

FIVE WALLED GARDENS

Why Browsers are Essential to the Internet
and How Operating Systems are Holding Them Back

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A REPORT FROM

moz://a

The open-source Mozilla Project is a global community of technologists, thinkers and builders working to keep the internet alive and accessible, so people worldwide can be informed contributors and creators of the web. We are the only major technology provider established as a non-profit foundation with a mission to ensure the internet is a global public resource, open and accessible to all. Millions of people worldwide choose our products — including the Firefox web browser — for an internet that puts people first, where individuals can shape their own experiences and are empowered, safe and independent.

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Introduction

This report has two purposes: first, to present Mozilla’s research (both recent surveys and years of knowledge) into consumer interaction with browsers. Secondly, to highlight the foreclosure of browser engines and independent browsers by operating systems. Part 1 of the paper is about operating systems, browsers, browser engines and how consumers behave. Part 2 highlights the online choice architecture practices by operating system providers which we believe have shaped consumer browser usage away from independent browsers.

The research we are releasing with this report paints a complex picture with many paradoxes: people say they know how to change their browser, yet many never do. Many people believe they can choose their browser, yet they have a bias towards software which is pre-installed, set to default and difficult to change. In fact, their browser choice on desktop computers has been thwarted for many years, and it has never truly existed on mobile devices. Our research corroborates what many regulators have already noticed: software can be designed to influence or even manipulate consumer outcomes. And operating systems are designed to maximize usage of their affiliated browsers.

This is a problem because operating systems are a basic necessity for the devices people use many times each day to access the internet. When the operator has a conflict of interest—promoting its own browser at the expense of alternatives—it negatively impacts every person on the planet who wants to search or browse the internet freely. It also impacts society more broadly.

Why? Because competition in browsers and browser engines is needed to advance innovation, performance, speed, privacy, and security. Effective competition requires multiple stakeholders to counter the power of a small number of giants and prevent them from dictating the future of the internet for all of us.

One of the ways Mozilla seeks to do this is through developing and investing in our Gecko browser engine. This matters because there are only three main browser engine providers left: Google, Apple and Mozilla - but Apple’s engine only runs on Apple devices. So, without Mozilla, the only cross-platform browser engine would be provided by Google. Putting the development of cross-platform web browsers in the hands of a single company creates not only a concentration of power, but also a single point of failure.

A healthy internet requires lawmakers, policymakers and regulators to work alongside stakeholders like Mozilla to champion competition, access, interoperability, privacy and security.

Where rules already exist or will soon come into force, we call for them to be enforced to ensure a level playing field for independent browsers; where new rules are needed, we call for them to be passed without delay.

This paper aims to shine a light on a part of the internet which is less talked about, despite the scrutiny that digital markets currently receive. We intend to follow it up with more work in the coming months on how some of these issues can be effectively addressed.

In raising these issues, we hope that this paper will be the start of a conversation, rather than a lonely intervention. We hope that regulators, academics and other companies will take up this work and apply it to different contexts and products. Most of all, we hope that this report will spark the change that is needed, so that independent browsers can be unshackled and free to offer consumers so much more than we are currently permitted to do.

BROWSERS AND BROWSER ENGINES ARE THE HEART OF THE WEB

The word “browser” is a misnomer. Browsers don’t just enable “browsing” the way televisions enable watching content. Browser engine technology is the most significant part of the web platform. It determines what is possible and is key for connectivity, productivity, creativity, commerce and entertainment over the internet. Millions of people spend significant portions of their working day and personal time using the internet, with the browser as the software agent helping them along the way.

Browsers matter to consumers, developers *and* the platforms that sit between them. Advances in browser engines (the technology under the hood powering browser products) mean better speed and performance for consumers, as well as innovation opportunities for developers. While the browser space is now dominated by the largest technology companies that also offer operating systems, this was not always the case. There have been and still remain many browsers from smaller, independent companies that do not have their own operating system – some of them full-featured general purpose browsers, such as Mozilla’s Firefox. Others have a specific niche, focusing on a particular feature, such as anonymity, speed and low data usage; productivity features and customizability; or privacy and crypto integration. An open and interoperable internet can only exist in a world where all types of browsers are able to compete, giving users a real chance to make choices based on features, business models and values.

Operating systems are the digital platforms upon which other applications are developed. They are not incentivized to want interoperability and openness. Each platform has its own rules and standards, and each platform wants to keep people within its walled garden. Controlling which browser or engine you use is one means to that end. As explained in this report, there are cascading effects of concentrated browser control that also impact search and advertising. This is concerning because browsers and browser engines are deeply connected to internet protocols, standards and governance over key issues around cybersecurity, advertising, tracking, profiling and targeting, privacy and more. The companies behind each browser represent different viewpoints of the internet as it should be.

Netscape Navigator was the original consumer browser and one of the most popular start-ups of its time; it IPO’d in August 1995 with a market value of \$2.9 billion and millions of consumers willing to pay to browse the web. Netscape even had a competitor (Opera), but unfortunately both companies faced what would become a notorious competition problem for software apps: **the powerful operating system rival.**

Like any product that runs on a computer or smartphone, a browser needs an operating system to function and to reach consumers.¹ When the dominant operating systems (Microsoft and Apple) decided to offer their own browsers bundled with every computer's operating system, the opportunities for independent browsers dwindled. The situation worsened with the development of mobile smartphones with proprietary and closed operating systems (Google and Apple), and with connected devices (Google, Apple, Amazon, Facebook) – with each operating system bundling its own browser. All of these platforms play a “dual role,” being the largest operating systems alongside providing other technology.² In the terminology of EU's Digital Markets Act, they have a “gatekeeper” position, operating as an unavoidable trading partner and necessary gateway to reach end-users. But they also provide their own competing product on the platform, in the form of a browser.

Beyond browsers, operating system bundling and self-preferencing has also extended to email clients, messaging, maps, video conferencing, music, document storage, photos and other common software. Across all of these important applications, the cost to society is lost opportunities for variety, product innovation, privacy and security. And this translates directly to consumer harm.

Consumers should have control over their online experiences and be able to choose which software they wish to use, including something different from what the operating system provider offers. People should not have to fight with operating systems that continuously pester, confuse and revert preferences in favor of their own software. Yet that is what happens today. The power that operating system providers wield and the actions they take through the designs of their user interfaces (known as “online choice architecture” or “OCA”) can prevent consumers from making free decisions about which services they wish to use.

1 See, for example, Case AT.39530 Microsoft (Tying), Commission decision of 16 December 2009, paragraphs 41 to 48; see also Digital Markets Act - Impact Assessment support study annexes, page 153

2 Concerns raised by the “dual role” also form part of the analysis behind the Digital Markets Act: see the Impact Assessment support study, page 154

Examples of consumer harm from operating system self-preferencing³

- **Limited or frustrated choice** - an operating system provider making it difficult or impossible for a consumer to switch browsers ultimately removes their ability to choose for themselves. It also hampers existing competitors and deters new products from entering the market and providing increased choice.
- **Lower quality** - where the monetary price for consumers is zero (as is the case for browsers) providers might be expected to compete on quality. But without effective competition from independent browsers, consumers may receive products which are lower quality.⁴
- **Lower innovation** - linked to quality is innovation. Consumers miss out on developments (for example, improved features and functionality). And a reduced likelihood of disruptive innovation might be accompanied by reduced choice for consumers.
- **Poor privacy** - consumers can be left with a product which subjects them to compulsory data sharing, misuse of data or other privacy harms. These outcomes can be an indication of low quality caused by ineffective competition.
- **Unfair contracts** - without proper choice, consumers may be forced to enter into contracts which might be exploitative or unfair.

OPERATING SYSTEMS MISUSE THEIR PRIVILEGED POSITION

Deceptive pattern practices targeted at consumers

Inhibiting Independent App Discovery - All five major platforms today (Google, Apple, Meta, Amazon, Microsoft) bundle their respective browsers with their operating systems and set them as the operating system default in the prime home screen or dock position.

For many people, this placement is sufficient and they will not see or pursue extra steps to discover alternatives. For example, Microsoft Windows users searching for Firefox face

3 See, for example, Report of the Digital Competition Expert Panel for the UK Government, "Unlocking Digital Competition", March 2019

4 Feature and security imitations on Internet Explorer, before Firefox came along; or feature limitations with Amazon's Silk browser or Apple's Safari browser are such examples.

a barrage of nudges (see below figure 8 onwards) to remain with Microsoft Edge in the start menu, in the App Store and even in Bing search. Discovery is not even an option on many voice assistant devices, such as those offered by Amazon, Meta, Google and Apple. These practices prevent consumers from controlling their experiences online and could be avoided if alternative options could be more easily discovered, accessed and used (see figure 1 below which illustrates how alternative search options are surfaced in Firefox).

Prohibiting Independent App Adoption - For consumers who seek and use alternative browsers, **many platforms make it difficult or impossible to: (1) delete the operating system's bundled browser; and/or (2) remove it as the operating system default.** This is important because browsers are often opened from other apps, such as if you click a link in a text message or use voice commands to navigate the web through a search widget. To illustrate, Apple lacked settings to switch away from Safari as the default browser until 2020 — meaning that iOS consumers trying to use another browser were locked into continued Safari usage for 13 years. Safari still cannot be deleted from iOS. This practice is repeated on Amazon and Meta devices (at least where they allow users to download alternative browsers - often they do not allow this).

Overriding Independent App Adoption - Even more egregious than prohibiting rival software adoption is **reversing it in favor of the operating system - and without consumer understanding.** This has been the case on Microsoft Windows computers for a number of years; consumers have faced increasingly aggressive practices, some of which have been aimed at reversing their decisions to use non-Microsoft software, for example, overriding default browser choice and reverting to Edge.⁵ When operating system providers use deceptive patterns in their OCA to direct consumers to their own products, they are also typically leveraging their market power in another market, seeking to exclude rivals. Independent companies are restricted in the innovation and quality they can offer consumers as a result. In the worst cases, they can be driven out of the market altogether. This harms consumers who suffer through lower quality products, unfair contracts, compulsory data sharing and limited switching options.⁶

OCA practices which limit consumer choice and distort consumer behavior can also weaken the competitive process. They incentivize companies to compete on aspects such as salience rather than competing on product attributes that benefit the consumer, such as quality (or, where relevant, price).⁷

5 <https://www.thewindowsclub.com/windows-keeps-changing-my-default-browser>

6 Day, G., & Stemler, A. (2020). Are Dark Patterns Anticompetitive?. Alabama Law Review, 72, 1; CMA Discussion Paper, Online Choice Architecture, How digital design can harm competition and consumers

7 Bordalo, P., Gennaioli, N., & Shleifer, A. (2021). Saliency (No. w29274). National Bureau of Economic Research; CMA Discussion Paper, Online Choice Architecture, How digital design can harm competition and consumers, paragraph 4.13

The research discussed in Part 2 of this report focuses on deceptive pattern practices. However, for years operating system platforms have also engaged in *commercial* practices to throttle browser companies from pre-installation and feature development that would pose a competitive threat to their dominant market positions. We briefly note these in our report to underscore the point that consumer-facing remedies alone cannot restore browser competition and innovation. Problematic conduct that harms distribution opportunities and product development must also be addressed.

