A Large Scale Study of User Behavior, Expectations and Engagement with Android Permissions

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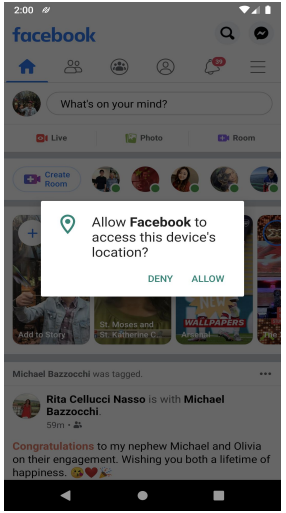
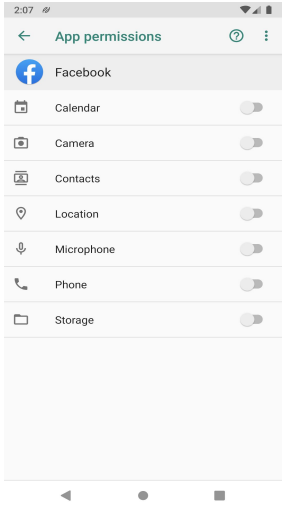
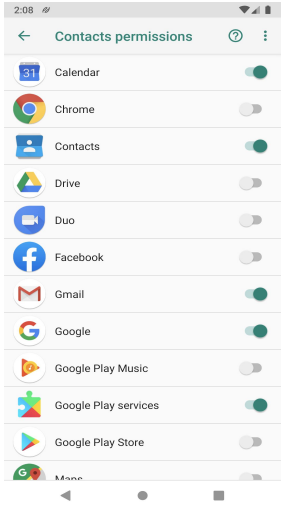
Controlling private data sharing with Android Permissions

Users choose what private data to share with app via Android permission system



Runtime permission request



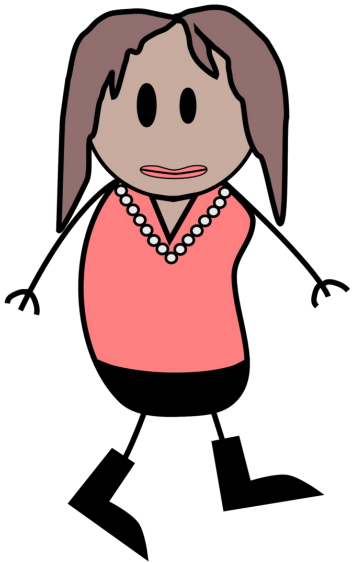


Android Settings menu

Many factors affect user's decision to deny a permission

Behaviors

Demographic



Expectations

Attitudes

Explanations

Goal: Study the interplay of all these factors; study the effect of one factor while controlling for others

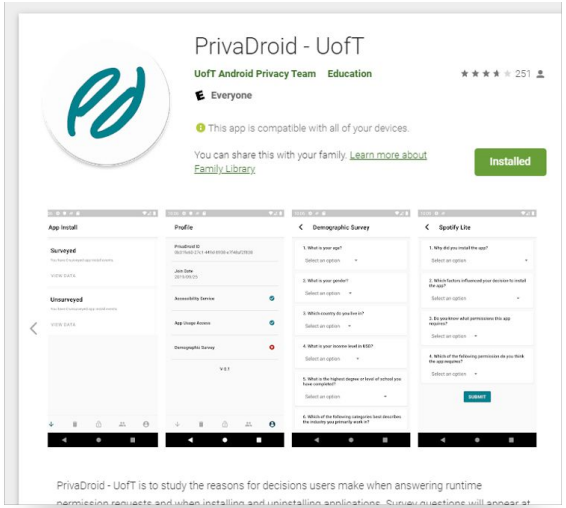
Challenge: collect these disparate types of data from the same individuals

