User Awareness and Behaviors Concerning Encrypted DNS Settings in Web Browsers

Alexandra Nisenoff, **Ranya Sharma**, Nick Feamster

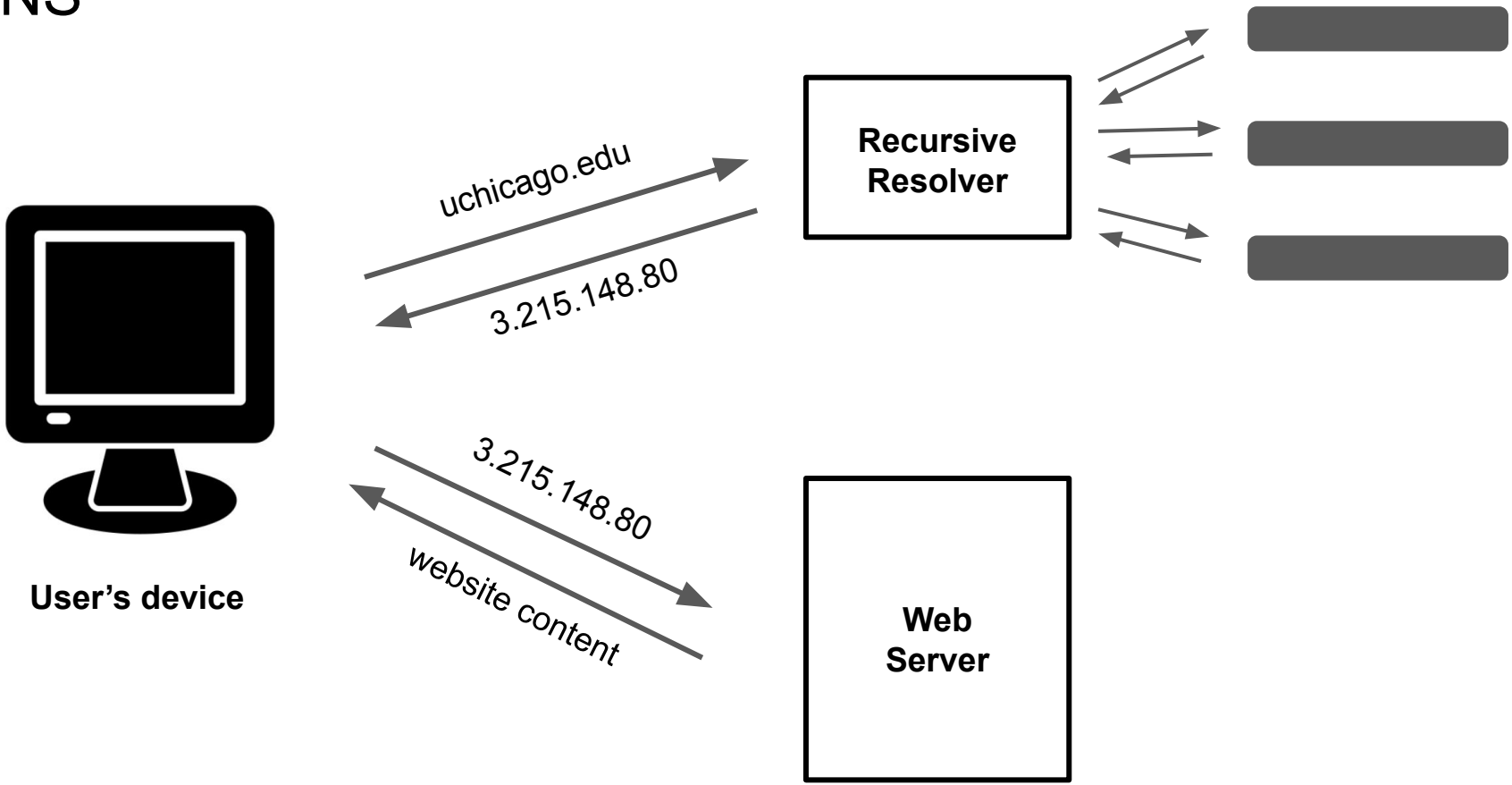
Carnegie Mellon University

Motivation

- Current encrypted DNS ecosystem has a power imbalance
  - Interferes with technical design

- Design choices affect
  - Market consolidation
  - User privacy
  - User experience

DNS

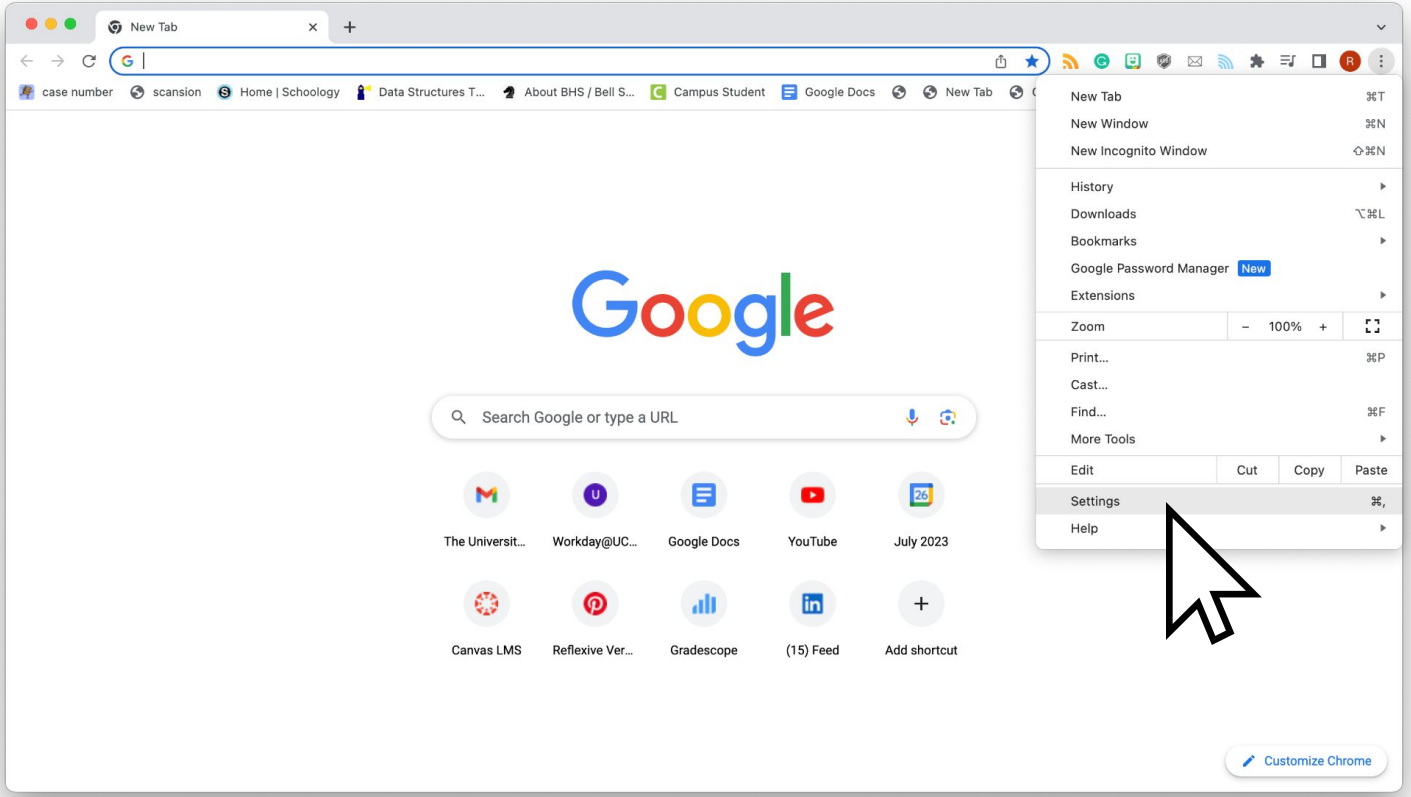

uchicago.edu
3.215.148.80
Recursive Resolver
3.215.148.80
website content
User's device
Web Server