Commercial practices targeted at independent software companies

Restrictive Contracts - regulators globally have criticized platform commercial agreements that tie their browsers to their operating systems and prevent OEMs (original equipment manufacturers) from pre-installing alternative default or secondary browsers on the homescreen.⁸ Common industry practice remains for Microsoft's OEM partners to install Microsoft Windows computers with Microsoft's software bundle (Edge, Outlook, Teams etc.) and Google's OEM partners to install Google Android devices with Google's software bundle (Chrome, Gmail, YouTube, Google Maps etc.).

Restrictive App Store Rules - regulators have also criticized but have yet to take action against control tactics such as Apple's current ban (and Microsoft's former ban) that eliminates alternative browser engines from app stores. This is why iOS had no alternatives to Safari for an entire decade – all alternative browsers had to be entirely redeveloped. Feature development remains at a standstill for alternative browsers on iOS because Apple — in control of both the browser engine and operating system — does not make available to rivals some of the necessary APIs and functionality, thereby limiting differentiation.⁹

8 See Case AT.40099 Google Android, European Commission decision of 18 July 2018, recital (1395): “*Second, Google and Alphabet should refrain from licensing the Play Store and/or the Google Search app to hardware manufacturers only on condition that they pre-install Google Chrome.*”

9 CMA Mobile Ecosystems Market Study, Final Report, Section 5

Part 1:

The Value of Browsers and the Harms from Operating System Self-Preferencing

WHY BROWSERS ARE FUNDAMENTAL TO CONSUMERS

In March and April 2022, we surveyed over 6,000 residents in the U.S., U.K., France, India and Kenya to learn more about their attitudes and preferences in relation to web browsers and search engines. In particular, we asked about their experience and knowledge around topics like installing web browsers, using multiple web browsers, and changing web browser and search engine defaults. We modeled this research on a survey commissioned by the Australian Competition & Consumer Commission (ACCC) that was published in September 2021.¹⁰ (For survey methods and confidence intervals, see Appendix.)

Web browser and search engine installation and use - a cross country survey

Our research shows that, for people in the five countries we surveyed, **browsers are used at least daily to access the internet**. While there are key differences between them, a majority in each country reported being confident in having a wide choice of browsers and knowing how to install a browser on their device. Yet, this theoretical confidence does not mean people consciously choose their software, nor does it translate to action: **a large number of people report never thinking about the browser or search engine they use. Many never actually install a browser on their device and even fewer report changing their default**. There may not be a simple explanation for the gap between assumed knowledge and action, or between attitude and behavior. However, it is evident that presenting consumers with clear and easy routes to choose and change their default browser will help them understand both the options available and how to make use of them. What is also evident (as explained in Part 2 of this paper) is that providers of operating systems do not currently offer these clear and easy choices to consumers.

¹⁰ Roy Morgan, Consumer Views and Use of Web Browsers and Search Engines – Final Report (September 2021), prepared for the Australian Competition & Consumer Commission.

Using a browser to navigate across the billions of websites and access online services is a cornerstone of digital life. Indeed, the vast majority of people report using the web browser on their devices *at least* daily to access the internet.

Table 1: Percentage of people who use a web browser to access the internet at least once a day¹¹

How often do you use a browser on your smartphone?¹²					
	U.S.	U.K.	France	India	Kenya
At least once a day	82%	84%	86%	95%	98%
Many times a day	55%	54%	55%	79%	88%

How often do you use a browser on your laptop/desktop?¹³					
	U.S.	U.K.	France	India	Kenya
At least once a day	76%	76%	81%	90%	93%
Many times a day	41%	42%	43%	63%	67%

Most people also report that they feel confident in their ability to find things on the internet. But in each country people reported being *less* confident that they have a wide choice of web browsers. In the United States noticeably fewer respondents were confident in either their ability to find things on the internet or in the choice of web browsers.

11 Mozilla Survey Study: The Installation, Use, and Personalization of Web Browsers, 2022.
 12 Source: *On your smartphone, how often do you use a web browser to access the internet?* Mozilla Survey Study: The Installation, Use, and Personalization of Web Browsers, 2022.
 13 Source: *On your laptop or desktop computer, how often do you use a web browser to access the internet?* Mozilla Survey Study: The Installation, Use, and Personalization of Web Browsers, 2022.

Table 2: Percentage of people who are confident in their ability to find things on the internet and that they have a wide choice of web browsers¹⁴

I feel confident that I'm able to find things on the internet¹⁵						
	Australia ¹⁶	U.S.	U.K.	France	India	Kenya
"Agree" or "Strongly Agree"	96%	68%	82%	77%	80%	90%

I'm confident I have a wide choice of other browsers if I am ever unhappy with the way I access the internet¹⁷						
	Australia	U.S.	U.K.	France	India	Kenya
"Agree" or "Strongly Agree"	80%	63%	68%	68%	72%	82%

Yet, despite their overall apparent confidence in finding things on the internet, a large number of people report that they've never thought much about how they access or search the internet, or the browsers and search engines they use. In fact, as shown in table 3 below, in the U.S., U.K. and India, *the majority of respondents* reported that they had never thought much about how they access or search the internet and the browsers or search engines they use to do so. As explained in the rest of this report, browser competition on both desktop/laptop and mobile devices has been constrained by operating systems for many years and it is therefore no surprise that these market dynamics have influenced consumer expectations, views and use of browsers.

14 Mozilla Survey Study: The Installation, Use, and Personalization of Web Browsers, 2022.

15 Source: *How much do you agree or disagree with each of the following statements? I feel confident that I am able to find things on the Internet.* Mozilla Survey Study: The Installation, Use, and Personalization of Web Browsers, 2022.

16 Australian data from Roy Morgan, Consumer Views and Use of Web Browsers and Search Engines – Final Report (September 2021), prepared for the Australian Competition & Consumer Commission.

17 Source: *How much do you agree or disagree with each of the following statements? I'm confident I have a wide choice of other browsers if I am ever unhappy with the way I access the internet.* Mozilla Survey Study: The Installation, Use, and Personalization of Web Browsers, 2022.

Table 3: Percentage of people who have never thought much about how they access or search the internet or the browsers and search engines they use¹⁸

I have never thought much about how I access and search the Internet¹⁹						
	Australia ²⁰	U.S.	U.K.	France	India	Kenya
“Agree” or “Strongly Agree”	41%	68%	59%	37%	57%	31%

I have never thought much about what browsers or search engines I use to access and search the Internet²¹						
	Australia	U.S.	U.K.	France	India	Kenya
“Agree” or “Strongly Agree”	34%	55%	54%	38%	54%	30%

Further underlining this point, a large number of people say they have **never installed a web browser** on their device, despite reporting that they know how to do so.

Table 4: Percentage of people who know how to install a web browser and percentage of people who have installed a web browser²²

Report knowing how to install a web browser on their device²³						
	Australia ²⁴	U.S.	U.K.	France	India	Kenya
Smartphone	81%	73%	75%	78%	97%	98%
Desktop/Laptop	87%	75%	79%	82%	93%	94%

18 Mozilla Survey Study: The Installation, Use, and Personalization of Web Browsers, 2022

19 Source: *How much do you agree or disagree with each of the following statements? I have never thought much about how I access and search the Internet.* Mozilla Survey Study: The Installation, Use, and Personalization of Web Browsers, 2022.

20 Australian data from Roy Morgan, Consumer Views and Use of Web Browsers and Search Engines – Final Report (September 2021), prepared for the Australian Competition & Consumer Commission.

21 Source: *How much do you agree or disagree with each of the following statements? I have never thought much about what browsers or search engines I use to access and search the Internet.* Mozilla Survey Study: The Installation, Use, and Personalization of Web Browsers, 2022.

22 Mozilla Survey Study: The Installation, Use, and Personalization of Web Browsers, 2022

23 Source: *Do you know how to download and install a new web browser to a smartphone? / Do you know how to download and install a new web browser to a laptop or desktop computer?* Mozilla Survey Study: The Installation, Use, and Personalization of Web Browsers, 2022.

24 Australian data from Roy Morgan, Consumer Views and Use of Web Browsers and Search Engines – Final Report (September 2021), prepared for the Australian Competition & Consumer Commission.

Have ever installed a web browser on their smartphone or desktop ²⁵						
	Australia	U.S.	U.K.	France	India	Kenya
Smartphone	38%	55%	48%	58%	93%	92%
Desktop/Laptop	64%	62%	57%	65%	91%	88%

As shown in table 5 below, a large number of people also say they have **never changed the default web browser** on their device, despite reporting that they know how to do so. This data suggests a potential dissonance between people’s perceived knowledge and their actions.

Table 5: Percentage of people who know how to change the default browser and percentage of people who have changed a default browser ²⁶

Report knowing how to change the default web browser on their device ²⁷						
	Australia ²⁸	U.S.	U.K.	France	India	Kenya
Smartphone	65%	47%	42%	49%	73%	74%
Desktop/Laptop	80%	49%	48%	54%	68%	72%

Have ever changed the default web browser on their device ²⁹						
	Australia	U.S.	U.K.	France	India	Kenya
Smartphone	36%	29%	24%	29%	59%	45%
Desktop/Laptop	59%	36%	37%	39%	63%	48%

25 Source: *Have you ever installed a web browser on your smartphone? / Have you ever installed a web browser on your laptop or desktop computer?* Mozilla Survey Study: The Installation, Use, and Personalization of Web Browsers, 2022.

26 Mozilla Survey Study: The Installation, Use, and Personalization of Web Browsers, 2022

27 Source: *If you were asked to change the default web browser on your smartphone today, would you know how to? / If you were asked to change the default web browser on your laptop or desktop computer today, would you know how to?* Mozilla Survey Study: The Installation, Use, and Personalization of Web Browsers, 2022.

28 Australian data from Roy Morgan, *Consumer Views and Use of Web Browsers and Search Engines – Final Report* (September 2021), prepared for the Australian Competition & Consumer Commission.

29 Source: *Have you or someone else ever changed the default web browser on your smartphone? / Have you or someone else ever changed the default web browser on your laptop or desktop computer?* Mozilla Survey Study: The Installation, Use, and Personalization of Web Browsers, 2022.

A sizable minority of people report that they would be uncomfortable downloading and installing a web browser or changing the default browser on their device (see table 6 below). Our research also found that in all five countries we surveyed, people who expected to be uncomfortable installing a web browser were far less likely to have done so. And in the United States, France and India, people who expected to be uncomfortable changing the default browser on their device were much less likely to do so.³⁰ As explained in Part 2, undertaking these tasks requires engaging with preferences and settings, which people may not be inclined to do or may perceive as being beyond their comfort zone.

Table 6: Percentage of people who would be uncomfortable or very uncomfortable installing a browser or changing the default browser on their device³¹

Would be “uncomfortable” or “very uncomfortable” downloading and installing a browser on their device³²						
	Australia ³³	U.S.	U.K.	France	India	Kenya
Smartphone	n/a	32%	31%	29%	22%	16%
Desktop/Laptop	n/a	26%	21%	22%	17%	14%

Would be “uncomfortable” or “very uncomfortable” changing the default browser on their device³⁴						
	Australia	U.S.	U.K.	France	India	Kenya
Smartphone	n/a	29%	28%	28%	16%	15%
Desktop/Laptop	n/a	24%	23%	23%	17%	15%

A sizable minority of people also report that they would need help changing the default browser on their device. In all five countries we surveyed, people who expected to need help changing the default on their device were, on average, *less than half as likely* to have made these changes.

30 Survey probabilities are the results of multivariate logistic regressions predicting browser installation and default changes. For more details, see Appendix.

