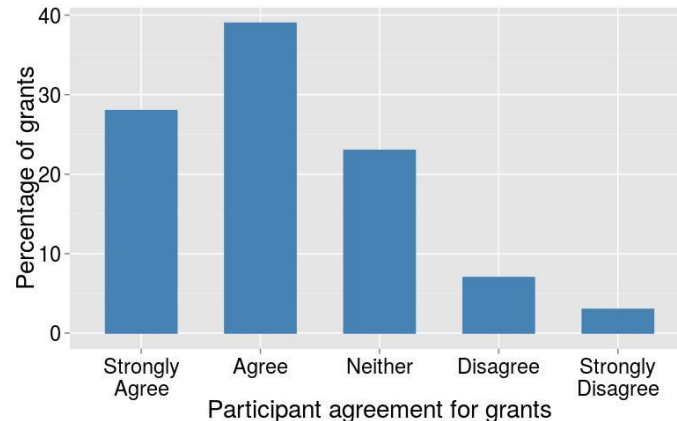
Reluctance

In-situ: “I don’t mind giving <app> access to my <permission>”

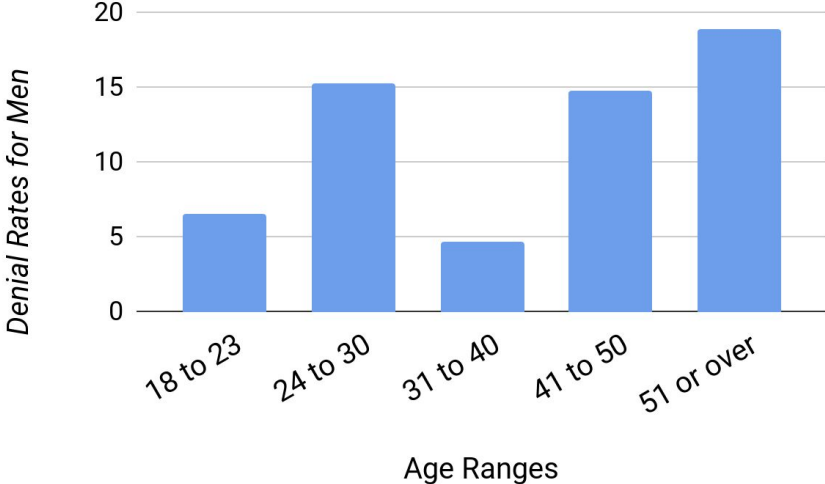
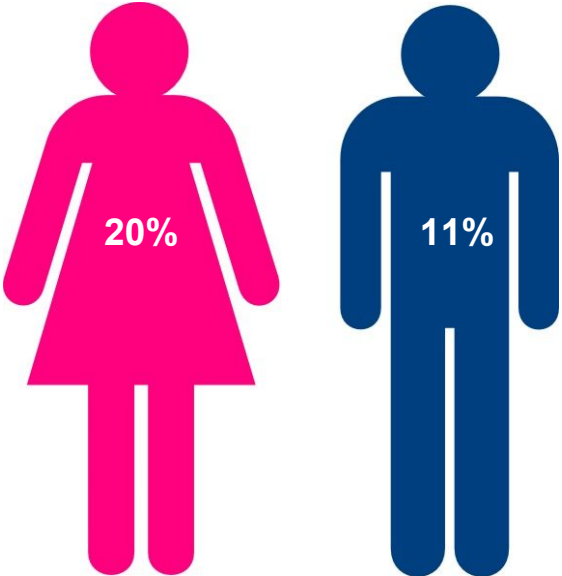
- Participants **disagree or strongly disagree with 10%** of grants
- **34% of participants** disagreed at least once

In hindsight: “How comfortable would you be with the <app> knowing <the pictures taken with your camera / who is calling you / ...>?”

- **Not at all comfortable** selected in **29%** cases
- **64% of participants** were uncomfortable at least once
- Least comfortable about Phone and Storage permissions



Influence of demographics on denial rate



Denial rate varies across age groups **for men**

Key Insights (1)

Permissions influence during app (un)installations:

- Small in terms of percentages, yet ...
- affects millions of app per day in absolute numbers.

Dominant reasons related to grants/denies are related to app functionality

- Users are reasoning about permissions “well” - based on **context** and functionality.
- Users understand their options/controls: 40% of the time, when participants denied a permission, they did so because they knew they could change it later
- Good news: Runtime dialogs help!