Our Study

Browsers

Mobile Operating Systems

Encrypted DNS in Chrome



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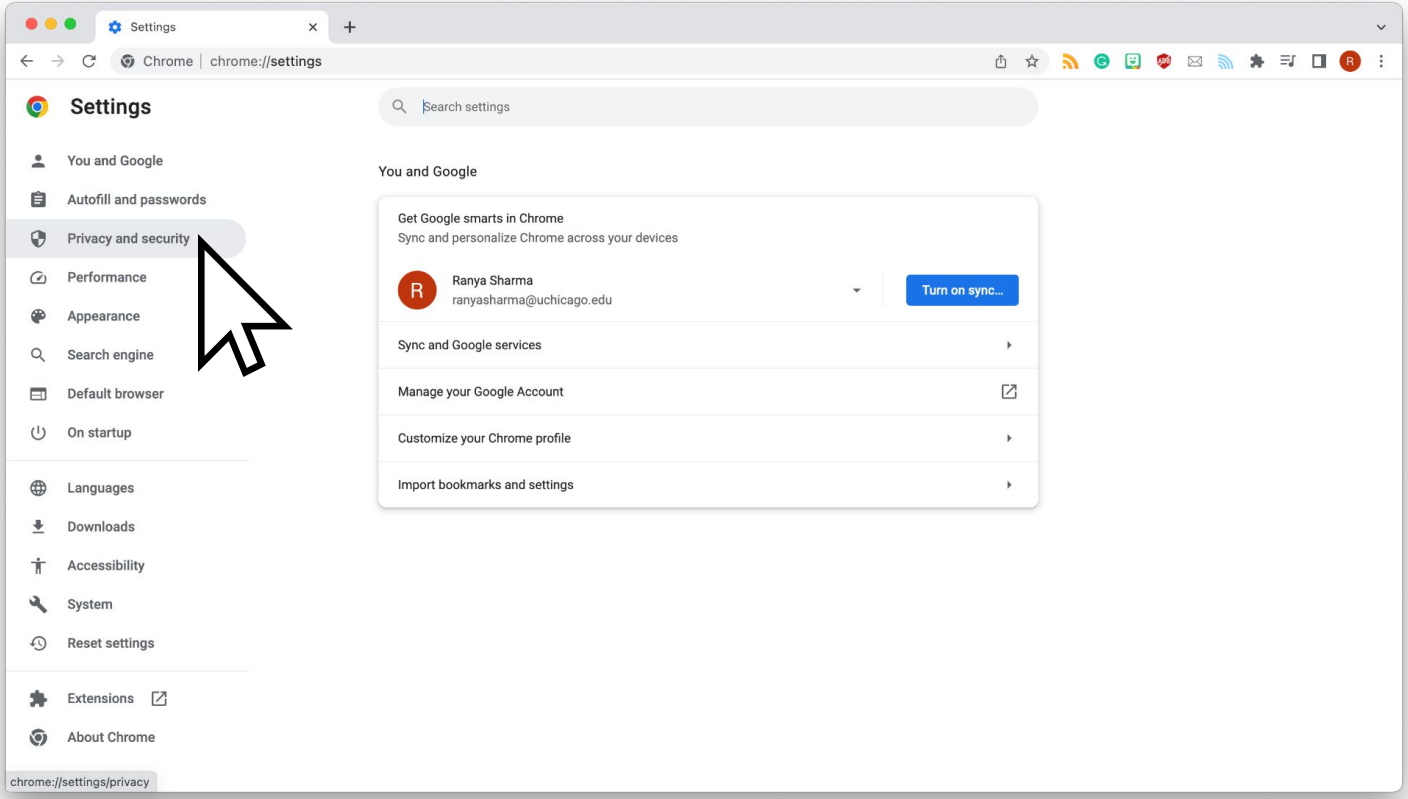

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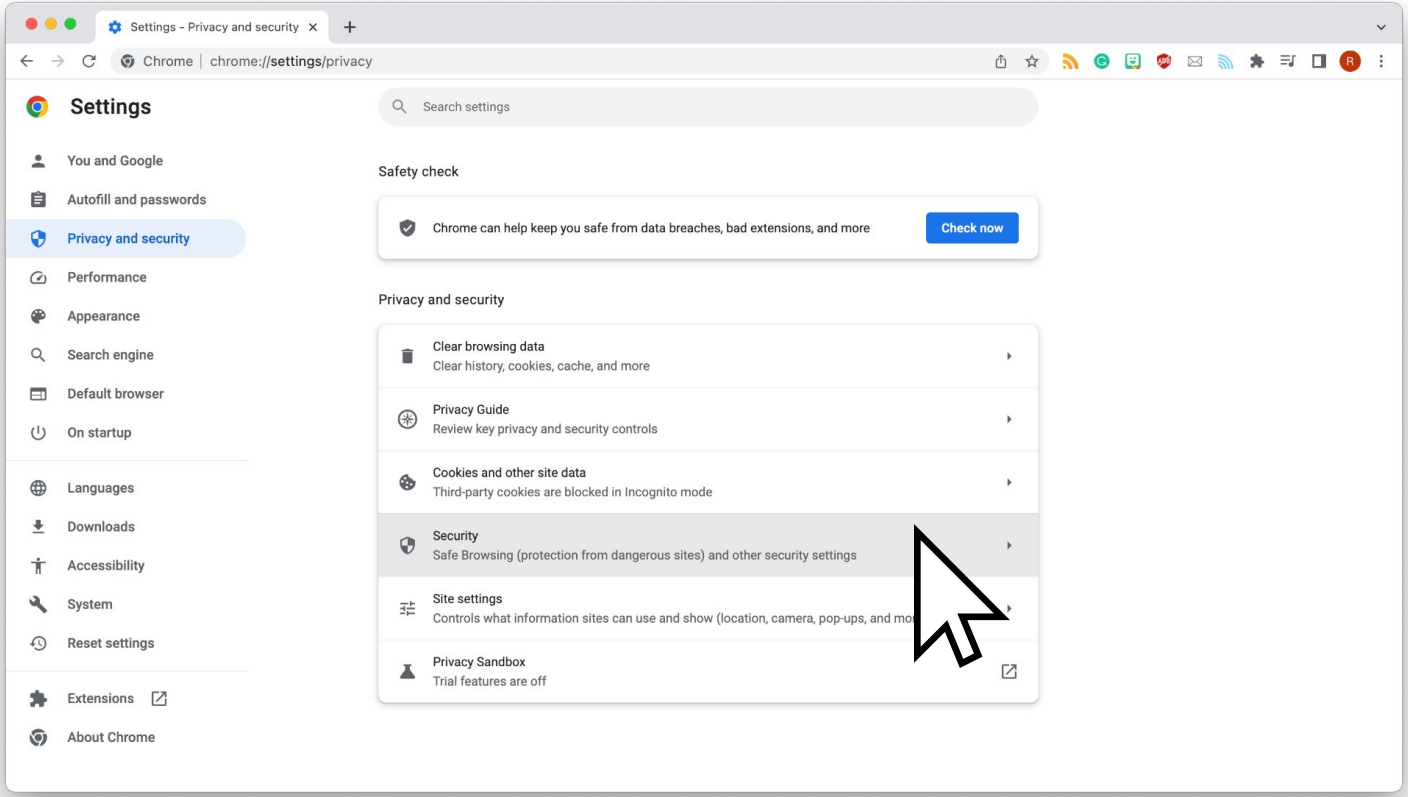

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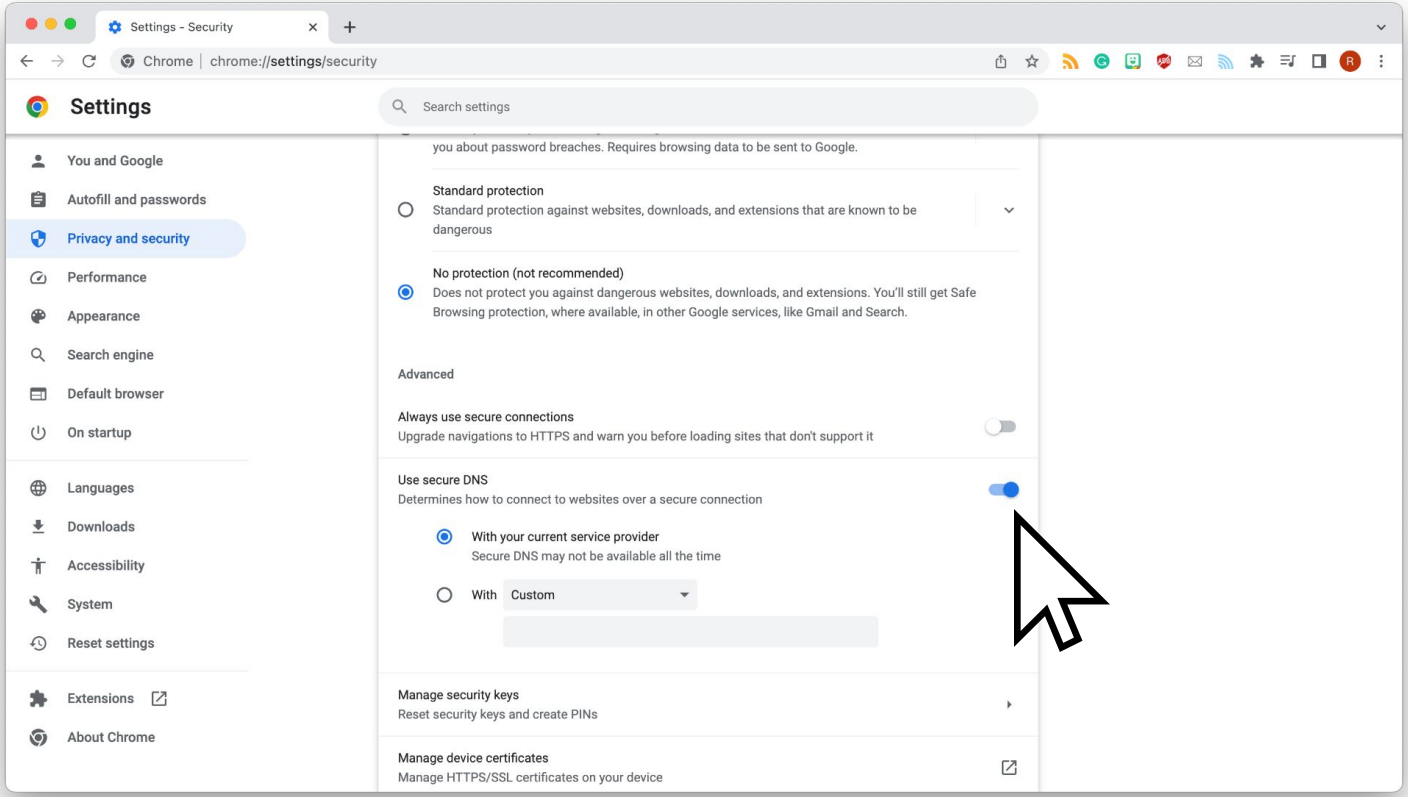