31 Mozilla Survey Study: The Installation, Use, and Personalization of Web Browsers, 2022

32 Source: *How uncomfortable or comfortable would you be completing each of the following tasks? Downloading and installing a new web browser on a smartphone. / Downloading and installing a new web browser on a laptop or desktop computer.* Mozilla Survey Study: The Installation, Use, and Personalization of Web Browsers, 2022.

33 Note: Data not collected by ACCC for Australia.

34 Source: *How uncomfortable or comfortable would you be completing each of the following tasks? Changing the default web browser on a smartphone. / Changing the default web browser on a laptop or desktop computer.* Mozilla Survey Study: The Installation, Use, and Personalization of Web Browsers, 2022.

Table 7: Percentage of people who would expect to need assistance changing the default browser on their device.³⁵

If you were asked to change the default web browser on your smartphone today, would you know how to?³⁶						
	Australia ³⁷	U.S.	U.K.	France	India	Kenya
Yes	65%	47%	42%	49%	73%	74%
Would need help	n/a	38%	45%	39%	25%	24%
No	n/a	15%	13%	12%	2%	2%

If you were asked to change the default web browser on your laptop/desktop today, would you know how to?³⁸						
	Australia	U.S.	U.K.	France	India	Kenya
Yes	80%	49%	48%	54%	68%	72%
Would need help	n/a	38%	40%	34%	30%	26%
No	n/a	13%	12%	12%	2%	2%

Age is also associated with action. In all five countries we surveyed, someone 60 years old is half as likely to install a web browser on their device as a 30 year old. Income, education level, and other demographics did not seem to be associated with whether or not an individual was likely to install a new browser or change the default browser on their device.

35 Mozilla Survey Study: The Installation, Use, and Personalization of Web Browsers, 2022

36 Source: *If you were asked to change the default web browser on your smartphone today, would you know how to?* Mozilla Survey Study: The Installation, Use, and Personalization of Web Browsers, 2022.

37 Note: Some data not collected by ACCC for Australia.

38 Source: *If you were asked to change the default web browser on your laptop or desktop computer today, would you know how to?* Mozilla Survey Study: The Installation, Use, and Personalization of Web Browsers, 2022.

Table 8: Percentage of people who have concerns about privacy and personal data collection online.³⁹

Concerned about personal data collection⁴⁰						
	Australia	U.S.	U.K.	France	India	Kenya
"Agree" or "Strongly Agree"	70%	61%	63%	59%	78%	84%

Believe you should be able to opt-out of data collection⁴¹						
	Australia	U.S.	U.K.	France	India	Kenya
"Agree" or "Strongly Agree"	89%	69%	79%	69%	78%	87%

Believe only data necessary for the product or service should be collected⁴²						
	Australia	U.S.	U.K.	France	India	Kenya
"Agree" or "Strongly Agree"	90%	69%	80%	72%	79%	82%

As shown in table 8 above, the majority of people in all countries expressed concern about the collection of data and personal information when using browsers and search engines, yet **this concern did not associate with the likelihood of installing a browser or changing the default browser**. This disconnect between people’s privacy concerns and their actions has been studied in academic literature. When the responsibility for privacy protections is put on individual consumers who must engage in ongoing activities to actively manage their privacy, this perceived lack of control can result in apathy.⁴³ In other words, privacy is important to people, but operating systems and other software providers shoulder the responsibility to address this concern.

39 Mozilla Survey Study: The Installation, Use, and Personalization of Web Browsers, 2022

40 Source: *How much do you agree or disagree with each of the following statements? I am concerned about the collection of my data and personal information when I use browsers and search engines.* Mozilla Survey Study: The Installation, Use, and Personalization of Web Browsers, 2022.

41 Source: *How much do you agree or disagree with each of the following statements? Search engines and browsers should allow me to opt out of collecting certain types of information about me, how they use it and/or what they can share.* Mozilla Survey Study: The Installation, Use, and Personalization of Web Browsers, 2022.

42 Source: *How much do you agree or disagree with each of the following statements? Search engines and browsers should only collect the information they need to provide their product or service.* Mozilla Survey Study: The Installation, Use, and Personalization of Web Browsers, 2022.

43 "What Can I Really Do?" Explaining the Privacy Paradox with Online Apathy. Hargittai and Marwick (2016)

BROWSERS ARE USED ON DESKTOP, MOBILE, VOICE AND MIXED REALITY DEVICES

Browsers play an essential part of day-to-day life for most people, a necessary tool for completing school assignments and work tasks, connecting with others through email and video conferencing, shopping, banking, entertainment and more. The browser is a connective tissue between our professional and personal lives and the larger world, as more and more facets of it become digital-first.⁴⁴ Our research has shown that, for those with access to more than one device, browsers on desktop (used in this paper to refer to both desktop and laptop computers) are often preferred to mobile browsers for activities that are time-intensive, complex or more comfortably performed with a larger screen or keyboard.^{45 46}

By contrast, people tend to use the mobile browser primarily for quick information-seeking tasks. Other activities include entertainment and accessing content without having to download a separate app.⁴⁷ People with both desktop and mobile devices report using their mobile browser multiple times a day.

Indeed, the UK's Competition and Markets Authority (CMA) found:

*“[O]ther than app stores, web browsers are the most important way for users of mobile devices to access content and services over the internet, **spending a higher proportion of their time on browsers than on any other single native app**”⁴⁸*

In the United States, 85% of adults own a smartphone. 15% of adults report being “smartphone-only” internet users, meaning they do not regularly have access to a desktop or laptop computer. Younger adults, lower income adults, and Black and Latino adults are more likely to rely on smartphones for online access.⁴⁹ In many parts of the world, smartphone dependency for internet access is significantly higher.

This probably under-reports actual usage because most people do not always realize they are using a mobile browser, such as when a web page opens after clicking a link

44 For example, browsers are crucial for business users to access “Software as a Service” (SaaS) products, a segment globally worth \$226bn in 2021. <https://www.businesswire.com/news/home/20210820005229/en/Software-as-a-service-SaaS-Global-Market-Report-2021-Focus-on-Customer-Relationship-Management-Enterprise-Resource-Planning-Human-Resource-Manufacturing-and-Operations-Supply-Chain-Management--ResearchAndMarkets.com>

45 Mozilla Study

46 Mozilla Study

47 Mozilla Study

48 CMA, Mobile Ecosystems Market Study, Final Report, paragraph 2.26

49 Mozilla Study

from an app, such as Facebook, from a text message or in the results of a search widget. We also observe people who associate their browser activity with “search” and therefore do not realize they are using a browser when engaging in search *through the browser*.⁵⁰

Moderator: “What search engine do you usually use when you search the internet?”

Respondent: “Well when I’m on my computer, I use Firefox 100% of the time. If I’m on my iPad or my iPhone, obviously I have to use Safari.”

— 54-YEAR-OLD, UNITED STATES⁵¹

Of the 4.2 billion mobile internet subscribers globally,⁵² roughly 72% of people use Android and 27% use iOS⁵³ devices. As to browser usage on these mobile devices, 65% use Chrome and 24% use Safari.⁵⁴ This leaves two companies in control of the vast majority of the world’s mobile browsing. And of these mobile internet users, income disparities mean that many people cannot afford the “choice” of using Safari on iOS.

The lack of browser diversity leaves people exposed when it comes to improved security and privacy. As noted above, browsers are powered by a “browser engine” which significantly impacts the capability of a browser.⁵⁵ Apple requires all developers deploying iOS browsers to use Apple’s own WebKit engine. However, because all software is susceptible to security vulnerabilities when such issues arise on WebKit, all iOS browser users are equally vulnerable until Apple finds, fixes and publishes patches.⁵⁶ This is just one reason why a range of browsers, using different browser engines, is desirable.

To give another example, Chrome has yet to implement solutions to block cross-site tracking, which means people navigating the web with Chrome have a less private browsing experience. **Independent browsers offer a means for consumers to choose a different browsing experience, and one that should be beyond the control of any big tech platform.** The situation is worse on voice assistants, smart home, and virtual or mixed reality devices. Browsers are relevant to these experiences but limited options exist (if at all) for alternative browsers.

50 Mozilla Study

51 Mozilla Study

52 GSMA: The Mobile Economy 2022, <https://www.gsma.com/mobileeconomy/wp-content/uploads/2022/02/280222-The-Mobile-Economy-2022.pdf>

53 Statcounter, Mobile Operating System Market Share Worldwide: <https://gs.statcounter.com/os-market-share/mobile/worldwide/#monthly-202106-202206>

54 Statcounter, Mobile Browser Market Share Worldwide: <https://gs.statcounter.com/browser-market-share/mobile/worldwide/#monthly-202106-202206>

55 CMA Mobile Ecosystems Market Study, Final Report, Appendix F: understanding the role of browser engines

56 CMA Mobile Ecosystems Market Study, Final Report, paragraph 8.114 onwards; See, for a recent example: <https://www.bbc.co.uk/news/technology-62602909>

Browsers and operating systems are often built by people in one small part of the world and targeted at, and optimized for, people in those areas. Yet consumers of these products are located globally - for example, almost 60% of Firefox desktop users have their browser set to a language other than English.⁵⁷ The research highlighted in Part 1 of this report shows that consumers in different parts of the world perceive and use their browsers differently. This can reflect a myriad of differences, including connectivity (both speed and reliability of internet connections) and cultural factors. Independent products can help to provide localized and targeted offerings that prioritize regional needs. This is particularly the case for open-source products like Firefox, which can be adapted by local communities and developed with local input - often by volunteers.⁵⁸ These types of positive impacts on consumers are difficult to measure and often ignored, particularly given that regulators and lawmakers focus on national markets.

CHOICE, INNOVATION, SECURITY AND PRIVACY ARE AT STAKE

What are browser engines and why do they matter?

A browser engine is a key and complex piece of technology on which the user-facing browser is built. They can determine the speed, quality and features of a browser, as well as its security and privacy characteristics, including vulnerabilities. While there were previously at least five major browser engines, today only Apple, Google and Mozilla maintain browser engines. Apple's engine is limited to being available on Apple devices, leaving only Google and Mozilla as the developers of browser engines which work across platforms. Why does this matter? Without Mozilla's Gecko engine, there would be no competition to Google's Blink engine, centralizing control of the web in the hands of a single company and creating a single point of failure for security and privacy.

Browsers are the foundation of the open web that people “browse” multiple times a day, every day. They are privileged applications that create technological compatibility between a device, its operating system and websites. Accordingly, browser technology is inextricably linked to what websites, apps and services *can do*, at what *quality and speed*, and at which

57 <https://data.firefox.com/dashboard/usage-behavior>

58 <https://pontoon.mozilla.org/>

level of *privacy and security*. The latter is especially relevant for consumers because where you browse to, what you type and your passwords can all be deeply personal and sensitive. Browsers serve as the “user’s agent” online and can offer protections against bad actors.⁵⁹ Given this privileged position, Mozilla’s Firefox has consistently offered multiple search engine options and multiple routes to facilitate this choice, as well as respecting user choice if a change is made.

Against this backdrop, a federal Court of Appeals in the United States concluded in 2001 that Microsoft engaged in anti-competitive conduct to draw people toward its bundled free Internet Explorer browser and away from one of its rivals, the Netscape Navigator browser. Microsoft’s motive was not only to increase its own browser market share, but also to push developers (who would follow consumers) to create software compatible for the Windows operating system.