Key Insights (2)

Users' decision making is **complex and varied!** There's no simple model:

- Often multiple reasons influence each decision
- Rationales differ across app categories
- Rationales differ across type of data (permission group)
 - Users often think requests for CONTACTS shouldn't be necessary and they postpone granting
 - Trust is more important for LOCATION and CAMERA than other permissions
- Findings hint at the existence of multiple & multi-dimensional privacy personas

Key Insights (3)

- There is some **reluctance** (10%) when granting permissions, and discomfort grows in hindsight (29%).
- Desire to deny a permission affects many people at some point:
 - 49% of participants deny permissions at least once.
 - 34% of participants have at least one app they think asks for a permission it shouldn't need
 - 34% of participants showed reluctance for at least one of the permissions they granted
 - 64% of participants are uncomfortable in hindsight with at least one of the permissions they granted
- Demographics have some influence: women deny twice as often as men

Thank you!

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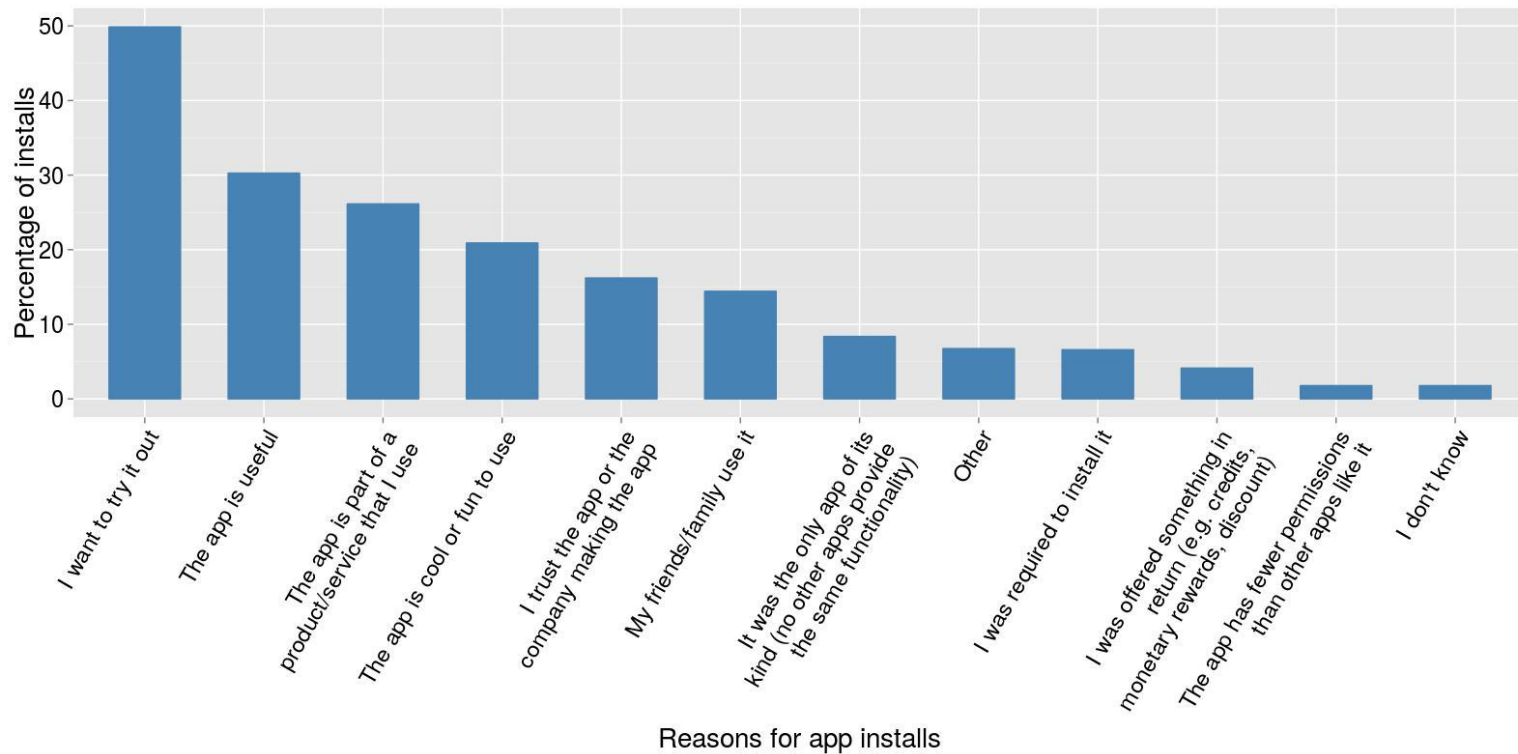
Additional slides (not used during presentation)