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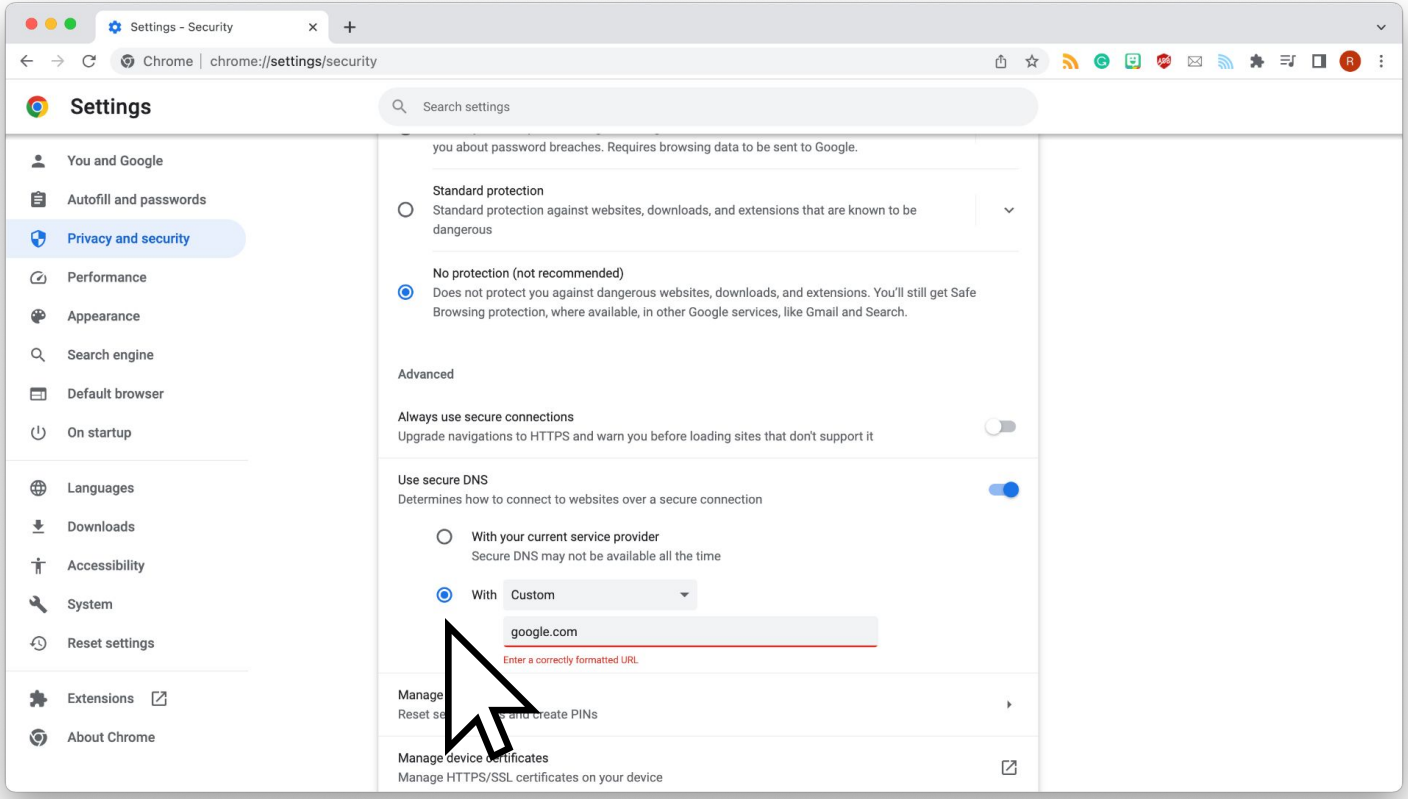