*“If a consumer could have access to the applications he desired — regardless of the operating system he uses — simply by installing a particular browser on his computer, then he would no longer feel compelled to select Windows in order to have access to those applications; he could select an operating system other than Windows based solely upon its quality and price. In other words, the market for operating systems would be competitive. Therefore, **Microsoft’s efforts to gain market share in one market (browsers) served to meet the threat to Microsoft’s monopoly in another market (operating systems) by keeping rival browsers from gaining the critical mass of users necessary to attract developer attention away from Windows as the platform for software development.**”⁶⁰*

Without browser diversity, a single company’s influence can shape the internet. After Internet Explorer crushed Netscape, Microsoft’s market position was so dominant that the company did not release another edition of its browser for *five years*. Security problems proliferated, and there was little innovation until competition arrived from Mozilla’s Firefox browser. Because of Mozilla’s Gecko engine, Firefox offered improved speed, security and customizations compared to Microsoft’s Internet Explorer 6. It also helped popularize the concept of tabbed browsing.⁶¹ Within two years, Firefox achieved over 10% of global desktop browser market share and succeeded in putting pressure on competitors to improve product quality and security.⁶² Thanks to competition, browser release cycles also rapidly acceler-

59 Indeed, browsers identify themselves to websites via what is known as a “user agent” string.

60 *U.S. v. Microsoft Corp.*, 253 F.3d 34 (D.C. Cir. 2001) at 60.

61 “BBC NEWS | Technology | Firefox Browser Takes on Microsoft,” December 20, 2017. <https://web.archive.org/web/20171220113953/http://news.bbc.co.uk/2/hi/technology/3993959.stm>.

62 Krasnoff, Barbara. “Timeline: Firefox vs. IE over the Years.” *Computerworld*, June 17, 2008. <https://www.computerworld.com/article/2535318/timeline--firefox-vs--ie-over-the-years.html>.

ated. Today, Firefox and many other major browsers providers release a new version every four weeks to offer the latest security updates and performance improvements, with specific bug fixes and security patches in the interim.

The arrival of Firefox and Gecko also meant a different perspective on the properties of the web. Mozilla continues to play a key role in making the internet more secure, fast, private and functional in multiple ways. For example, online commerce and navigation is safer today through protocols and initiatives the organization drove, including TLS 1.3 and Let's Encrypt.⁶³ Mozilla has created foundational compilers and programming languages like Rust and Web Assembly, which are now coordinated by new open-source communities for emerging industry applications. Mozilla has also contributed significantly to global standards bodies which help to guide and steer the future of the internet, for example working on issues such as voice and speech recognition, mixed reality experiences and royalty-free video and audio codecs that make content streaming better and more affordable for consumers.

A browser is complex and expensive software to develop, and maintaining a browser engine is an enormous portion of this cost. The Firefox code base contains over 20 million lines of code⁶⁴, which must be continuously improved. The “browser engine” is the core software component of a web browser; it transforms the myriad content hosted on millions of web servers into a standard visual representation that people can interact with using their browser. Over the years, billions of dollars have been invested into browser engines.

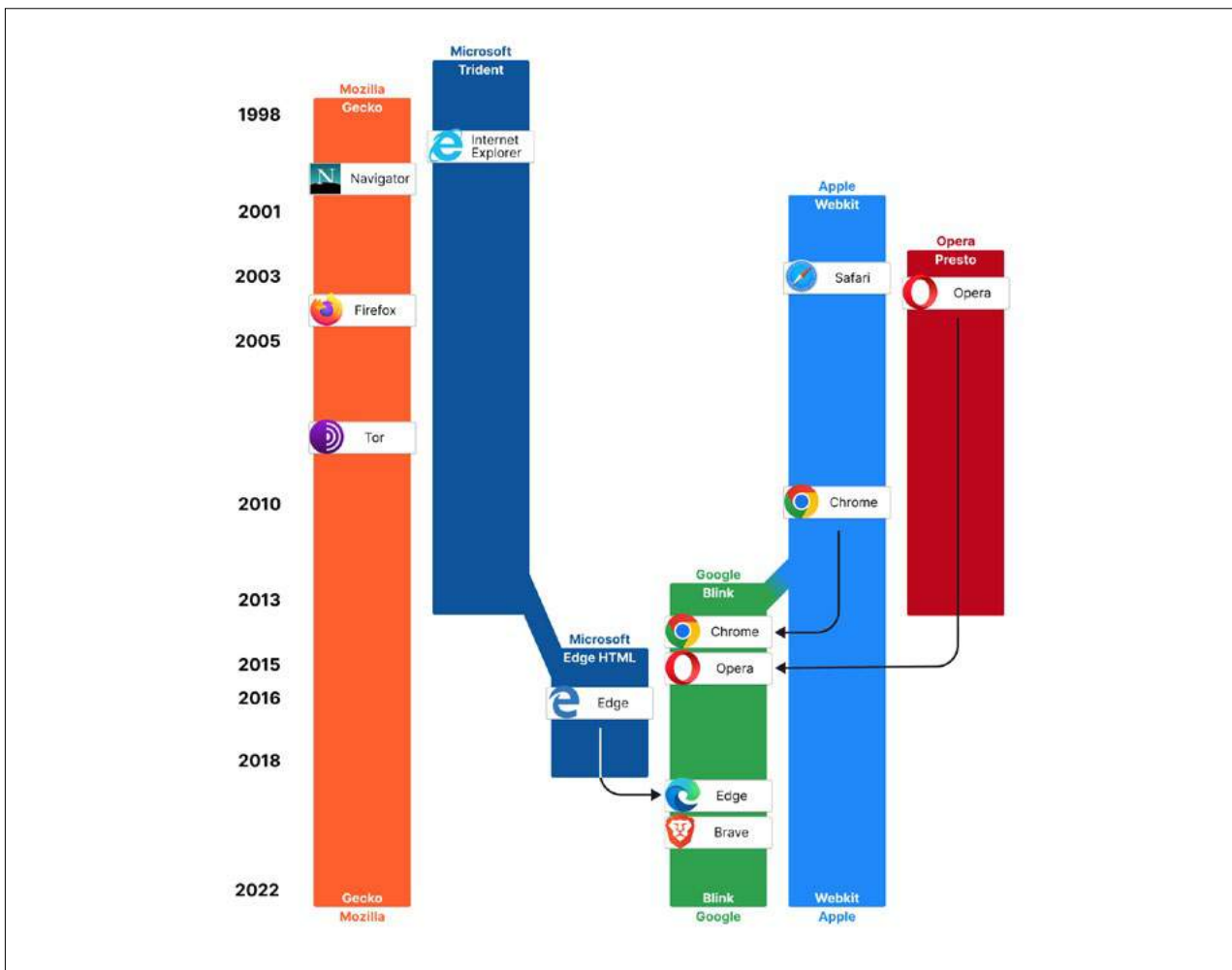
Unfortunately, as shown in the diagram below, the diversity of browser engines has converged such that there are only three main browser engines left today.⁶⁵ We believe this is the network effect from years of: (1) both Google and Apple engaging in mobile operating system and browser bundling; and (2) Apple requiring rival browsers to use its WebKit browser engine. Browser bundling with Android and iOS made it vital for all developer websites and services to be compatible with Chrome and Safari. Apple's requirement forced more browser usage towards WebKit and away from competing engines like Gecko, Trident and Presto.

63 Mozilla co-founded the Let's Encrypt project to provide free digital certificates that enable site owners to adopt HTTPS encryption. This promotes security and privacy for all internet users. See https://en.wikipedia.org/wiki/Let%27s_Encrypt

64 See <https://hacks.mozilla.org/2020/04/code-quality-tools-at-mozilla/>

65 For a visualization, see CMA Mobile Ecosystems Market Study, Appendix F, page 26

Figure 1 - timeline of modern browser engine development⁶⁶



Web compatibility refers to the desired state of services and websites performing equally across all browsers and operating systems.⁶⁷ The failure by developers of the most popular websites and services to implement common standards and protocols on a timely basis results in breakage based on incompatibilities. Our research shows that web compatibility issues are one of the top reasons people abandon a browser.^{68 69} We also frequently see examples of perceived web incompatibility in our research, where people believe they are not able to use Google products like Gmail on Firefox or believe that these products will not work well when accessed in a browser other than Google Chrome.

66 Adapted from CMA Mobile Ecosystems Market Study, Appendix F, Figure F10

67 See also: CMA report on Mobile Ecosystem (Appendix F, para. 3): “[...]. If the browser engine in a user’s browser does not have a particular capability, then a user will be unable to properly engage with the relevant web content. For example, if a user’s browser engine lacks the ability to process a particular video format, the user will not be able to watch a video using that format which has been uploaded to a web page”. Also, “Online content providers try to ensure that their content is compatible with multiple browser engines so that it reaches as many consumers as possible. However, where browser engines’ capabilities differ, online content providers may choose to produce content which is not supported by all browser engines”

68 Mozilla Study

69 Mozilla Study

Moderator: "Okay. Do you remember how you heard about Chrome?"

Participant: "When I first got Gmail and then when I started using Google Drive. When I opened my Gmail account, it periodically asked me, you know, if--it just asked me would you like to get Chrome? It's better."

— 34-YEAR-OLD, TAIWAN⁷⁰

Faced with both web incompatibility issues and the costs of maintaining a separate browser engine for iOS, Opera abandoned its browser engine in 2013⁷¹ and Microsoft followed suit in 2019⁷². Both companies adopted Google's Blink/Chromium browser engine for their primary browsers and continue to offer WebKit versions on iOS. In particular, Microsoft's 2019 decision to abandon Trident reveals the scale of the challenge of maintaining a browser engine. Microsoft is a company with currently more than 150,000 employees and a market capitalization of around \$2 trillion. Yet it decided to abandon a key piece of software and instead use a browser engine created and maintained by one of its main rivals.

By contrast, Mozilla has fewer than 1,000 employees and a fraction of the revenues earned by the five major platforms. We continue to invest in our Gecko browser engine and improve web compatibility. **This matters because, when it comes to maintaining a browser engine that works across multiple platforms, without Mozilla there is only Google to develop the internet.** Apple's WebKit engine only runs on Apple devices. Putting the development of cross-platform web browsers in the hands of a single company (regardless of the nature of that company) creates not only a concentration of power, but also a single point of failure. Google has many strengths, but it is motivated to maximize profit and gain market share for its own products. And what is best for Google (or any of the platforms) will not always be in the best interest of the wider internet, consumers and other developers. This makes it vital that Firefox and Gecko have meaningful opportunities to reach consumers and offer pro-competitive contributions to the internet ecosystem.

70 Mozilla Study

71 <https://press.opera.com/2013/02/13/opera-gears-up-at-300-million-users/>

72 <https://blogs.windows.com/windowsexperience/2018/12/06/microsoft-edge-making-the-web-better-through-more-open-source-collaboration/>

HOW OPERATING SYSTEMS CONTROL THE USE OF BROWSERS AND BROWSER ENGINES

Today, all providers of major operating systems routinely bundle their affiliated browsers with their operating systems. As demonstrated in Table 9 below, operating systems from Microsoft, Apple, Google, Amazon and Meta control the majority of the consumer technology that people take for granted, across computers, smartphones, tablets, connected cars, voice speakers and internet of things devices. In some instances, independent browsers are permitted on the platform, but the operating system provider's browser will always be pre-installed and set to default. In other instances, there is not even an option for consumers to download or use alternative browsers.