Challenge: collect data from large, international set of participants

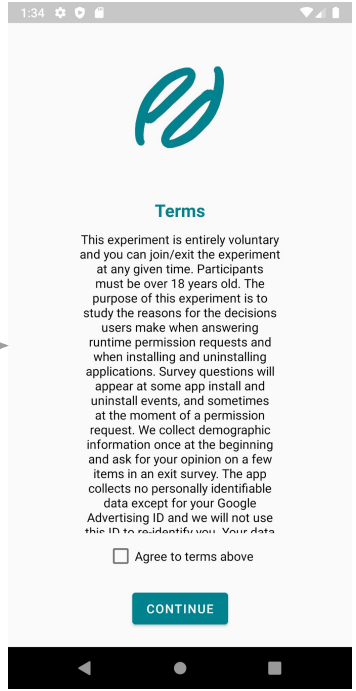
PrivaDroid as experiment tool

Online mobile Ad

Platforms



Google Play Store



PrivaDroid App

What do we collect

Demographics:
Gender, age, education, country/region

Behavior:
Grant/Deny decisions
Apps installed

Expectations:
Whether participants expected the permission request

Rationales:
Why participants granted or denied a permission

Explanations:
Apps' explanations in pre-prompts, for permissions

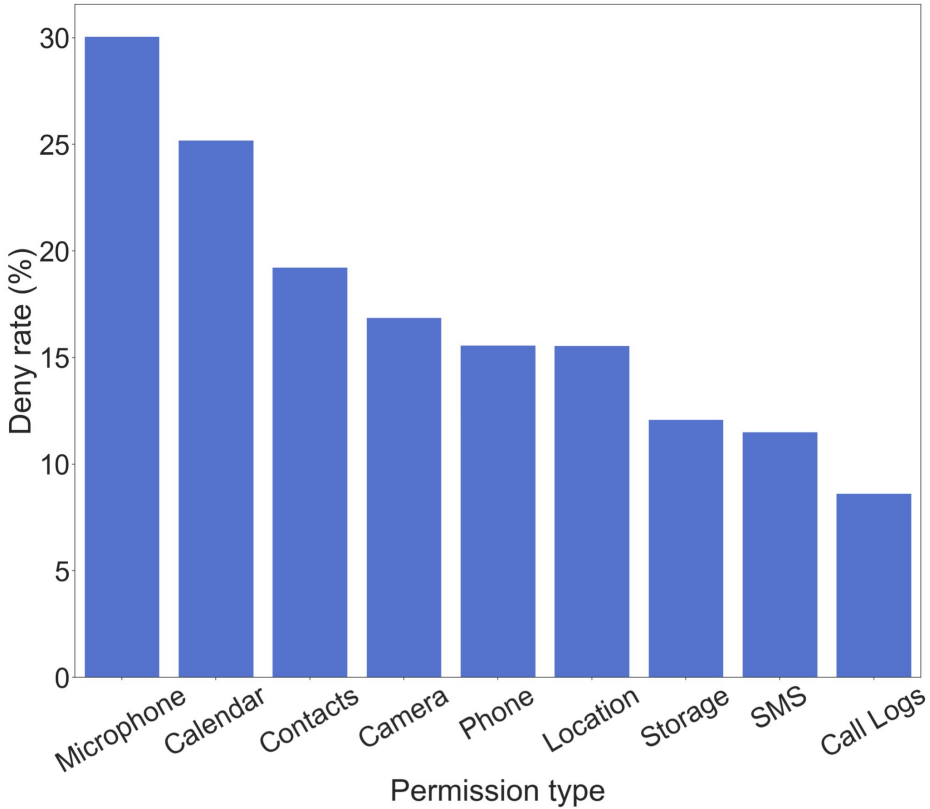
Attitudes:
Privacy sensitivity scores

Permission data summary

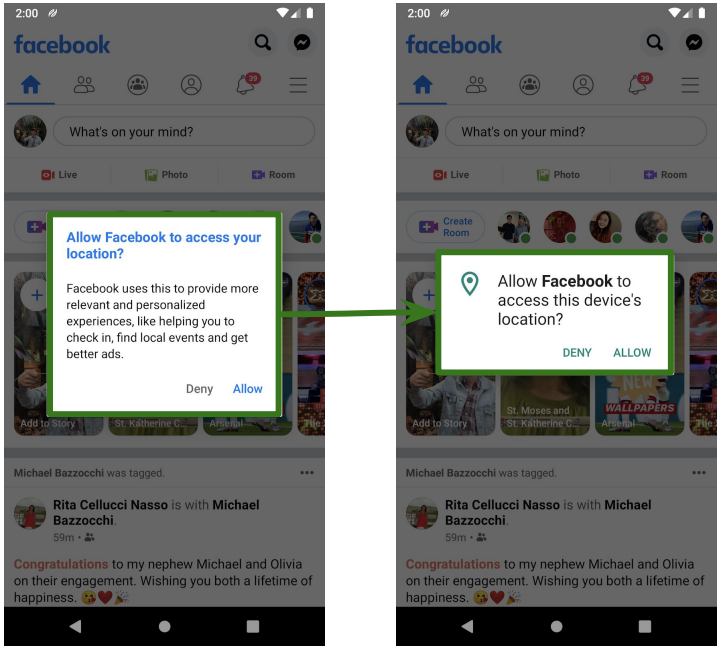
Study ran from Nov 2019 to May 2020

10 countries and regions, 1,719 participants