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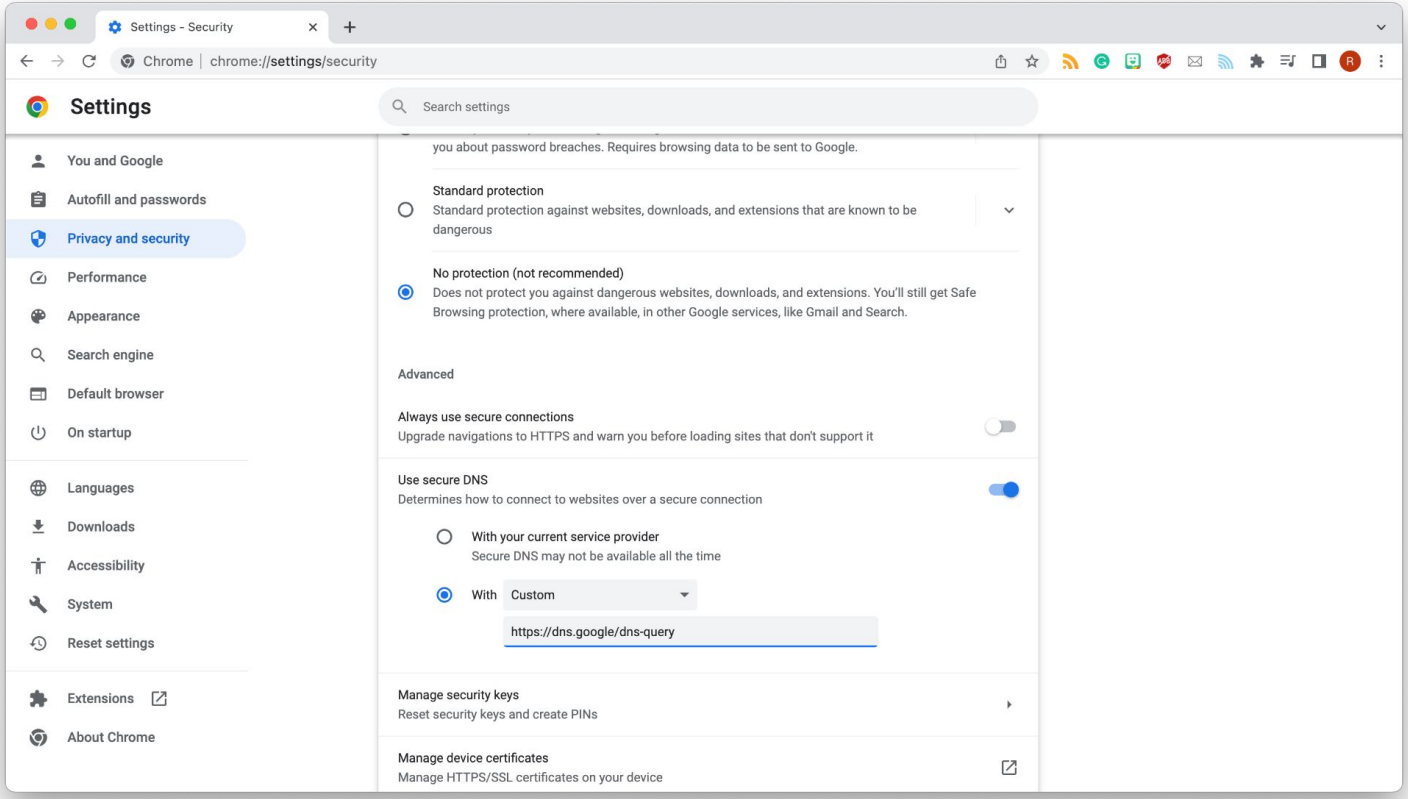
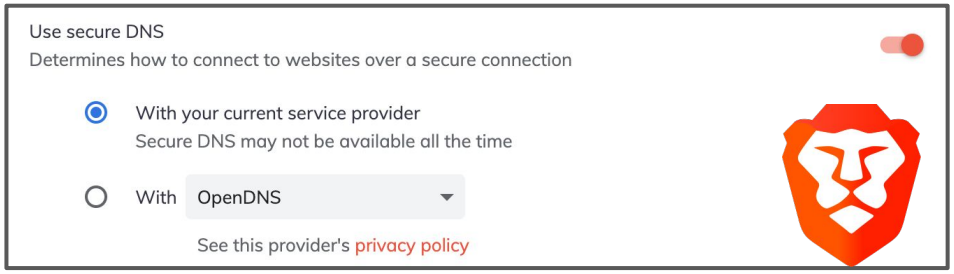
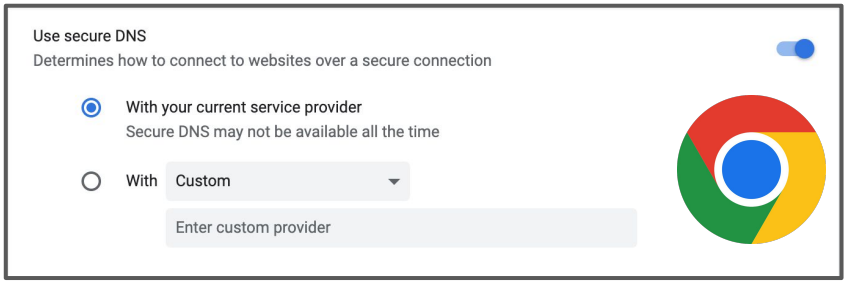
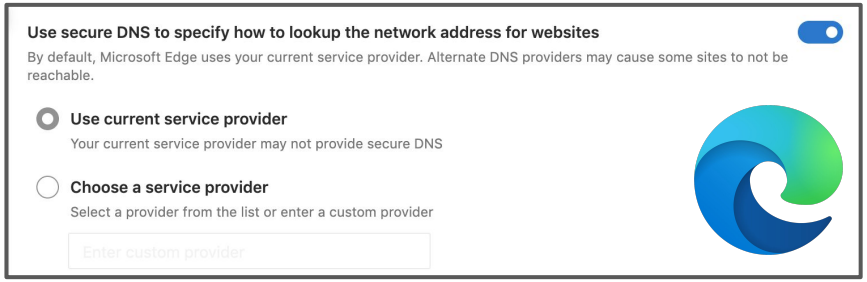
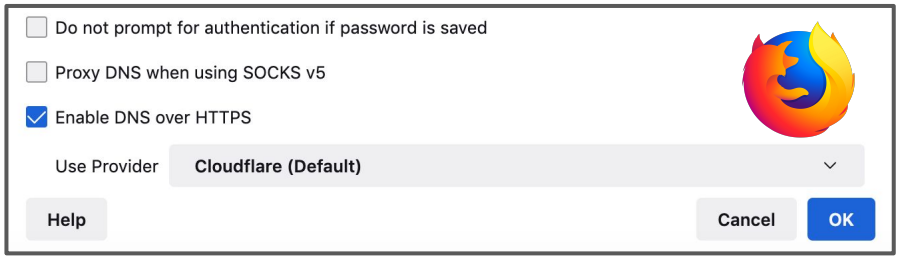