Table 9: Operating systems and their browsers

Company	Browser	Operating System
Microsoft	Edge	Bundled on Windows computers, Xbox consoles
Apple	Safari	Bundled on Mac OS and iOS devices
Google	Chrome	Bundled on Chrome OS (used on Chromebook computers); Android (smartphones); and operating systems for other Google devices such as Nest
Amazon	Silk	Bundled on Fire OS (used on Fire TV, Echo, Fire tablet devices) ⁷³
Meta	Portal/Oculus Browser	Bundled on the operating systems for Portal ⁷⁴ , Oculus ⁷⁵ and other Meta products

Although this practice has been at the core of major antitrust action in the U.S. and E.U., it continues to this day – primarily because the commitments offered by Microsoft and Google to the regulators were inadequate to address those issues. Each platform has mirrored the same practices as Microsoft in 1996 to develop software internally, bundle with their operating systems and impose hurdles to keep alternative software out.

73 <https://docs.aws.amazon.com/silk/latest/developerguide/what-is-silk.html>

74 https://store.facebook.com/en-gb/help/portal/articles/apps-and-photos/apps/use-the-web-browser-on-meta-portal/?utm_source=www.google.com&utm_medium=portalredirect

75 https://www.oculus.com/experiences/gear-vr/1257988667656584/?locale=en_GB

Keeping developers and consumers captive within the platform remains a major motive; it is free advertising in the form of increased brand association when consumers use multiple affiliated platform apps. It is also lucrative, as in the case of platforms like Apple, Meta and Amazon, which rely on Microsoft or Google for search services. Data is another major motive: **although consumers don't pay to use browsers, their browsing history is valuable data for platforms with advertising businesses like Meta, Amazon, Google and Microsoft.** It is not coincidental that many of these companies have yet to implement robust anti-tracking technologies in their browsers or deprecate third-party cookies. By leaving users' data exposed for cross-site tracking and targeted advertising in their browsers and ensuring the success of those browsers on their own platforms, these companies gain access to consumer data which is valuable to their other lines of business.⁷⁶

Operating systems today set their browser as the default and make it difficult or impossible for a vast majority of consumers to change the bundled default, delete the bundled default, and discover and use alternative browsers. From launch, Firefox faced operating system attempts to stifle competition, but without the volume and sophistication of deceptive practices seen today. Firefox was downloaded over 100 million times in its first year⁷⁷ and reached over 30% of global desktop market share in 2010.⁷⁸

Despite its desktop popularity, Firefox has struggled from the outset to gain market share on mobile devices. In 2007, iPhone was the first device to prohibit web downloads and require all software to be installed through its App Store. Combined with Apple's browser engine restriction, Firefox was not available on iOS until 2017 and could not be set as default until 2020. **Apple's control tactics cost consumers an entire decade of independent choice,** during which Safari became (and remains) the dominant browser used on Apple's smartphones and mobile devices (iPad, Apple Watch, HomeKit, etc.).

"I don't really like Safari, I just never liked it. Like sometimes it comes up on my phone, sometimes you open certain pages and it just pops up."

— 34-YEAR-OLD, UNITED STATES⁷⁹

Default settings can create burdens for consumers who prefer to use a browser other than the default, but who are unable to or unaware how to change their default. We know from our research that some consumers adopt unnecessarily cumbersome workarounds to stick with their preference.

76 See, for example, Digital Markets Act - Impact Assessment support study, page 16

77 <https://blog.mozilla.org/press/2005/10/firefox-surpasses-100-million-downloads/>

78 <https://gs.statcounter.com/browser-market-share/desktop/worldwide/2010>

79 Mozilla Study

"When something opens in Safari, I switch it over to another browser. I just copy and paste."

— 26-YEAR-OLD, UNITED STATES⁸⁰

Android never outright banned web downloads or rival browser engines. But Google's commercial agreements with OEMs has made it challenging for rival browsers to gain preinstallation opportunities.⁸¹ Web incompatibility continues to hamstring the Firefox experience on Android. And Google has bundled Chrome on Android since 2012.⁸² These business practices also cost consumers an entire decade of independent choice, during which time Chrome (and Blink/Chromium) became the dominant browser and engine integrated on Google smartphones and mobile devices (Android, Pixel, ChromeOS, Nest, Chromecast, etc.).

Meta and Amazon are neither browser engine developers nor are they considered creators of browsers. However, they too have their own operating systems with their own browsers, and incentives to keep consumers from browsing the web on independent software. The smart speakers (and other other voice-activated devices) and virtual reality devices Meta and Amazon develop are likely to continue to gain traction in the future. So too will operating system bundled browsers on connected and self-driving cars being developed by Google, Apple and Amazon.⁸³

Another way that operating system providers override browser choice is through webview. Developers of Android apps often embed a "view component" in their applications that is capable of rendering web pages. For example, if a user opens a link in the Facebook or Twitter app, it will open a webpage that is viewable within the Facebook or Twitter app. To achieve this in-app experience, the component available to developers on Android is called WebView,⁸⁴ which is configured to always render pages using the system browser engine (Chrome/Blink). Android's WebView cannot be configured to use any alternative provider.⁸⁵

Although Mozilla has an alternative component for this, called GeckoView, there is no way to configure it as an alternative to the native WebView provider on Android. An increasing amount of browsing occurs within non-browser apps – including social media apps like

80 Mozilla Study

81 European Commission decision in Case AT.40099, Google Android, 18 July 2018

82 Isaac, Mike. "Chrome Web Browser Finally Comes to Android Phones, Tablets." Wired. Accessed June 21, 2022. <https://www.wired.com/2012/02/chrome-android/>.

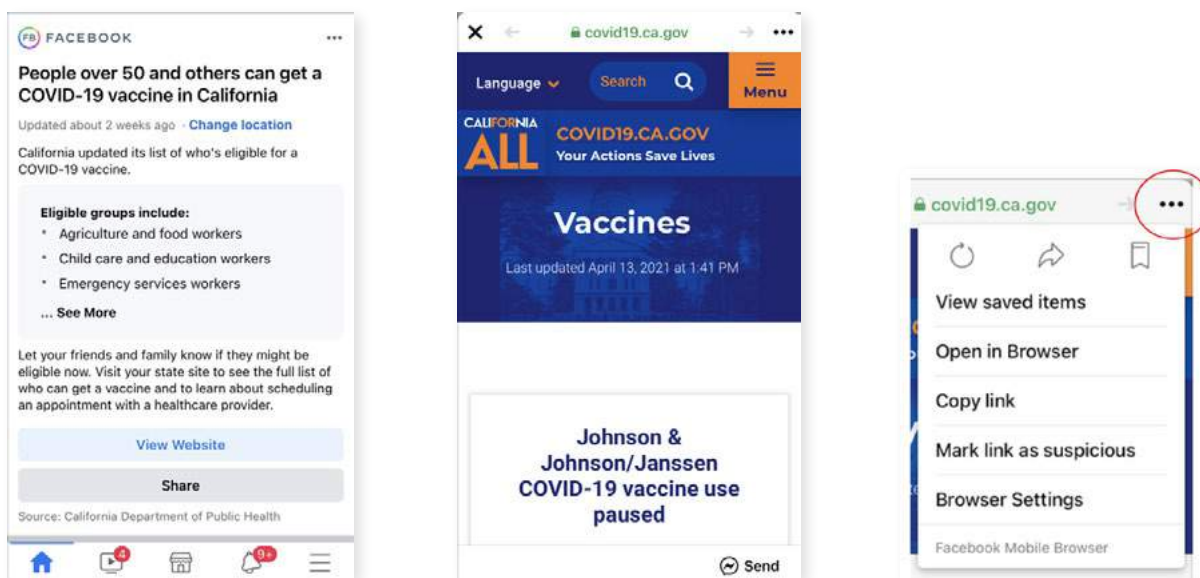
83 <https://www.politico.com/news/magazine/2021/12/27/self-driving-car-big-tech-monopoly-525867>

84 Android WebView - <https://developer.android.com/reference/android/webkit/WebView>

85 "Vendors shipping OS images which include GMS and the Play Store must use Google's provided WebView configuration" from WebView Providers - https://chromium.googlesource.com/chromium/src/+//HEAD/android_webview/docs/webview-providers.md

Facebook, Twitter and Reddit – to keep consumers from leaving those apps.^{86 87} This creates further challenges to web compatibility because less webpage traffic goes through alternative browser engines and instead to Blink/Chromium. This then leads to more broken websites on the open web, despite other independent browsers being equally (if not more) standards-compliant. The example below shows an instance from Facebook.

Figure 2: Example of web pages opening in affiliated browsers



Link to webpage as shown on Facebook

Clicking “View Website” opens webpage in a Facebook Browser

Browser settings do not enable consumer to use the default browser to view webpages

These trends show that without regulation major operating systems will continue to strip consumers of choice when it comes to the range of browsers they can use. The constraints imposed by the largest platforms on consumer choice directly impact people’s ability to control their online experiences. They also block independent browser developers from entering markets and expanding their products. As the U.K.’s CMA recently found in relation to mobile ecosystems, weak competition resulting from the positions and actions of operating system providers can lead to a reduction in disruptive innovation and dampened

86 Decision of 18.7.2018, CASE AT.40099 Google Android, fn 58. See also paragraph 116 and related footnote.

87 There have also been privacy and security concerns raised with the view component provided by certain apps: <https://www.abc.net.au/news/2022-08-22/tiktok-in-app-browser-can-monitor-keystrokes-researcher-finds/101356198>

incentives for smaller competitors to invest and innovate.⁸⁸ It can also lead to reduced incremental innovation, as the operating system provider limits the threat of people switching from its browser and therefore faces reduced competitive threat, as was the case for Internet Explorer before Firefox's entry and the position of Safari on iOS today.⁸⁹

The U.S. House of Representatives Judiciary Committee report "Investigation of Competition in the Digital Marketplace" commented on the pro-competitive innovation that browser diversity can drive in other markets, in this case "Rust" which is one of the most popular modern programming languages today:^{90 91}

Browser diversity is also important for ensuring an open internet and reduces the risk that web developers will build sites optimized for the leading engine as opposed to web standards. Moreover, as developers work on advancing browser engine technology, they create technologies that can improve the overall internet ecosystem. For example, Rust is a programming language that Mozilla engineers developed while writing the Servo layout technology for browser engines. Developers use Rust for other applications today, including gaming, operating systems, and other new software applications. There is a general concern that, without vibrant competition, this form of innovation will suffer, discouraging the development of new browser engine technology.

In the absence of enforcement, significant concentration has occurred and, in some cases, markets have tipped in favor of one or two companies. Ultimately, the resulting harm has already accrued to consumers and developers:

- **Desktop operating systems**—Windows remains unchallenged as the dominant desktop operating system.⁹²
- **Mobile operating systems**—Android and iOS remain the dominant mobile operating systems for smartphones (following failed attempts at market entry from other companies, including Mozilla⁹³). Native app requirements for their operating systems ensured that developers had little or no incentive to also develop for competing mobile operating systems. Most who tried, quickly failed. This includes Amazon's Fire OS, Microsoft's Windows OS, and Mozilla's Firefox OS.
- **Browsers**—Netscape failed. Competition from alternative browsers to those bundled on Windows, Android, iOS, Meta and Amazon devices is suppressed.

