

Away From Prying Eyes: Analyzing Usage & Understanding of Private Browsing

Hana Habib, Jessica Colnago, Vidya Gopalakrishnan,
Sarah Pearman, Jeremy Thomas, Alessandro Acquisti,
Nicolas Christin, Lorrie Faith Cranor



Incognito



InPrivate



Private Browsing





Users have misconceptions about private browsing

- Prevents all tracking from websites and advertising companies (Gao WPES'14)
- Prevents search engines from recording searches (DuckDuckGo 2017)

Are these misconceptions
putting users at risk?

Combining empirical data with a survey

What does private browsing look like in the wild?

How does observed browsing behavior differ from reported behavior?



Methodology

We conducted an empirical analysis of browsing behaviors

- Data collected through the Security Behavior Observatory (SBO)¹
- Collects metadata from home computers related to:
 - system events
 - installed software
 - browsing activities
- Analyzed data captured by Chrome + Firefox extensions

¹sbo.cs.cmu.edu/

A lot of data collected over 3 years

451
SBO participants

41% used private browsing

167,128
browsing sessions

4% had private browsing

Manually annotated private browsing sessions

- Identified 15 common use cases
- 25% of sessions annotated by two researchers ($\kappa = 0.81$)
- Remaining sessions single-coded

Compared normal browsing and private browsing activities



Domains & Domain
Categories



Search Engine
Queries



YouTube Videos
Viewed

Followed up with survey to SBO + MTurk

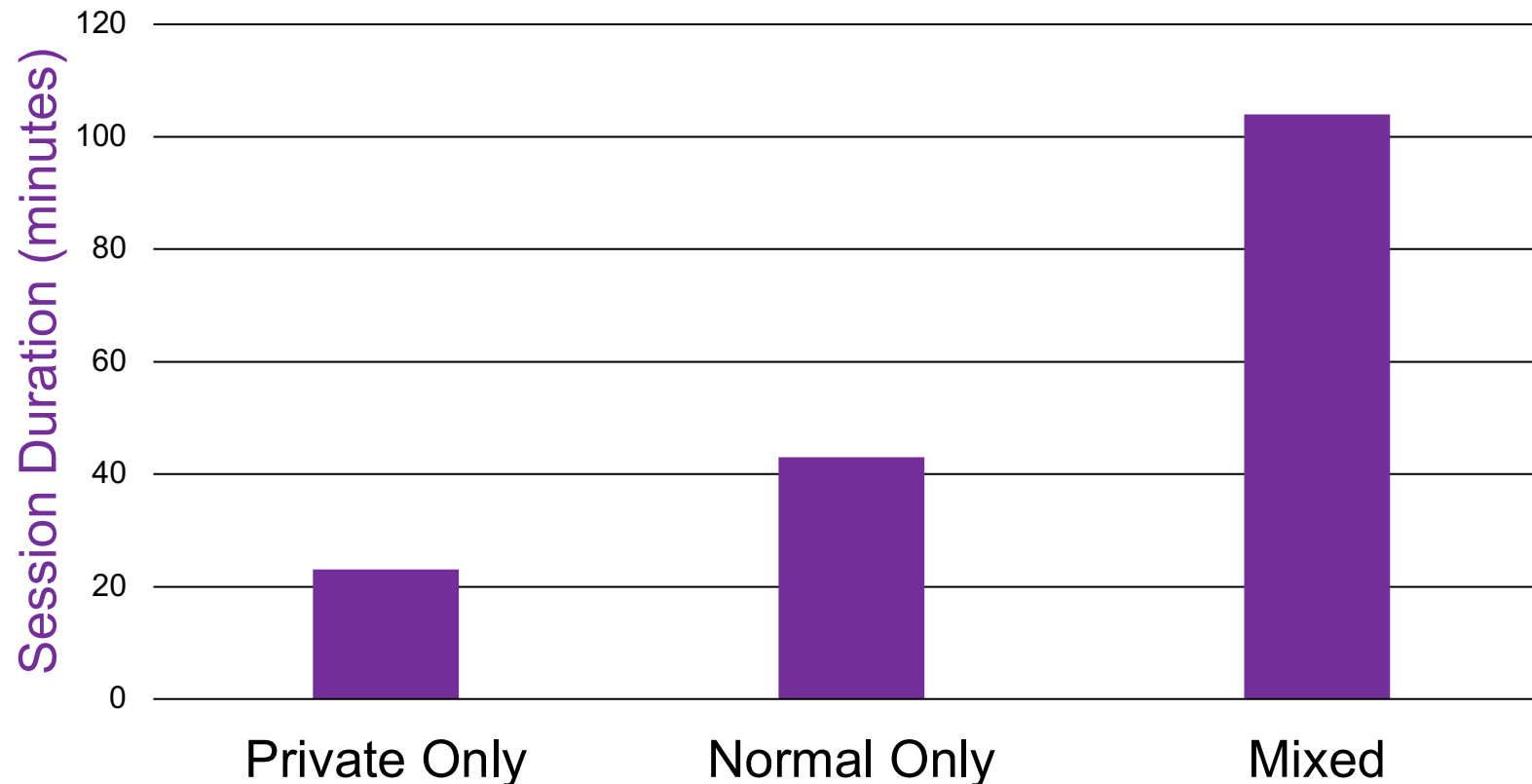
- Common use cases for private browsing
- Why private browsing is used for certain use cases
- Users' understanding of private browsing