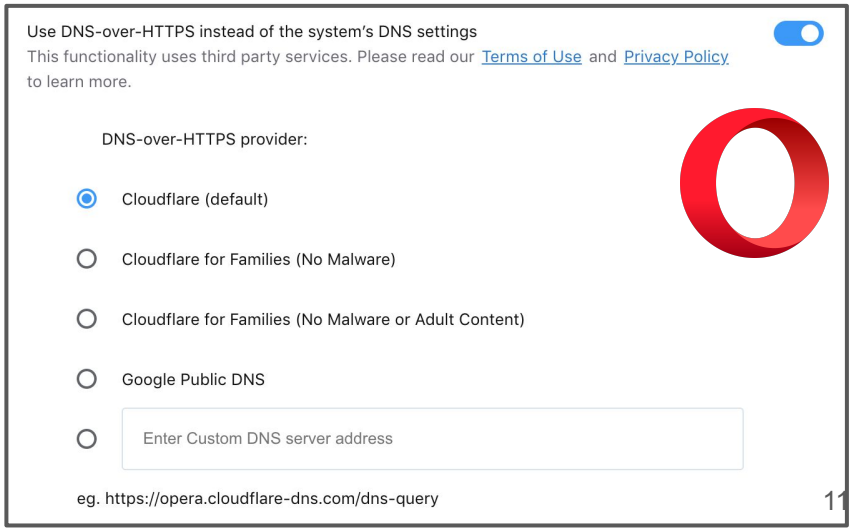
Enabling DNS-over-HTTPS



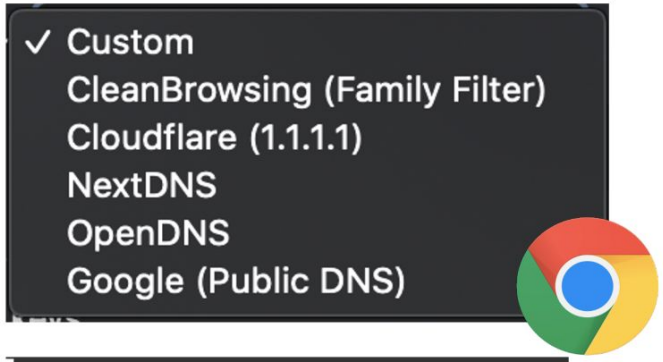


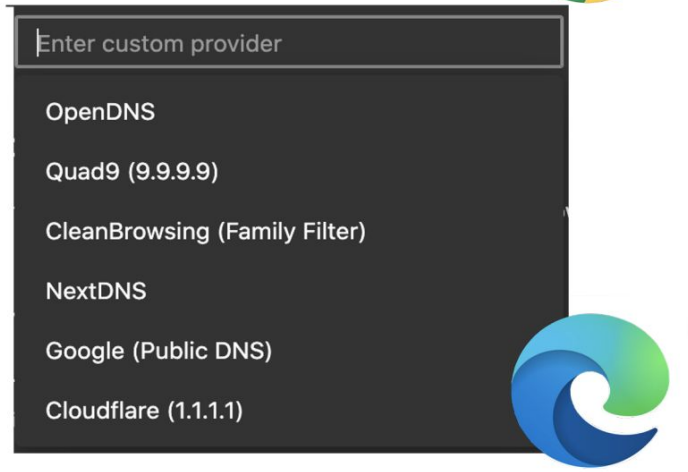


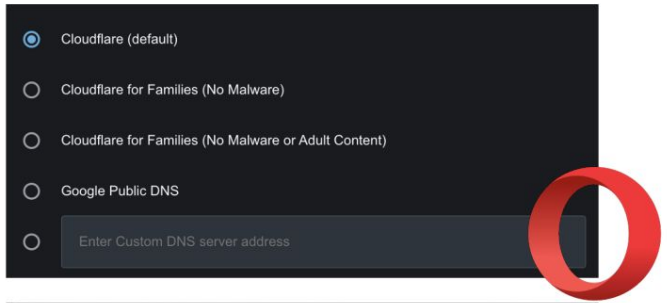


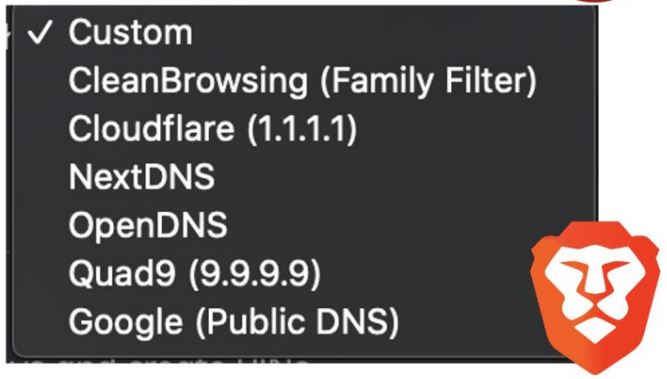


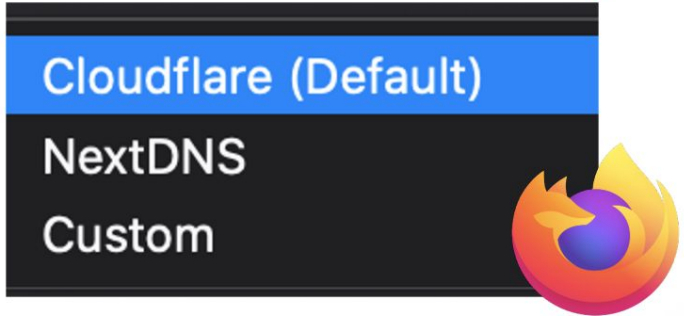
Choosing a Trusted Resolver











Research Questions

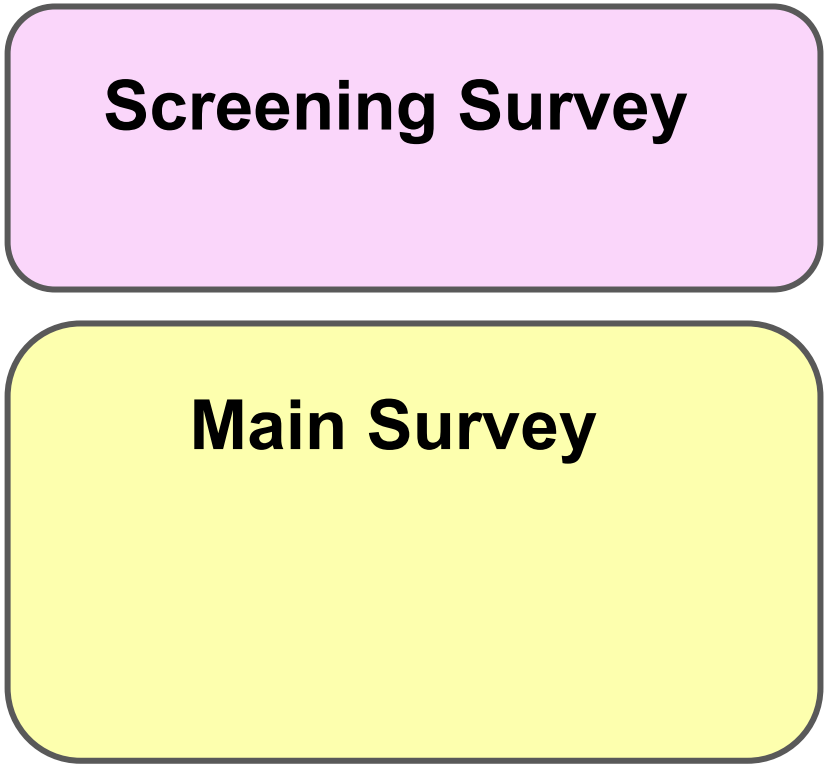
1. Are users **aware** of encrypted DNS settings in browsers and devices?

2. What encrypted DNS settings do users have **enabled**?

3. When **shown** encrypted DNS **settings** for different browsers, **which** settings **do users select**?

4. When the **technical aspects** of these systems are **explained** to users, how do their choices of settings **change**?

Our Study Methods



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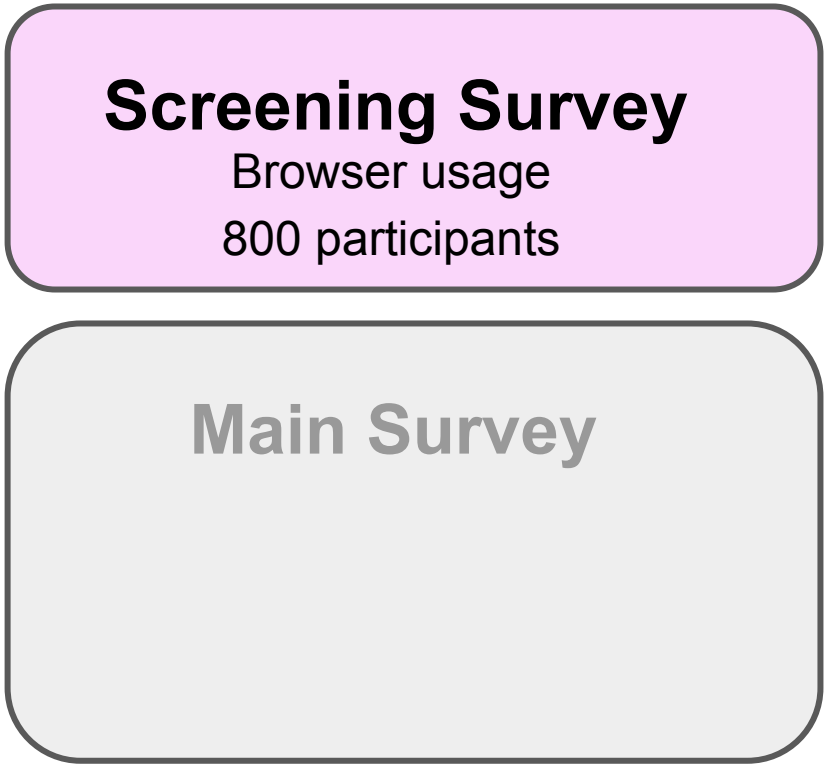


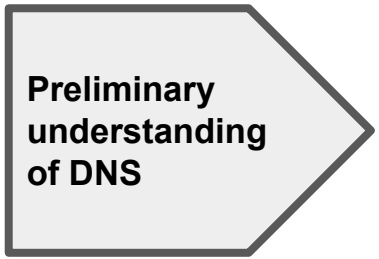
Our Study Methods

Screening Survey

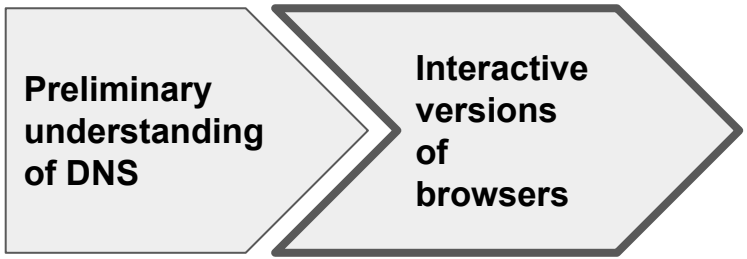
Main Survey

- 184 participants
- Participants assigned to subgroups
- Up to 50 participants from each subgroup participate in main survey