88 CMA Mobile Ecosystems Market Study, Final Report, 10 June 2022, page 260 onwards

89 CMA Mobile Ecosystems Market Study, Final Report, 10 June 2022, paragraph 7.14

90 <https://www.turing.com/blog/rust-is-the-most-popular-programming-language/>

91 "Investigation of Competition in Digital Markets: Majority Staff Report and Recommendations", July 2022

92 Around 68% of desktop operating systems in the US are Windows and 76% worldwide <https://qs.statcounter.com/os-market-share/desktop/united-states-of-america>

93 <https://techcrunch.com/2015/12/08/mozilla-will-stop-developing-and-selling-firefox-os-smartphones/>

- **Browser engines**—Consolidation of operating systems and their browsers fractured web compatibility. Three major browser engines exited the market, leaving only Mozilla and Google to steer cross-platform internet development.

INDEPENDENT BROWSERS IMPROVE SEARCH AND ADVERTISING

Google Chrome is captive to Google Search (powered by Google advertising) and Microsoft Edge is captive to Bing search (powered by Microsoft advertising). Independent browsers are the only companies able to freely consider search defaults on behalf of their consumers. They are also among the few companies to encourage discovery, evaluation, adoption and innovation of alternative search and advertising experiences.

Browser Amplification of Search

- **Exclusivity** - since the launch of Firefox, Mozilla has always provided users with a choice of multiple different search options. Software choice and customization are key aspects of open source development and Mozilla's mission.
- **Defaults** - Firefox is the only major browser to have switched its search default to an independent search company. From 2014 to 2017, Yahoo was its search default in the U.S.A., and also in Taiwan and Hong Kong for a shorter period. Customized distributions of Firefox are also available with other default search engines: Bing, Mail.ru, Web.de, Seznam, and Qwant.
- **Discovery** - every standard Firefox search query surfaces alternative search engines to increase awareness and make switching easier. This is absent from Edge, Chrome, and Safari. Contrast Figure 3 below with the examples set out in Part 2 of this report.
- **Evaluation** - trying other search engines is also made easier on Firefox through features like search shortcuts, autocomplete and keyboard shortcuts. Comparable features do not exist on Edge, Chrome, or Safari.
- **Adoption** - in contrast to the operating system examples highlighted in Part 2 of this report, Mozilla does not engage in online choice architecture practices to block, harass or trick consumers to use software, including search engines.

Firefox has also supported extensions since 2004, which increase discovery, evaluation and adoption of alternative search engines.

Queries typed by consumers into the Firefox URL bar show a prompt below to make it easier for consumers to search with other engines. Consumers can customize the search engines that appear in the prompt. As shown in Figure 3 below, the words “This time, search with:” precedes a line of alternative options.

Figure 3: Discovery of Search Alternatives in Firefox

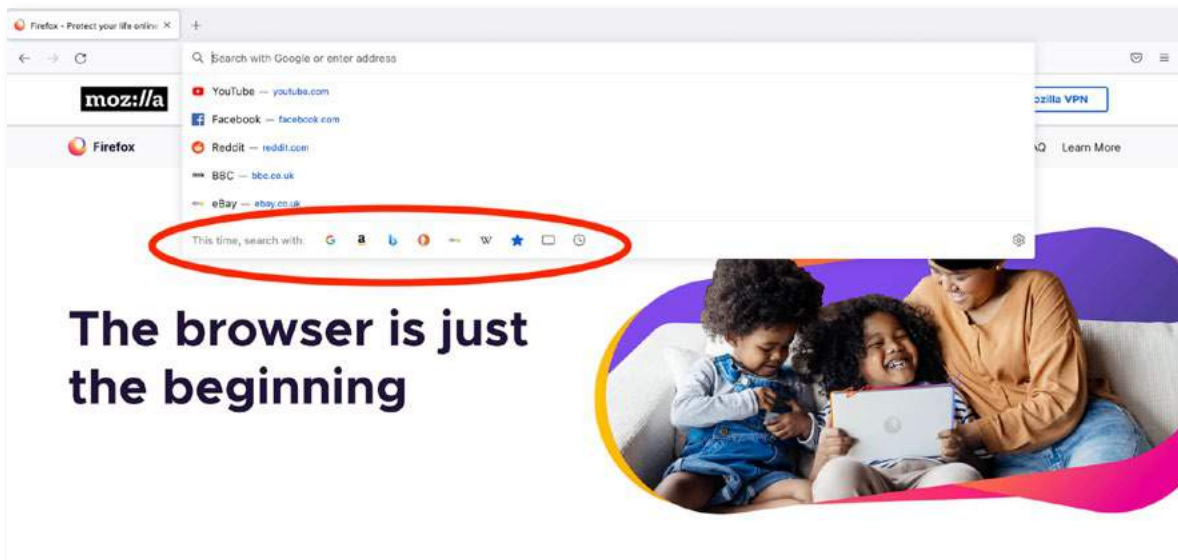
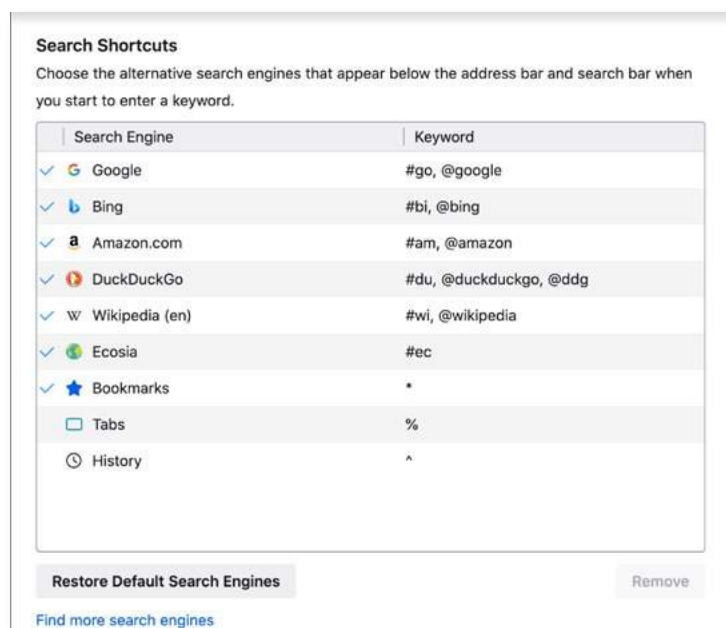


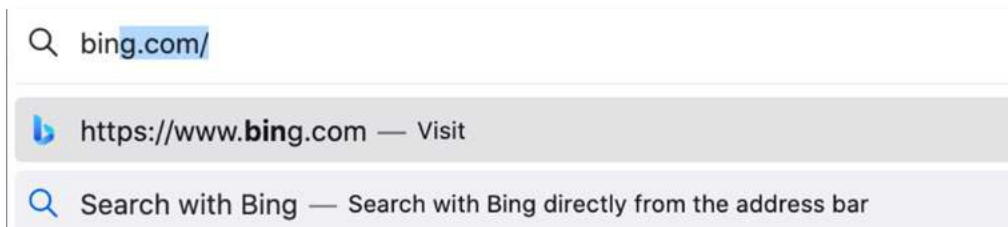
Figure 4 below demonstrates how Firefox users can choose their secondary search engines and see keyboard shortcuts from the Firefox “Preferences” menu under “Search”.

Figure 4: Evaluation of Search Alternatives in Firefox



If Firefox detects a consumer is typing the letters for a navigational search to “Bing” it will auto-complete the address and show the prompt below to make it easier for the consumer to search with Bing directly from the address bar, or to visit the Bing website if they prefer.

Figure 5: Direct access to alternative search options on Firefox



Firefox consumers can use keyboard shortcuts in the address bar such as “@DDG” or “@Bing” to enable an easy route to search directly from the address bar with DuckDuckGo or Bing.

Figure 6: Shortcuts to access alternative search options on Firefox



An important signal of consumer demand in the search market is the selection of defaults by independent browsers. Firefox users who frequently search are highly sensitive to which search product serves their needs best. One of the reasons that Mozilla ended its partnership with Yahoo was poor search product performance. Looking to the future, supply-side search remedies can improve the quality and reach of alternative search products. However, without a variety of independent browsers, alternative search engines will have few opportunities for default and secondary distribution and use.

In other words, browsers are relevant in the supply chain for search. This is why enhancing competition in the browser market is essential for independent search competition. In this context, remedies that would simply shift revenue from one dominant operating system to another, at the cost of independent browsers, will not further the long term health of search or the internet. By contrast, attempting to improve search and advertising competition

through default placement alone would significantly harm Mozilla and independent browsers. Global competition authorities have recognised default search placement as a source of income, funding independent browser operations, product development, investments into new features and technologies and allowing browsers to be provided free of charge to consumers.⁹⁴ Without default search placements, Mozilla's ability to fulfill its public benefit mission or serve as a counterweight amidst the tech giants in the internet ecosystem would be undercut.

Browsers also bring innovation to search and advertising. "Firefox Suggest" supplements the default search engine to create a more complete search experience that starts not at the Search Engine Result Page ("SERP"), but directly in the address bar **before** the SERP.⁹⁵ When a person starts typing, it suggests relevant results and websites. The outcome is to optimize web navigation and create opportunities for new specialized search and advertising experiences. At the same time, Mozilla does not believe that advertising needs to be as privacy invasive as it currently is today. For more than a decade, Mozilla has been at the forefront of launching anti-tracking technologies and propelling browser innovation forward to prevent advertisers from engaging in pervasive cross-site tracking.

94 For example the CMA Mobile Ecosystems Market Study; the ACCC's Digital platform services inquiry

95 <https://blog.mozilla.org/en/products/firefox/firefox-news/firefox-suggest/>

Browsers and the Quest for More Private Advertising

2009 - Mozilla leads the Do-Not-Track (“DNT”) Working Group at W3C. This is a signal sent by the browser to websites indicating that the user does not wish to be tracked online. All major browsers implement DNT. The advertising industry fails to adopt DNT and the initiative ultimately fails.

2015 - Firefox launches “Tracking Protection.” This was an important but small step. It is off by default and blocks ads that track.

2018 - Firefox launches Facebook Container based on several months of work to isolate first party cookies.⁹⁶ This is another small step forward against tracking.

2019 - Firefox launches with Enhanced Tracking Protection (“ETP”) based on learnings from earlier efforts alongside an “anti-tracking policy”.⁹⁷ ETP is a success, and drives all major browsers except Chrome to implement similar features.

2020 - Firefox blocks third-party fingerprinting resources⁹⁸ and includes protections against redirect tracking.⁹⁹ Mozilla leads the formation of the Privacy Community Group at the W3C.¹⁰⁰

2021 - Firefox takes on supercookies,¹⁰¹ introduces Total Cookie Protection,¹⁰² and trims HTTP Referrers to protect privacy.¹⁰³ Mozilla leads the formation of the Privacy Advertising Technology Community Group at the W3C.¹⁰⁴

2022 - Firefox launches Total Cookie Protection by default¹⁰⁵ and adds manual protections against link decoration.¹⁰⁶ Mozilla continues work on Privacy Preserving Advertising¹⁰⁷ through both criticism of and collaboration with Google, Apple, Meta and others.

