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
• Browsing history
• Form data
• Most cookies
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

<table>
<thead>
<tr>
<th></th>
<th>SBO (n = 227)</th>
<th>Mturk (n = 305)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>61%</td>
<td>43%</td>
</tr>
<tr>
<td>Age ≥ 65</td>
<td>10%</td>
<td>1%</td>
</tr>
<tr>
<td>Graduate degree</td>
<td>34%</td>
<td>8%</td>
</tr>
<tr>
<td>Technical</td>
<td>25%</td>
<td>16%</td>
</tr>
<tr>
<td>Mean IUIPC control, awareness, collection</td>
<td>4.4 – 5.8</td>
<td>5.6 – 6.2</td>
</tr>
<tr>
<td>Private browsing users</td>
<td>73%</td>
<td>91%</td>
</tr>
</tbody>
</table>
Results
Private browsing typically interspersed with normal browsing

![Session Duration (minutes)]

- Private Only
- Normal Only
- Mixed
Private browsing typically interspersed with normal browsing
Private browsing not just for porn

<table>
<thead>
<tr>
<th>Use Case</th>
<th>% of private browsing sessions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Log into service</td>
<td>38%</td>
</tr>
<tr>
<td>General browsing</td>
<td>37%</td>
</tr>
<tr>
<td>General searches</td>
<td>33%</td>
</tr>
<tr>
<td>Access adult content</td>
<td>24%</td>
</tr>
<tr>
<td>Stream audio/video</td>
<td>19%</td>
</tr>
</tbody>
</table>

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

- 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
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
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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