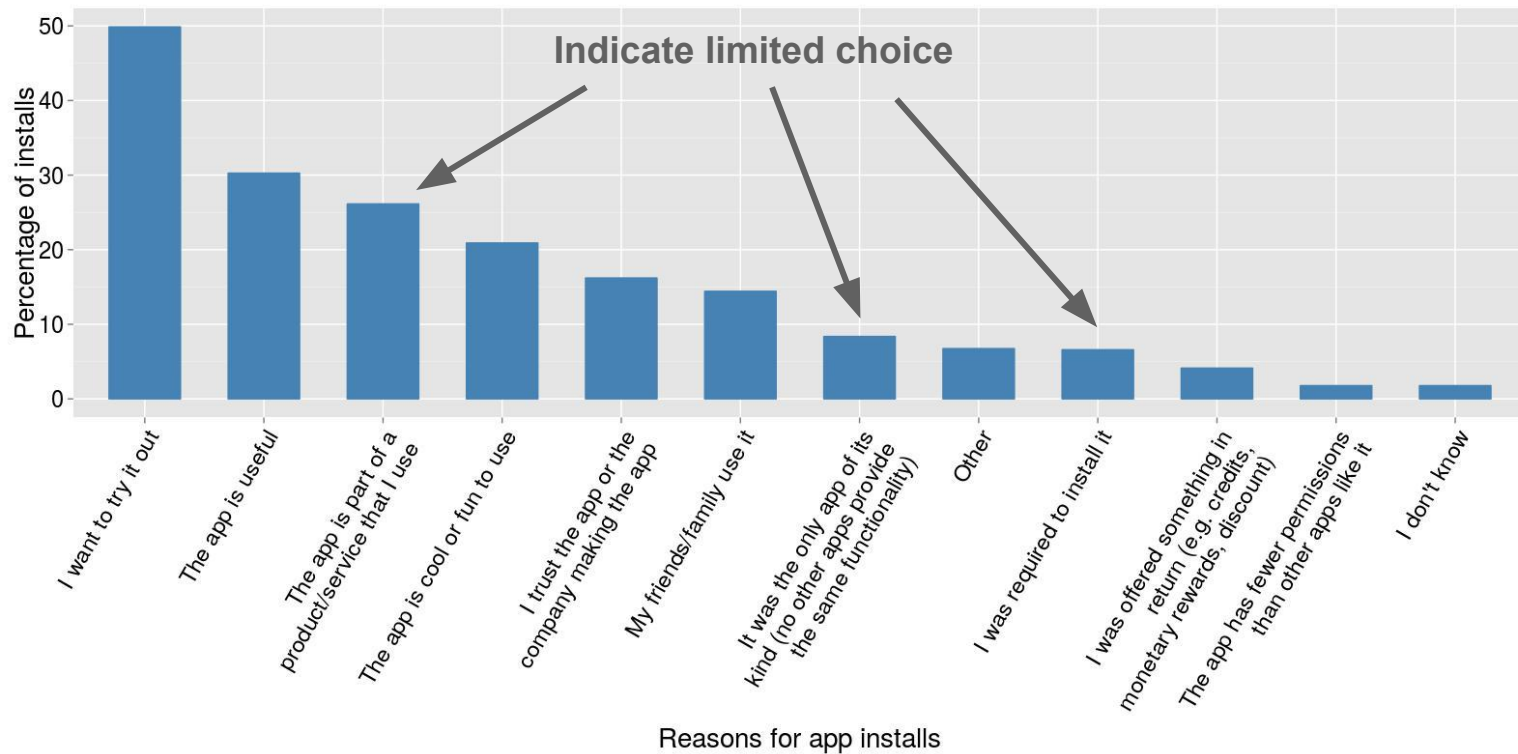
Ethical considerations

- Participants were informed of all data types collected before joining the experiment
- Participant responses were anonymized, thus no PII used in data analysis
- Data from participants who quit early was discarded
- We implemented E2E encryption in Paco, so data gathered is only available to those participating and those doing data analysis (us).