96 <https://blog.mozilla.org/en/products/firefox/facebook-container-extension/>

97 <https://blog.mozilla.org/security/2019/01/28/defining-the-tracking-practices-that-will-be-blocked-in-firefox/>

98 <https://blog.mozilla.org/security/2020/01/07/firefox-72-fingerprinting/>

99 <https://blog.mozilla.org/security/2020/08/04/firefox-79-includes-protections-against-redirect-tracking/>

100 <https://www.w3.org/community/privacycg/>

101 <https://blog.mozilla.org/security/2021/01/26/supercookie-protections/>

102 <https://blog.mozilla.org/security/2021/02/23/total-cookie-protection/>

103 <https://blog.mozilla.org/security/2021/03/22/firefox-87-trims-http-referrers-by-default-to-protect-user-privacy/>

104 <https://www.w3.org/community/patcg/>

105 <https://blog.mozilla.org/en/products/firefox/firefox-rolls-out-total-cookie-protection-by-default-to-all-users-world-wide/>

106 <https://9to5mac.com/2022/06/29/tracking-parameters-urls-firefox/>

107 <https://blog.mozilla.org/en/mozilla/the-future-of-ads-and-privacy/>

Part 2:

The Consumer Design Tactics Used By Operating Systems to Undermine Consumer Choice

HOW ONLINE CHOICE ARCHITECTURE IS USED TO REMOVE CONSUMER CHOICE AND CONTROL

Online choice architecture (OCA) refers to the way design can shape the online environments in which people interact and make decisions.^{108 109} Design and experience choices can affect consumers and shape markets in significant ways (intentionally or not, and with or without consumer awareness) by influencing when, if and how people make decisions on their devices.¹¹⁰ Software developers in both private and public sectors use choice architecture to deliberately encourage outcomes that they believe are desirable or advantageous.

Choice architecture is an umbrella term for a wide variety of online practices. For example, OCA in operating systems might be used in a positive way to help people choose between similar products by pre-installing options that are the best choice for most people in a specific region. However, this same OCA practice can also be used in a negative way if the pre-installed choice does not align with most people's best interests and instead pushes people toward a product that benefits the operating system developer.

While people generally strive to make the best decisions in order to meet their goals, life is busy and people typically make trade-offs in order to balance the time and energy they have with the number of online tasks they hope to accomplish. Shortcuts can help people make decisions. For example, rather than undertaking endless research on which browser to use, people may focus only on software that is readily available on the homescreen or offered by a familiar brand.

For platforms with market power, OCA can be improperly used to maintain this market position, leverage this power into adjacent markets and influence consumer choices, for

108 CMA, "Evidence Review of Online Choice Architecture and Consumer and Competition Harm", 5 April 2022

109 CMA Discussion Paper, "Online Choice Architecture - How Digital Design Can Harm Competition and Consumers," April 2022

110 Sunstein, Cass R. *Choosing Not to Choose: Understanding the Value of Choice*. 1st edition. New York, NY: Oxford University Press, 2015

example through the software that people use on their operating systems. The U.K.'s CMA published the following taxonomy of choice architecture practices as a way to help recognize, categorize and explain the impact of these practices.

Figure 7: A Taxonomy of OCA Practices¹¹¹

Choice structure	Choice Information	Choice pressure
Defaults Ranking Partitioned pricing Bundling Choice overload and decoys* Sensory manipulation* Sludge* Dark nudge* Virtual currencies in gaming Forced outcomes	Drip pricing* Reference pricing Framing Complex language* Information overload	Scarcity and popularity claims Prompts and reminders Messengers Commitment Feedback Personalisation

We have followed this categorization of **choice structure**, **choice information** and **choice pressure** in our analysis of operating system OCA.

As noted in a recent research paper on negative OCA “...dark patterns are strikingly effective in getting consumers to do what they would not do when confronted with more neutral user interfaces.” In their research, Luguri and Strahilevitz found that, contrary to what might be expected, milder examples of deceptive and unfair practices were much more likely to be effective than more aggressive ones: “...aggressive dark patterns generate a powerful customer backlash whereas mild dark patterns usually do not. Therefore, counterintuitively, the strongest case for regulation and other legal interventions concern subtle uses of dark patterns.”¹¹²

The following part of this report highlights examples of negative online choice architecture from operating system providers in the context of browsers. This represents a small number of examples and likely a small proportion of the browser-related practices that occur since tracking and recording such practices can be challenging. Equally, studying and recreating them represents difficulties for researchers, due in part to their targeted nature and volume.¹¹³

111 “Online Choice Architecture - How Digital Design Can Harm Competition and Consumers - Discussion Paper,” n.d., 76.

112 Luguri, Jamie and Strahilevitz, Lior, Shining a Light on Dark Patterns (March 29, 2021). 13 Journal of Legal Analysis 43 (2021)

113 As noted by Lauren E. Willis, demonstrating digital deception can be hindered due to the “the micro-targeted nature of the design and delivery of digital business materials.... Consumer testing and experiments flounder because subjects cannot be identified who match, in pertinent respects, the consumers to whom specific digital materials were directed. Successful micro-targeting entails reaching consumers in the contexts and at the moments when they are most likely to respond in the manner desired by the business.” Willis, Lauren E., Deception by Design (August 12, 2020). Loyola Law School, Los Angeles Legal Studies Research Paper No. 2020-25, 34 Harvard Journal of Law & Technology 115 (2020)

EXAMPLES OF CHOICE STRUCTURE

As it relates to operating systems, the first category of OCA practices refer to the way in which choices are structured on the device. This can determine which apps and settings consumers can or are likely to see, how cognitively challenging or time consuming it is to choose an app or change a setting, how different options are ranked or presented, which options are designed to have the greatest and least resistance, and what happens once a consumer has taken action. Examples of harmful choice structure on operating systems include setting default choices that are not in consumers' best interests, changing the order or appearance of options to self-preference the platform, or making it difficult for consumers to make decisions by overloading choices.

Research conducted by the European Commission showed that choice structure practices like defaults and false hierarchy are among the most prevalent manipulative design practices.¹¹⁴ There is strong evidence that these practices (in particular default settings)¹¹⁵ have a significant effect on consumer behavior, and that they directly impact competition.¹¹⁶ In the context of browsers, the European Commission noted Microsoft's use of defaults to push consumers to its Edge browser as an example of pre-selection:¹¹⁷

Figure 8: Extract from European Commission report highlighting harmful design practices



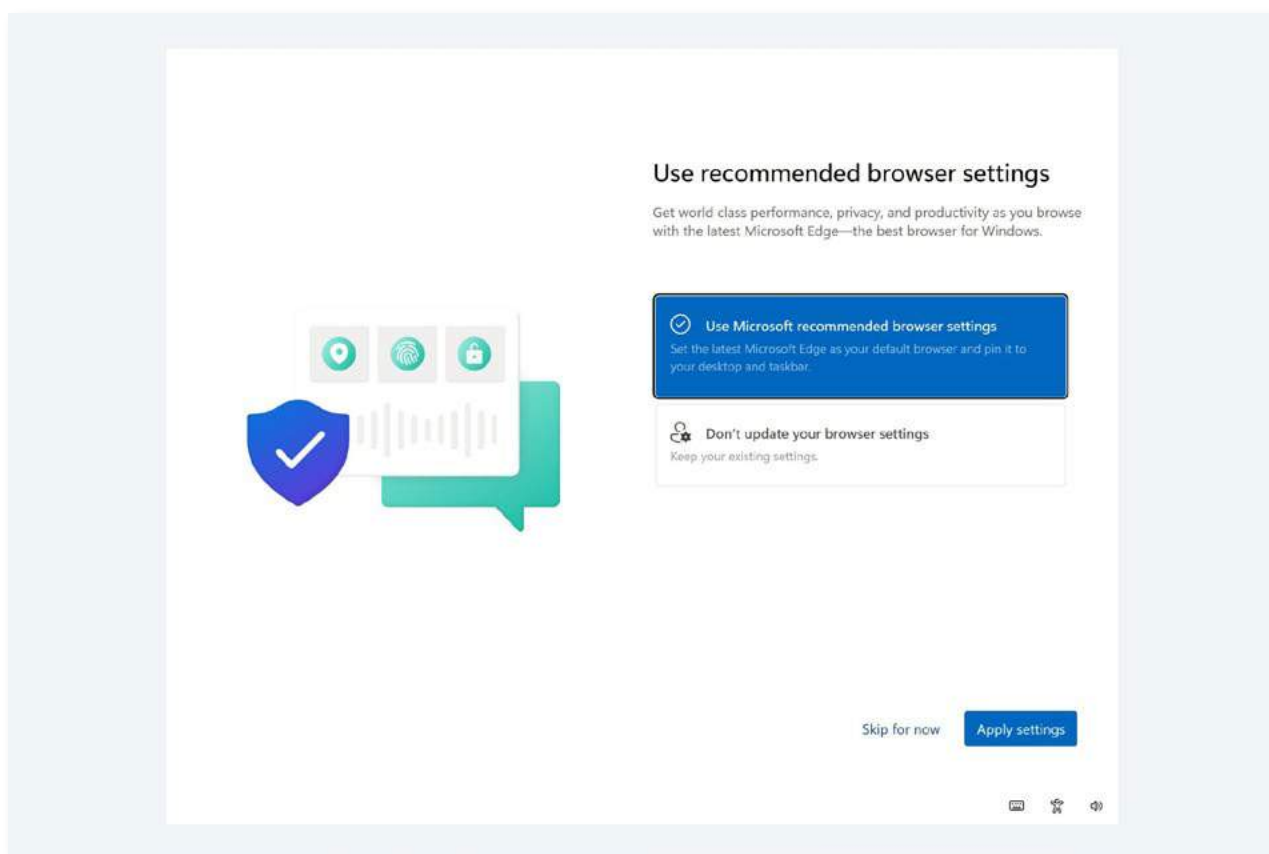
This extract from the European Commission's report shows a boot-screen presented by Microsoft to Windows 10 users. Users must navigate through this mandatory full-screen presentation, which includes a pre-selected option to set Edge as the default browser.

The screen also features graphics such as a lock icon that falsely suggests this is a security-related choice for the user. Clicking the pre-selected option overrides prior choices to set Firefox as the default browser.

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- 114 European Commission, "Behavioural study on unfair commercial practices in the digital environment: dark patterns and manipulative personalisation", page 45
- 115 "Online Choice Architecture - How Digital Design Can Harm Competition and Consumers - Discussion Paper," page 18
- 116 CMA Mobile Ecosystems Market Study, Appendix F: understanding the role of browser engines. Note, in particular, para. 17 and following: "There is a strong correlation between the browsers that are pre-installed and/or set as defaults on mobile devices and their usage (as measured by their share of supply). [...]"
- 117 European Commission, "Behavioural study on unfair commercial practices in the digital environment: dark patterns and manipulative personalisation", pages 283-4

Both before and since the Commission’s report, similar practices have been reported. In mid-2022, Windows 11 users were presented with a message that had the “Use Microsoft Recommended Browser Settings” option not only pre-selected but highlighted in blue (see Figure 9 below). This pre-selected option is accompanied by a checkmark, while the alternative “Don’t update your browser settings” is accompanied by a confusing icon. The use of the words “settings” and “update” imply that the user may be harmed if they select this option because, for example, they may not be running the most recent version. The screen includes additional irrelevant security-themed graphics, such as a fingerprint and lock icon, that appear designed to trick the user into thinking this is a security setting. The use of a “Skip for now” (emphasis added) rather than a “Dismiss” option also suggests to users that Windows will continue to present this screen to them unless or until they accede to Microsoft’s recommendations.