Main Survey



Main Survey



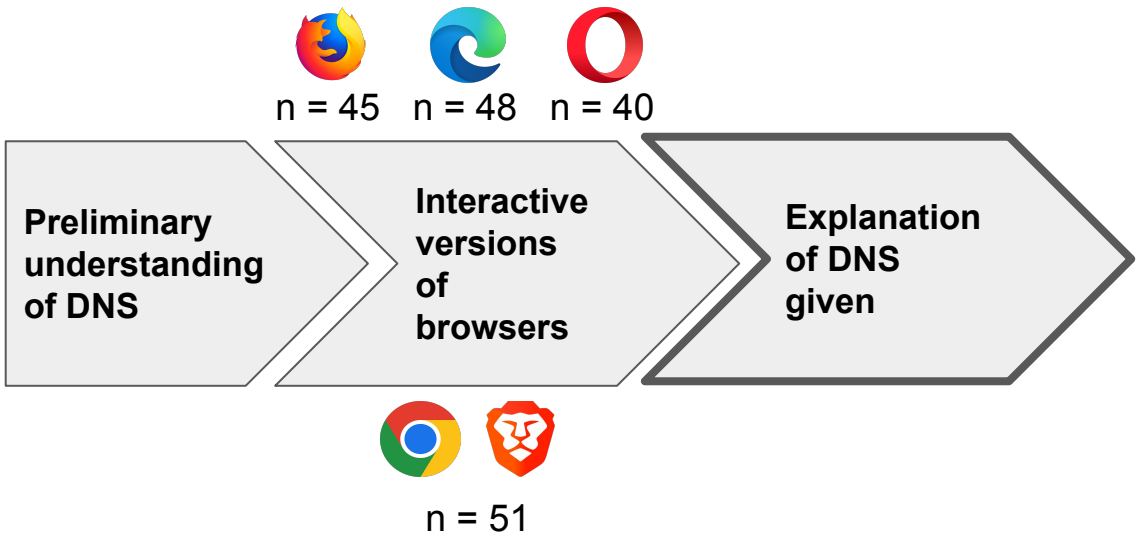
n = 45

n = 51

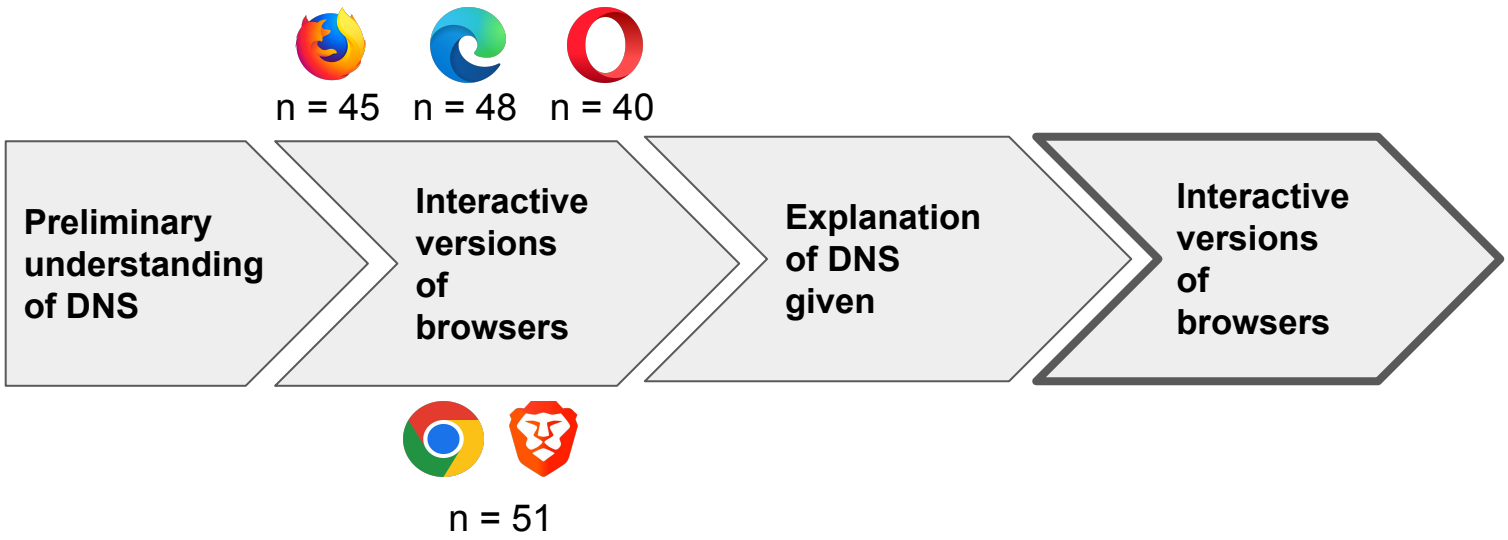
n = 48

n = 40

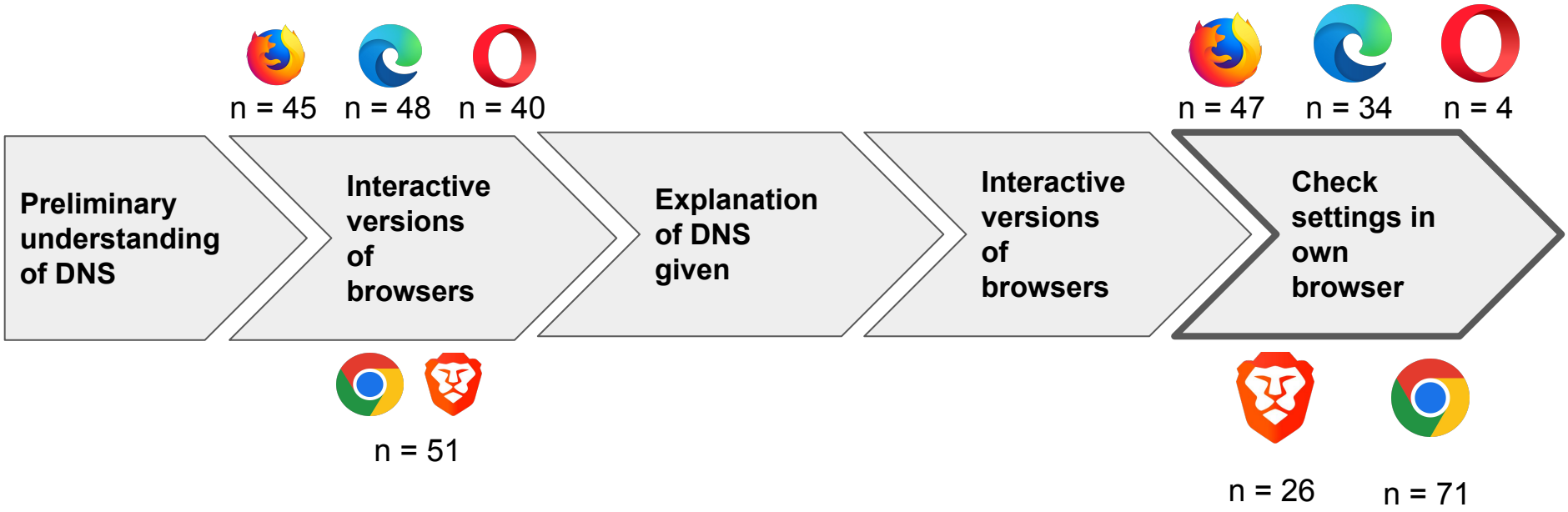
Main Survey


n = 45
n = 48
n = 40
Preliminary understanding of DNS
Interactive versions of browsers
Explanation of DNS given
n = 51

Main Survey

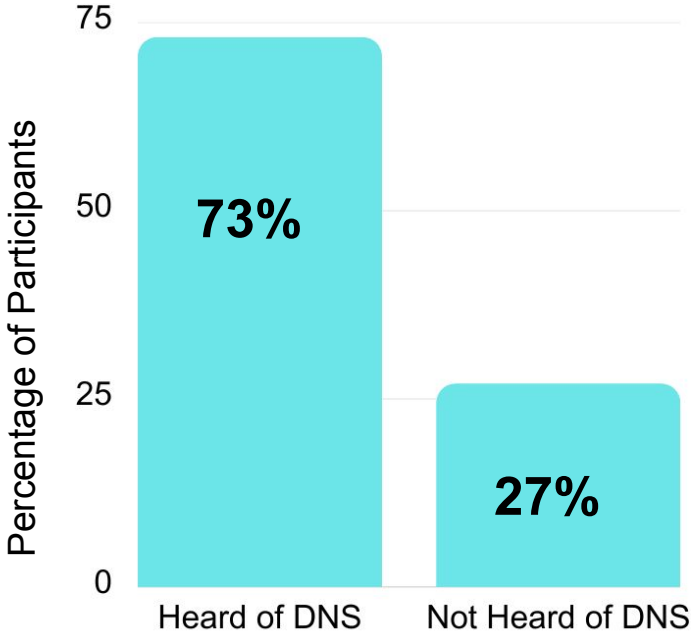

n = 45
n = 48
n = 40
Preliminary understanding of DNS
Interactive versions of browsers
Explanation of DNS given
Interactive versions of browsers
n = 51

Main Survey

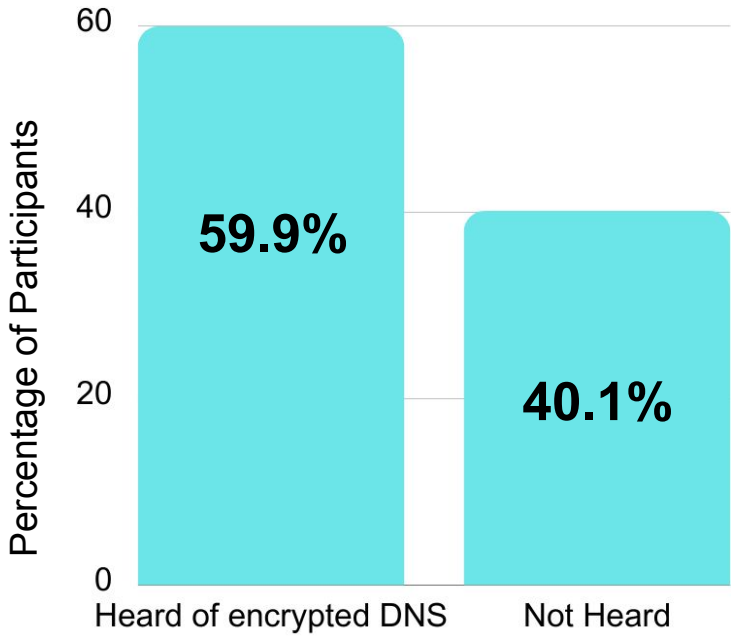

n = 45
n = 48
n = 40
n = 47
n = 34
n = 4
Preliminary understanding of DNS
Interactive versions of browsers
Explanation of DNS given
Interactive versions of browsers
Check settings in own browser
n = 51
n = 26
n = 71

Are users aware of encrypted DNS settings?