~36K permission decision events (30% surveyed) and overall 16.7% deny rate



Explanations



Explanation

Permission request

Explanation must have:

- A keyword about data collection, e.g. access, collect, etc.
- A keyword about a permission/resource type, e.g. camera, photos, etc.

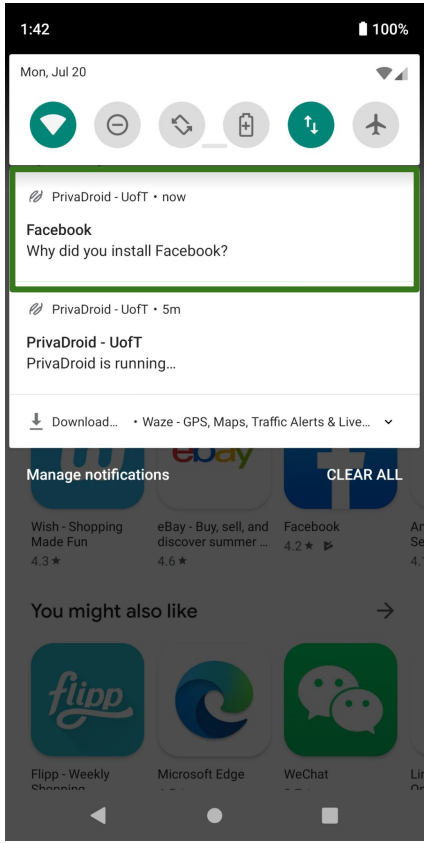
Deny rate 15.4% without explanation -> 7.1% with explanation

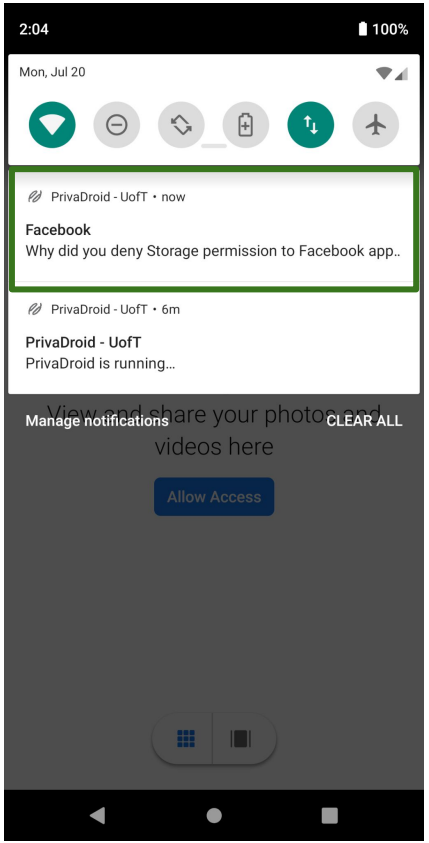
Mixed effects logistic regression (MELR) shows presence of explanation reduces deny rate

Expectations

Unexpected requests deny rate: 26.9%
Expected requests deny rate: 12.2%

MELR model shows unexpected runtime requests significantly increase likelihood that a user denies a permission. Model shows this is true even when controlling for other factors.