Demographic differences between survey populations

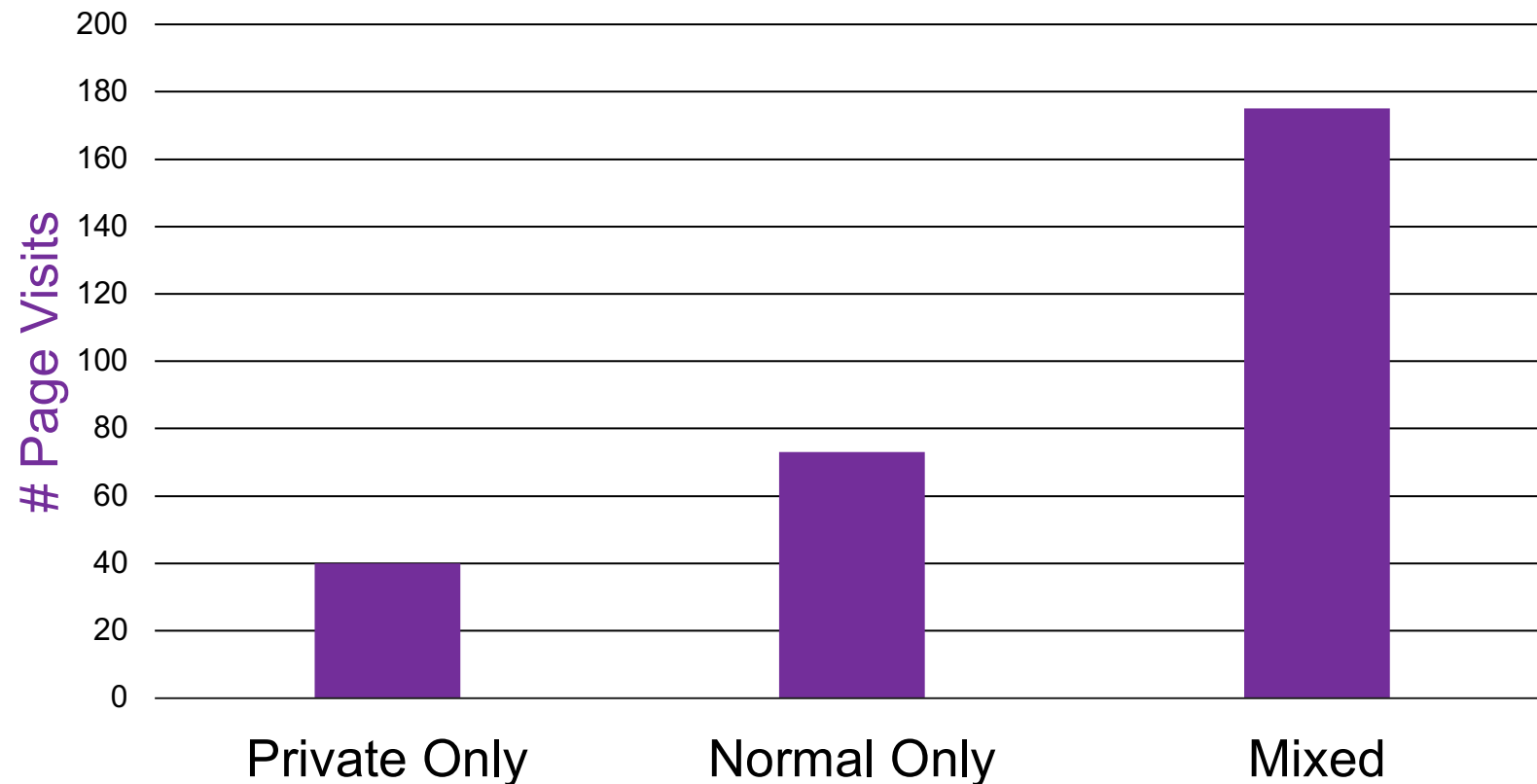
	SBO (n = 227)	Mturk (n = 305)
Female	61%	43%
Age \geq 65	10%	1%
Graduate degree	34%	8%
Technical	25%	16%
Mean IUIPC control, awareness, collection	4.4 – 5.8	5.6 – 6.2
Private browsing users	73%	91%

Results

Private browsing typically interspersed with normal browsing



Private browsing typically interspersed with normal browsing



Private browsing not just for porn

Use Case	% of private browsing sessions
Log into service	38%
General browsing	37%
General searches	33%
Access adult content	24%
Stream audio/video	19%

Observed in 5-15% of sessions: visits to social media, shopping, searches for adult-content, sensitive browsing/searches