High percentage of participants reported **having heard of DNS** prior to the survey



Of the participants who reported **having heard of DNS**, more than half had heard of **encrypted DNS**.



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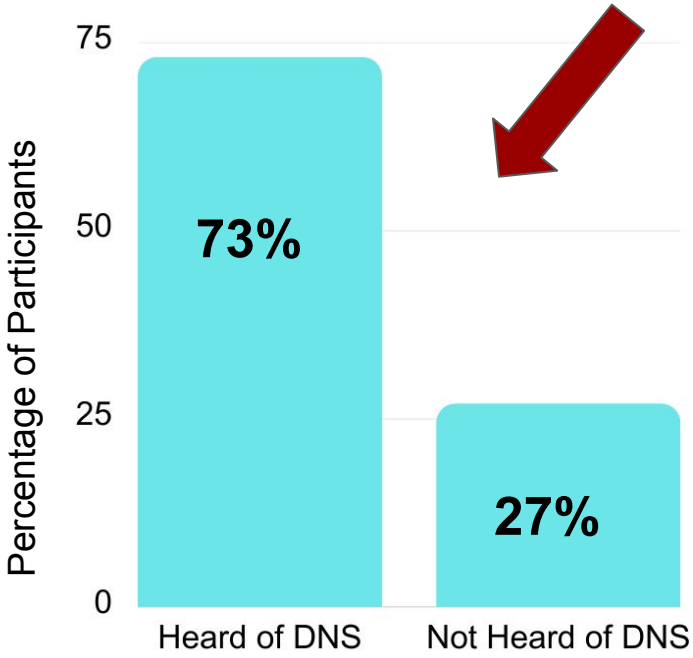

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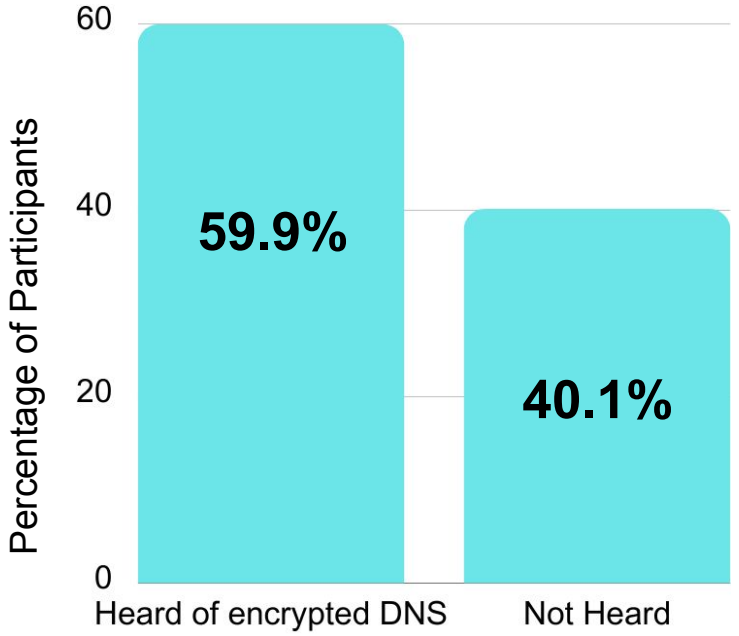

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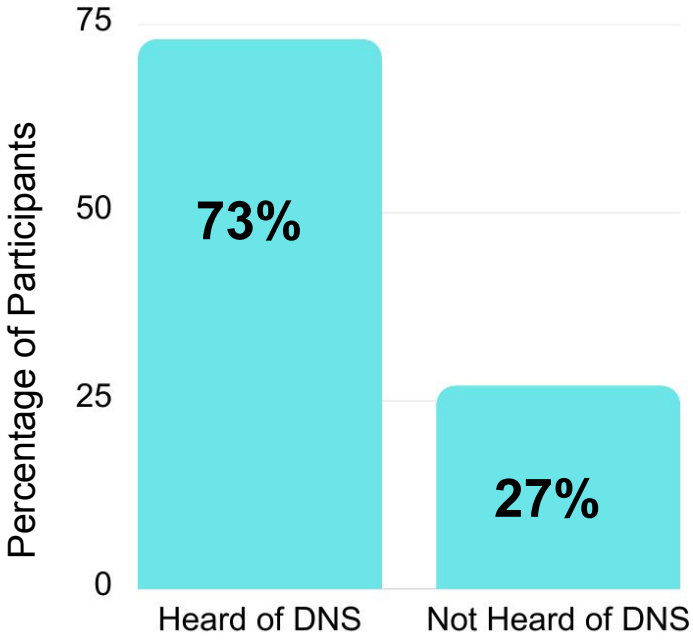

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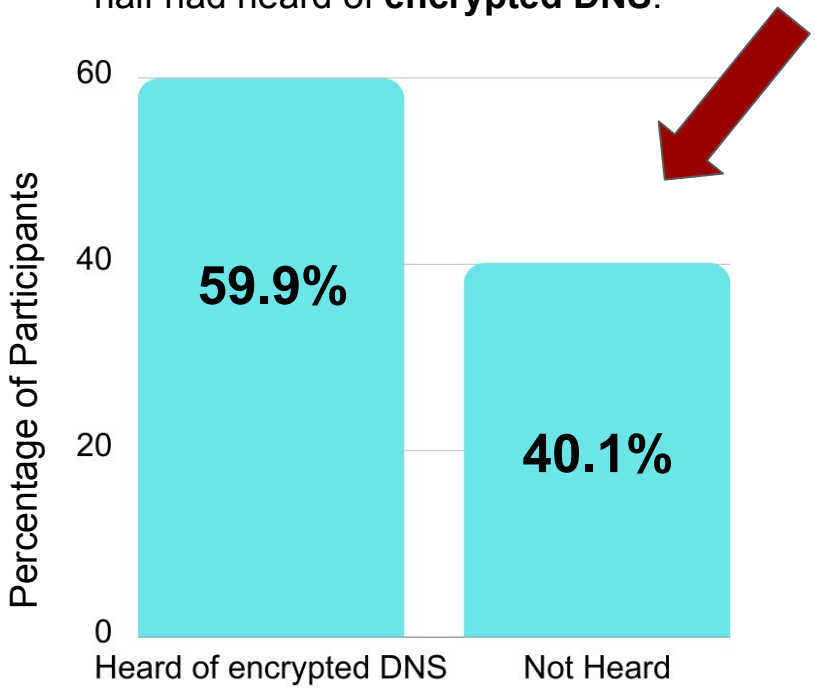
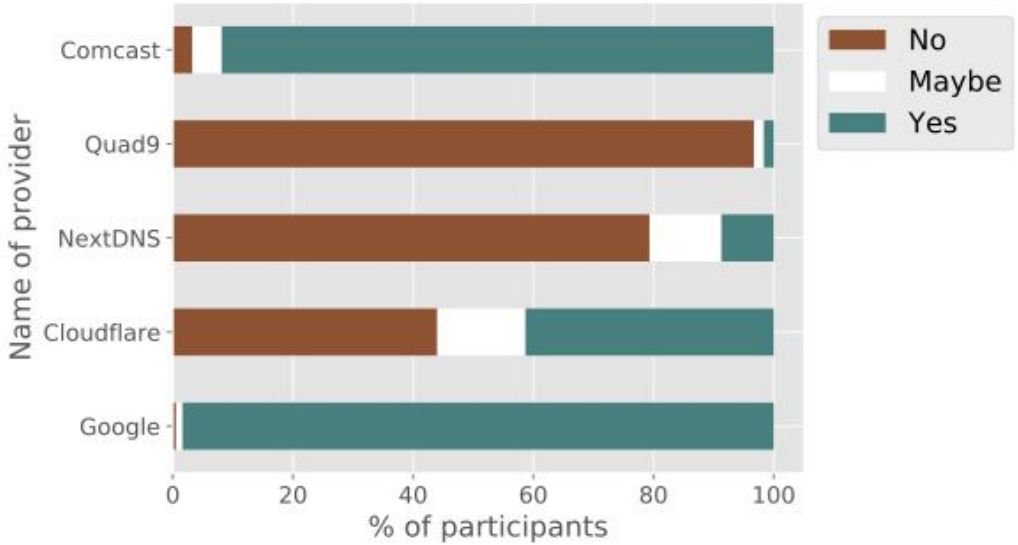


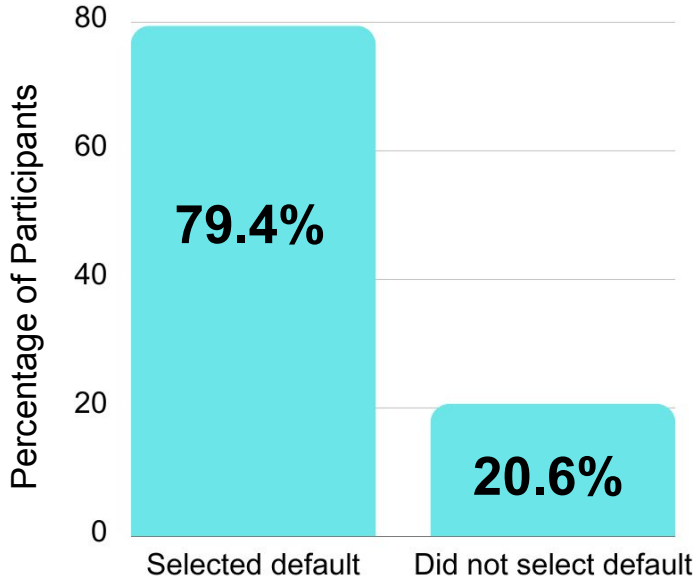
Are users aware of encrypted DNS settings?