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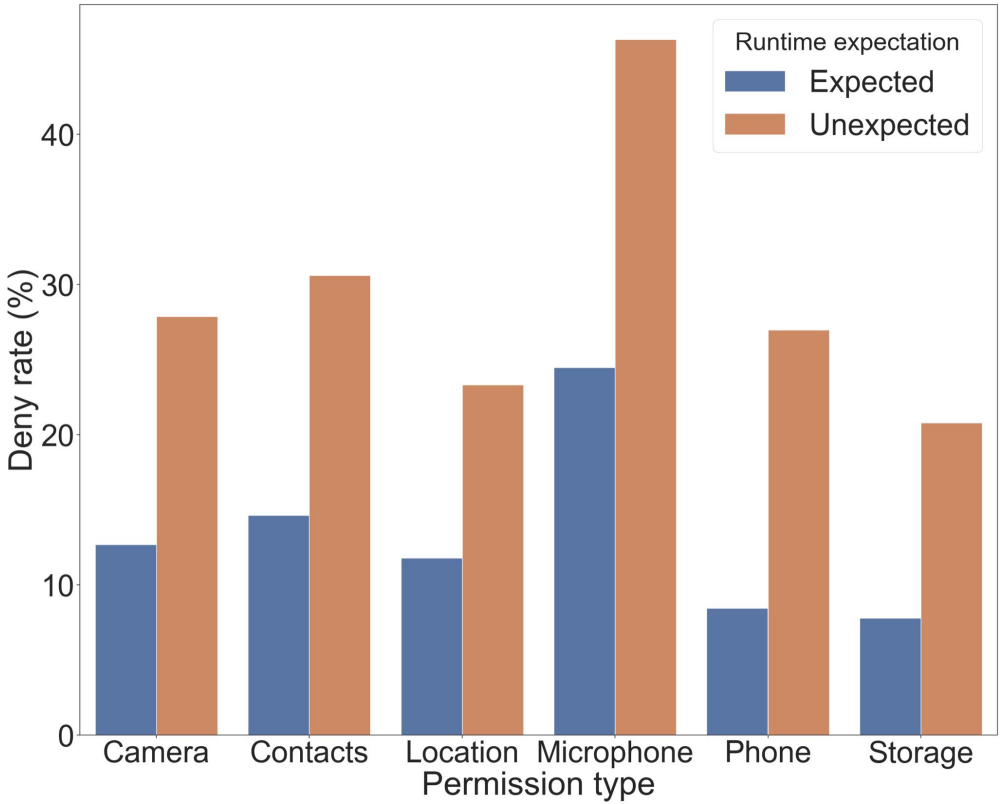
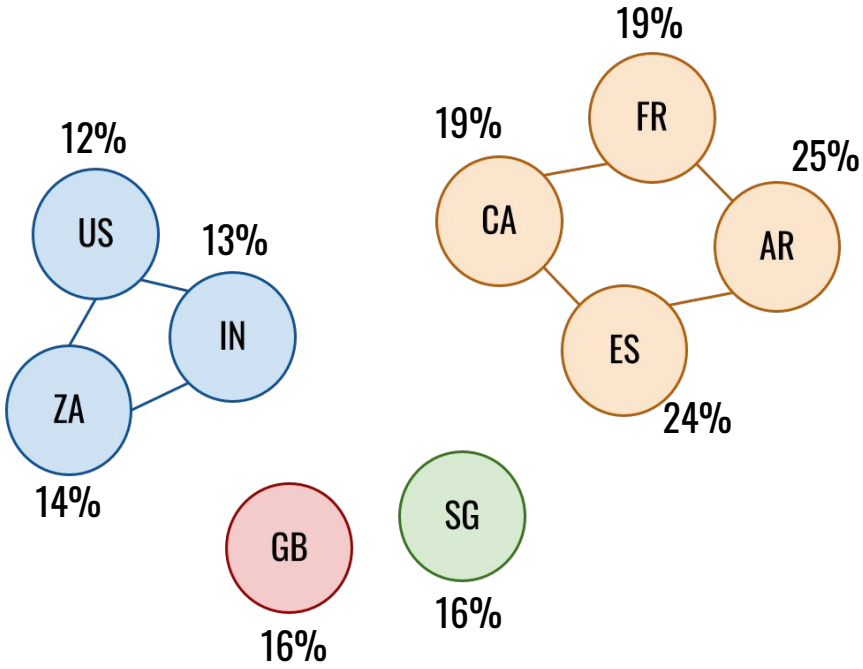