Private browsing contains higher proportion of sensitive activities

■ Private browsing mode ■ Normal browsing mode

Search engine queries

- Adult content → 12% vs 0.5%
- Health related → 3% vs 0.4%



Private browsing contains higher proportion of sensitive activities

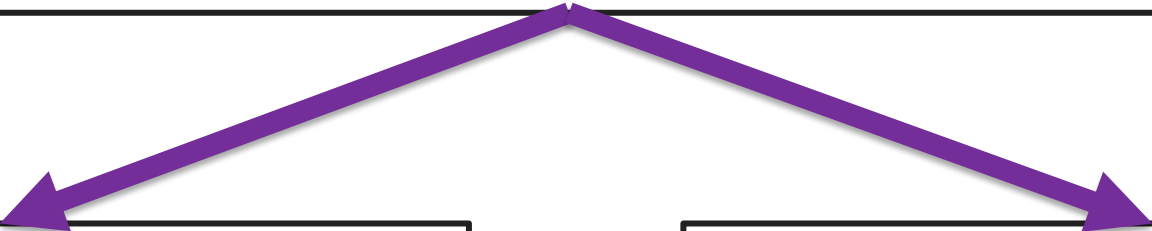
YouTube videos

- (proportionally) 3x as many violated policy on nudity/sexual content
- (proportionally) 2x as many had content warnings



Reported vs observed private browsing

39% of SBO survey respondents reported using private browsing but did not contribute private browsing activity to the SBO



58% used private browsing on someone else's computer

62% used private browsing on their mobile device

Empirical data consistent with self-reports

- Top use cases similar:
 - Searches
 - Adult content
 - Logging into a service
- Only 4 participants had significant unreported private browsing activities

Participants had various reasons for using private browsing

Practical

- Avoid price discrimination
- Prevent unwanted video recommendations


“[private browsing] lets me think I am seeing ‘real’ prices for tickets/items instead of prices generated for me...”

“I don’t want my browsing history dictating what videos I might want to watch ”

Participants had various reasons for using private browsing

Security

- Keep passwords and personal information safe
- Protection from malicious activity



Online Event Registration

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First Name Last Name

Address

City State ZIP Code

City State ZIP Code

Participants had various reasons for using private browsing

Privacy threats:

- Web tracking
- Targeted advertising

Most were concerned about other users of the device

Major misconceptions about anonymity and cookies

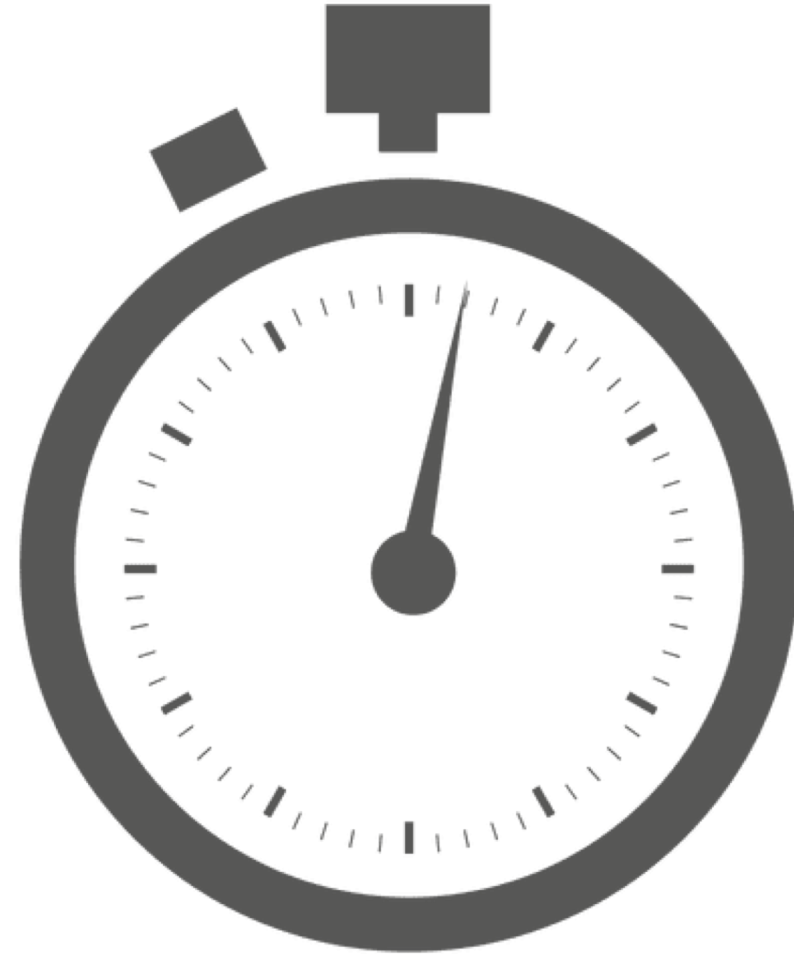
75% thought private browsing prevents cookies from being sent to websites

48% thought private browsing encrypts web traffic

41% thought private browsing hides their IP address

Design Recommendations

**Automatically time out
private browsing windows**



Actively diffuse misconceptions

- Browser landing-page disclosures (Wu WWW'18)
- Just-in-time notices



Takeaways

- Private browsing small percentage of all activities
- Private browsing used for practical purposes, as well as privacy/security
- Participants had many misconceptions
- ...

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