Comcast and Google were widely known providers,
while NextDNS and Quad9 were scarcely heard of



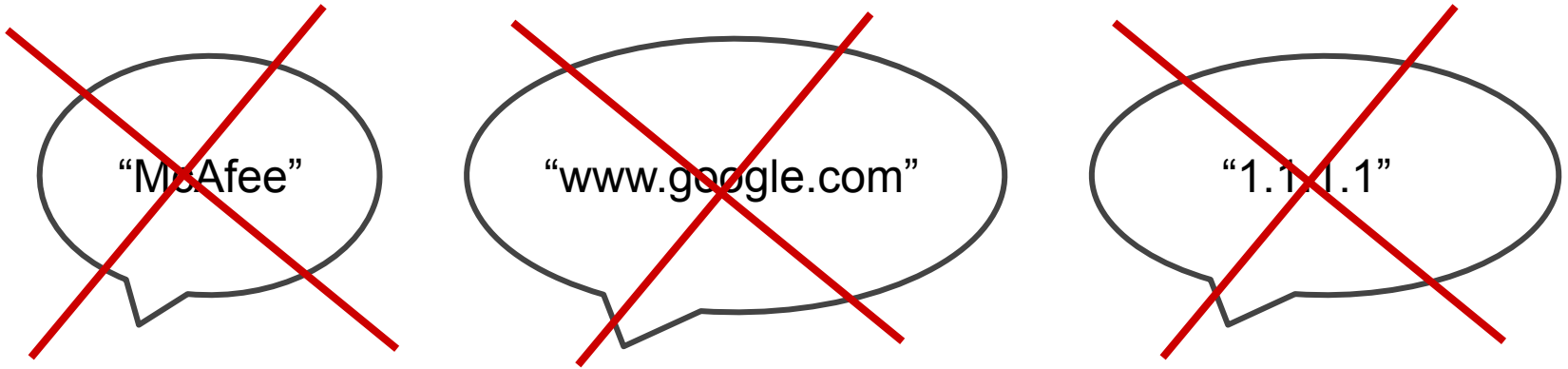
What encrypted DNS settings do users have enabled?

Most participants selected the default settings in their browsers



No participants correctly configured a custom DNS resolver in their browser.

Custom Resolvers

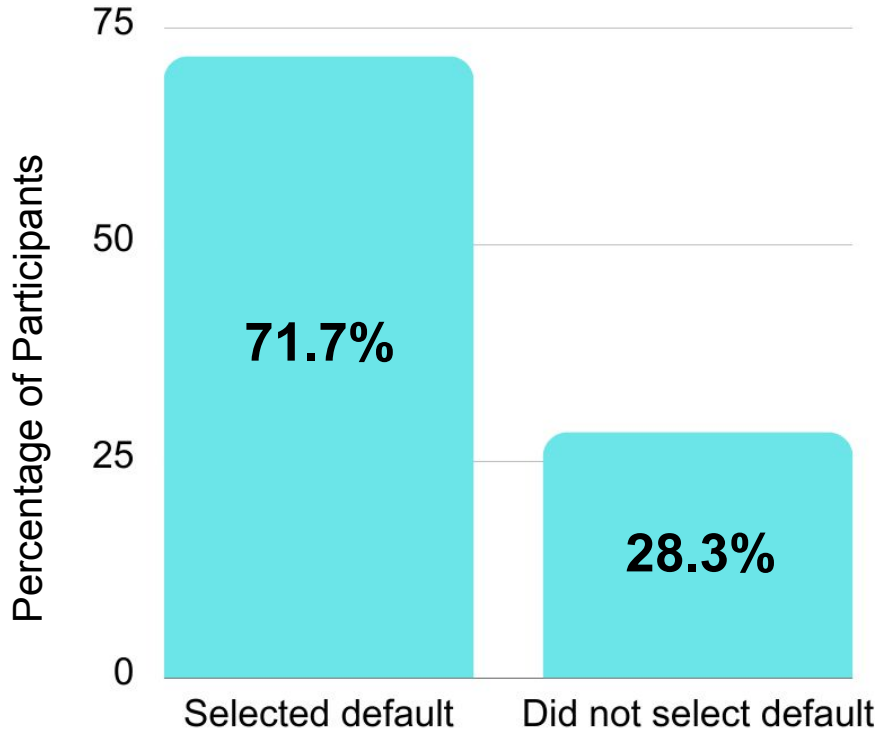


https://dns.google/dns-query

https://dns.cloudflare.com/dns-query

When shown encrypted DNS settings for different browsers, which settings do users select?

Most participants continued to use the default settings shown to them



When shown encrypted DNS settings for different browsers, which settings do users select?

Name of setting and perceived impact

- “Secure DNS”
- “DNS-over-HTTPS”

Participants associated Secure DNS with **safety** and **security**.

“The wording makes it sound like enabling DNS would make my browser more secure,” (P6).

“I don't know a lot about it but it seems like an extra step of protection,” (P50).

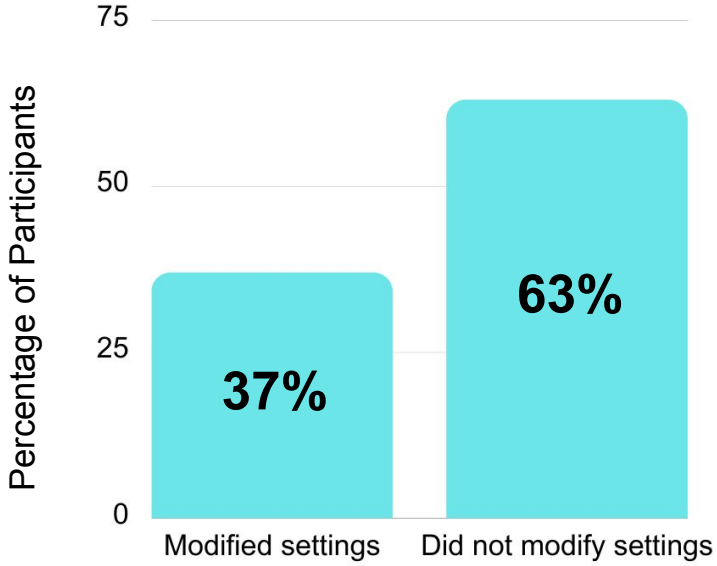
Instead of interpreting DNS-over-HTTPS as meaning **DNS *using* the HTTPS** protocol, they interpreted DoH as meaning use **DNS *instead* of HTTPS**

"I have no earthly idea what DNS is, while I at least have a passing familiarity with HTTPS," (P3).

"From the little I know I believe that HTTPS is more secure than DNS," (P30).

When the technical aspects of these systems are explained to users, how do their choices of settings change?

Nearly 40% of participants modified their settings after being shown an explanation of DNS and encrypted DNS



Recommendations

Provide a basic primer on DNS function (and privacy risks)

- Explain DNS function, privacy risks, tradeoffs associated with each setting

Provide privacy policies for the resolvers

- Will lead to more informed choices
- Will help users understand the differences between the recursive resolvers

Be thoughtful of the technical protocol terminology

- DNS-over-HTTPS name confusion

Provide users with the necessary format to select a custom resolver

- Add instructions, guidelines, and warnings for more clarity

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- Work is needed to:
  - Improve user awareness
  - Provide users with more information
  - Design intuitive setting interfaces

Acknowledgements
This work was supported by NSF Award SaTC-2155128, NSF Award TWC-1953513