Cross country analysis

- Challenging to understanding country to country comparison
  - Privacy attitudes, cultural values, regulatory frameworks, etc.
  - Only observations about the participants in our study
- Deny rates and distribution
  - 2 distinct cliques of countries found via pairwise ANOVA tests on the deny rate distributions
  - Participants from countries in the same clique are drawn from populations with the same mean deny rates



HK is excluded because of not enough female participants

Factors influencing deny rate

- Mixed effects logistic regression model with 12 features
  - Privacy sensitivity (4)
  - Explanation (1)
  - Runtime expectation (1)
  - Whether permission decision is in Settings menu or runtime (1)
  - Demographic variables (4)
  - Permission type (1)
- Participant and app are included as random effects

Variable	Values	β Coefficient (p-value)
control	[-2, 2]	-0.044
awareness	[-2, 2]	0.109
collection	[-2, 2]	0.404 (***)
secondary_use	[-2, 2]	-0.264 (*)
has_explanation	Binary	-0.725 (***)
settings_menu	Binary	2.04 (***)
country/region (reference: US)	**Canada**	0.870 (***)
	Argentina	0.555 (***)
	UK	0.567 (***)
	France	0.795 (***)
	Spain	0.883 (***)
	South Africa	0.068
	India	0.118
	Singapore	0.42 (.)
gender (reference: Male)	Female	0.299 (**)

Variable	Values	β Coefficient (p-value)
age (reference: Below 30 years)	Between 30 and 50	-0.104
	Above 50	-0.006
education (reference: Bachelor's degree)	**Less than high school**	-0.249 (*)
	High school or equivalent	-0.193
permission (reference: Location)	Calendar	0.259
	Camera	0.011
	Contacts	0.258 (**)
	Microphone	0.606 (***)
	Phone	-0.093
	SMS	-0.265
	Storage	-0.379 (***)
runtime_expected (reference: Yes)	No	1.216 (***)
	Not surveyed	0.306 (***)

Random Effect	Variance
App (intercept)	1.889
User (intercept)	1.785

Significance codes:
p < 0.001 (***),
p < 0.01 (**),
p < 0.05 (*),
p < 0.1 (.)

Limitations

- Selection Bias: Participants more likely to
  - Respond to mobile advertising
  - Be tolerant to data collection by a mobile app
  - Be incentivise by financial rewards
- Incomplete visibility:
  - Can’t see events for apps before study period, such as pre-installed or popular apps
  - Not enough data to analyze behaviors of individual apps

Conclusions

- Mobile advertising effective in recruiting participants
- Including rationales for permissions benefits the apps by reducing deny rate by more than half (7.1% vs 15.4%)
- Both install-time and runtime expectations affect users permission decisions
  - this is true regardless of demographics and permission type
- Participant demographics, their privacy attitudes, expectations, explanations and permission types all play a role in permission denial decision

Thank you!