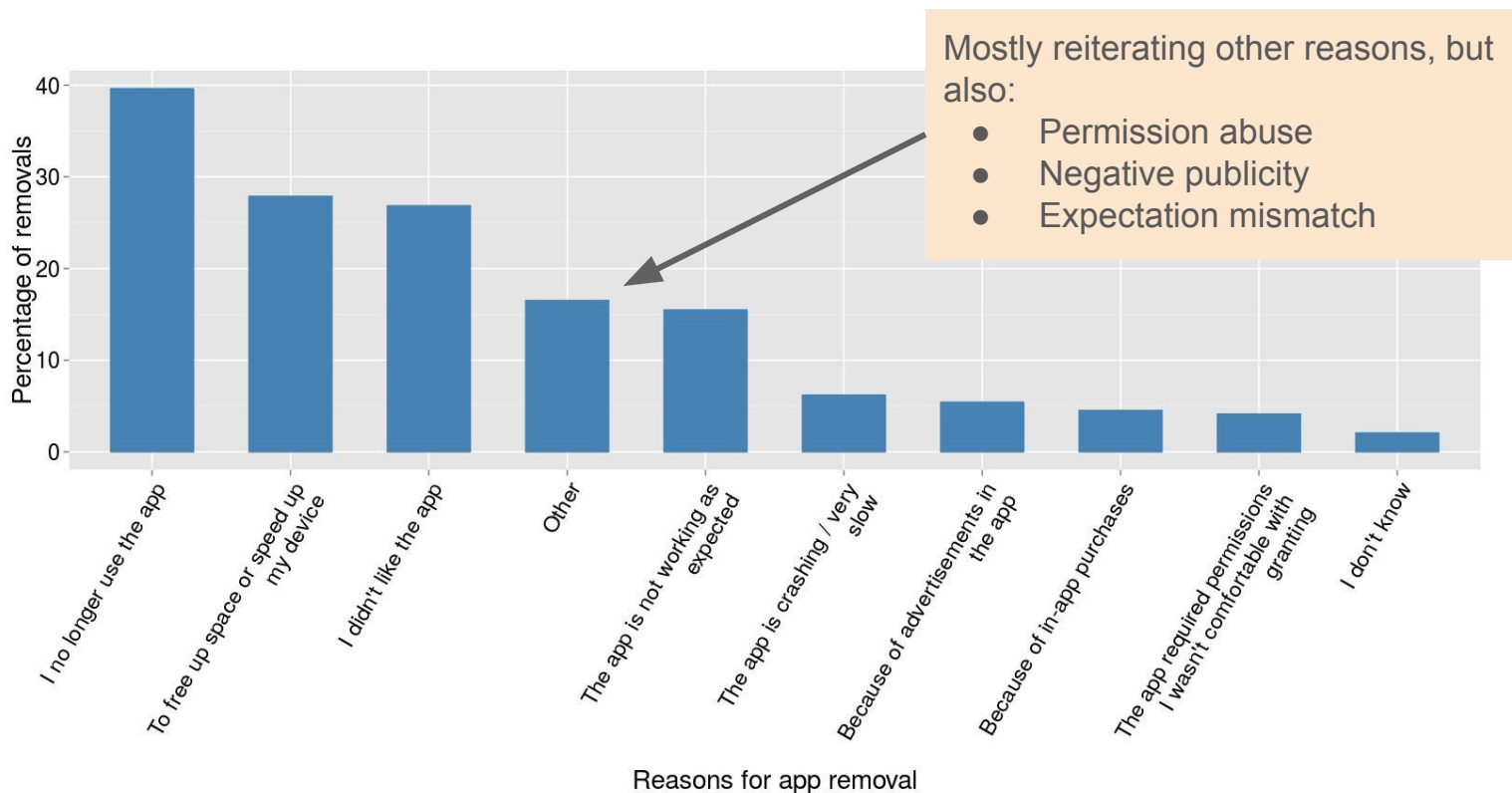
Reasons for installing an app



Reasons for installing an app



Reasons for removing an app



Participant employment data

Employment	Participants
Arts & Entertainment	8
Business & Finance	6
Education	8
Engineering	12
Health Care	12
Human Resources	2
Information Technology	14
Management	19
Miscellaneous	15
Religion	3
Retail & Sales	17
Retired	5
Self-Employed	6
Student	18
Undisclosed	5
Unemployed	7