Figure 9: Windows 11 modal



As noted by Laguri and Strahilevitz “it is the mild dark patterns tested—like selecting an option that is good for a company’s bottom line but maybe not for consumers by default or by providing initial choices between “Yes” and “Not Now”—that are most insidious.”¹¹⁸

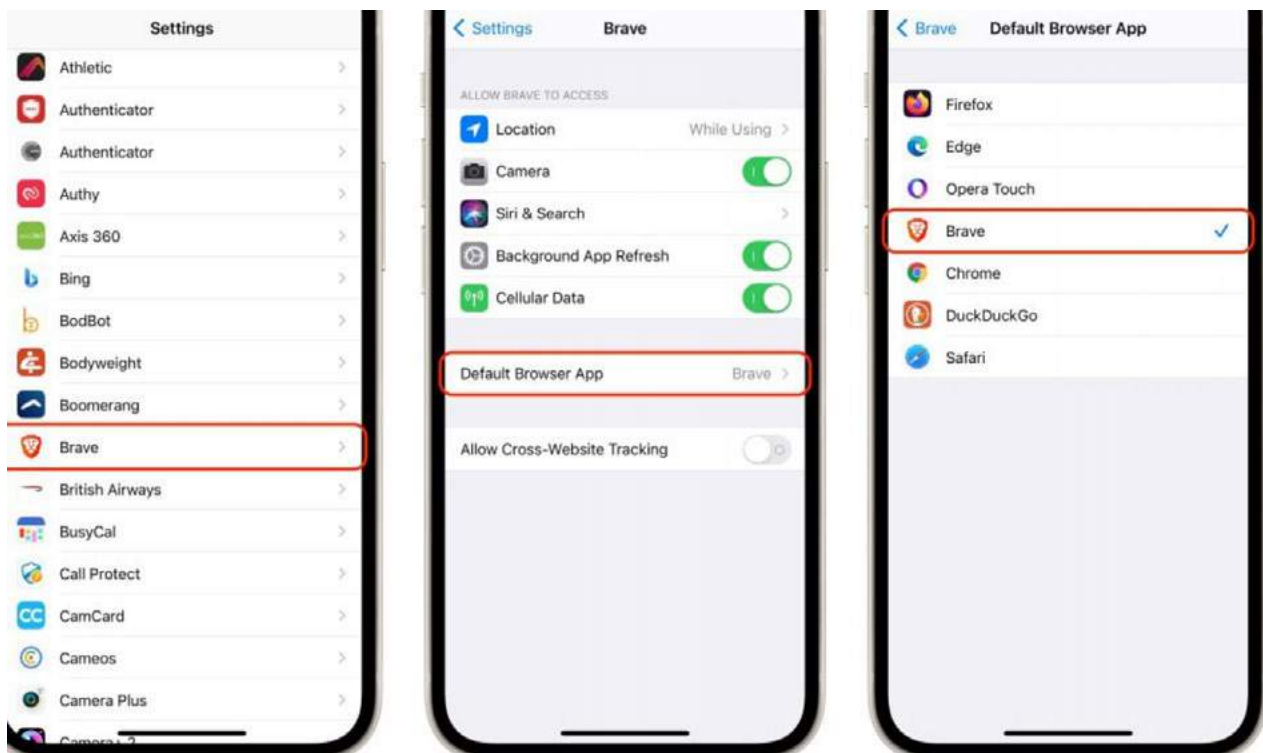
118 Luguri, Jamie and Strahilevitz, Lior, Shining a Light on Dark Patterns (March 29, 2021). 13 Journal of Legal Analysis 43 (2021), page 81

EXAMPLES OF CHOICE INFORMATION

The information provided to consumers when making choices can be framed in ways that highlight certain aspects over others. It can also be difficult to understand or access information until consumers have gone further through the process. For example, operating systems make it difficult for consumers to set Firefox as a default browser by using complex visuals and adding unnecessarily complicated steps that ordinary consumers would not remember or may not feel technically competent to perform. This distorts and reduces true consumer decision-making and weakens competitive pressure. Further examples of confusing or complex choice information presented to browser users on various operating systems are included below.

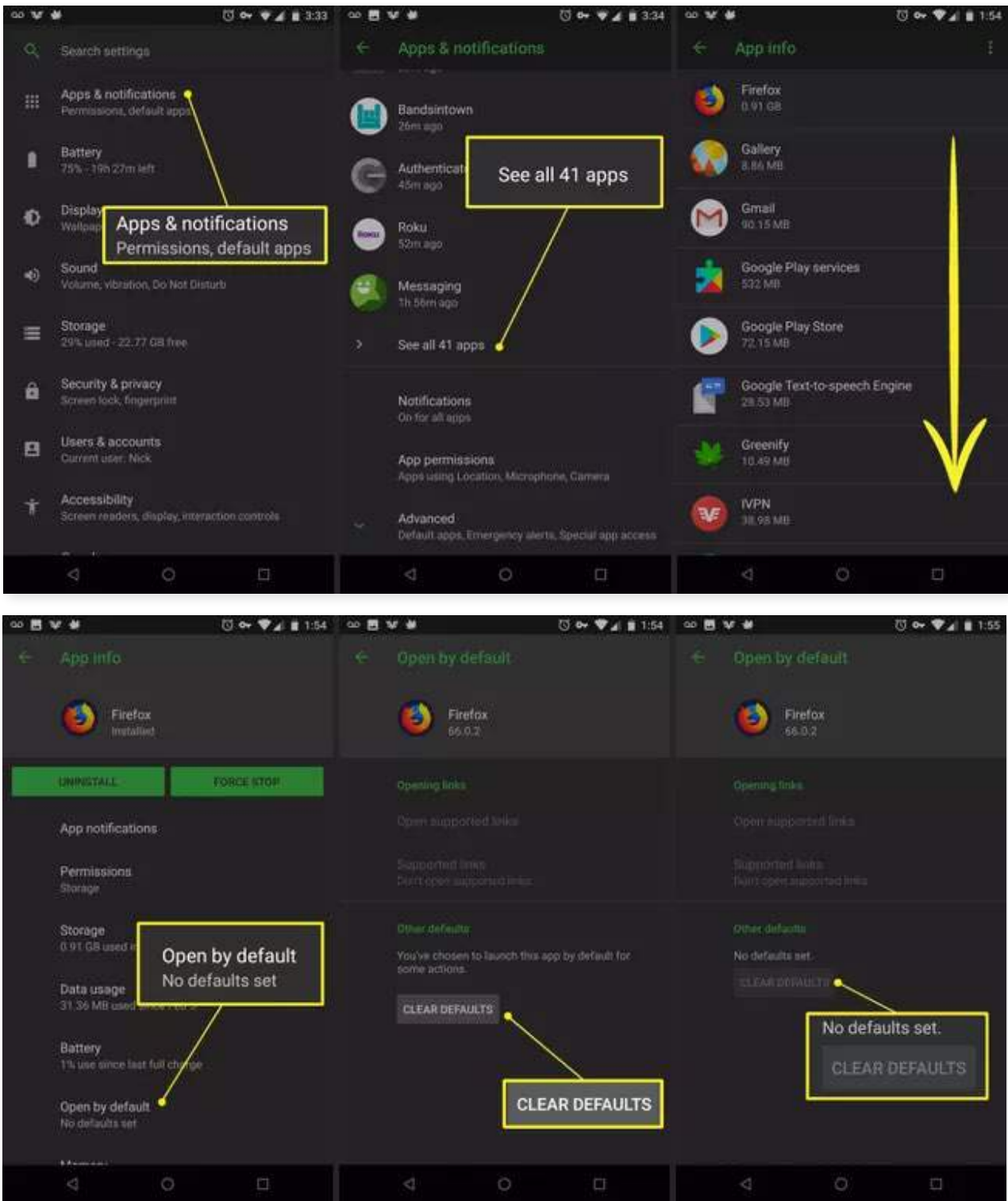
The following diagram shows the complexity of changing the default browser on iOS 14. There is no specific menu where a user can select their default browser; instead they must click on a browser within the settings menu and then select the option to change the default browser within the list of options for amending that particular browser's settings.

Figure 10: Multi-step iOS default settings menus



Even if a user works out how to change their default, they should be presented with easy routes to change these settings at a later point. Figure 11 below demonstrates the five step process an Android user would need to follow to clear the default settings on their smartphone.

Figure 11: Android menus for selecting default browsers¹¹⁹



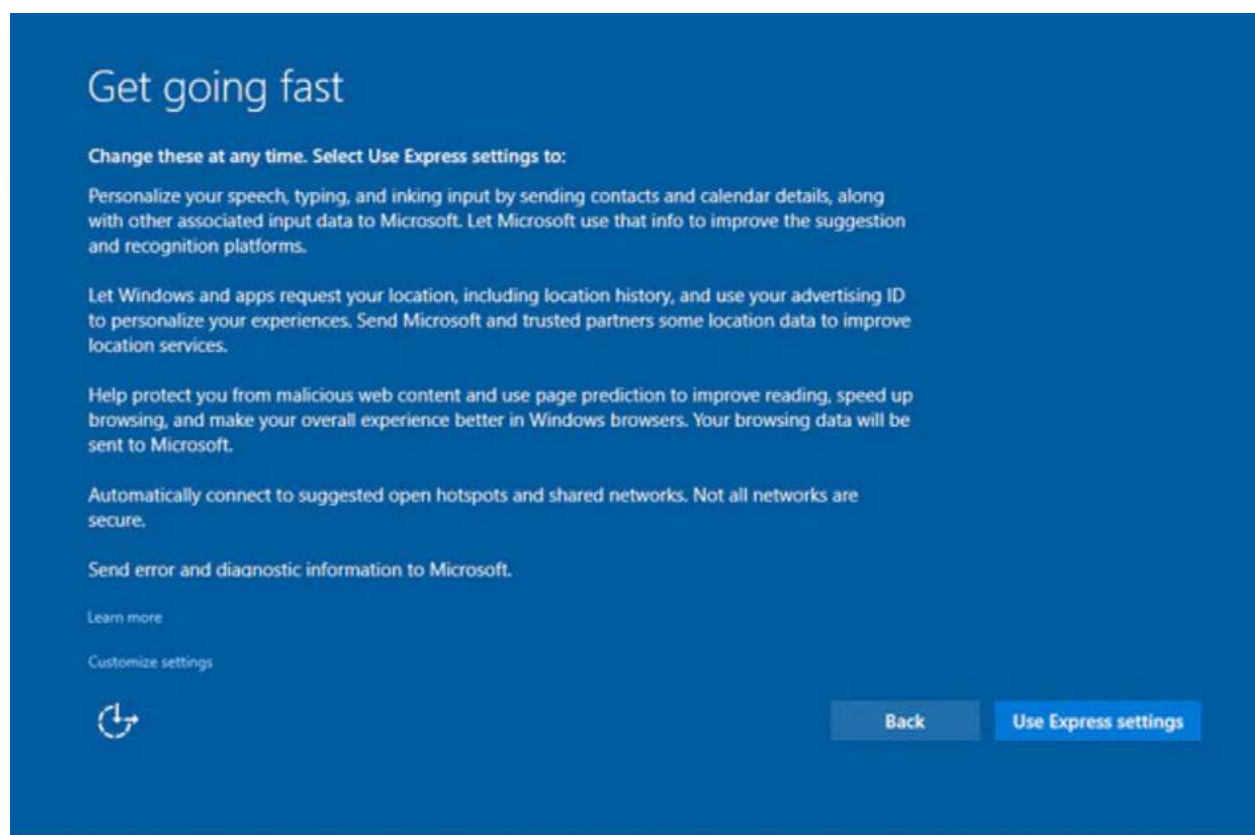
119 <https://www.lifewire.com/set-and-clear-android-default-apps-3886190>

EXAMPLES OF CHOICE PRESSURE

Operating systems can exert pressure on consumers to make certain choices using indirectly related factors, such as consumer habits, time pressure or trusted messengers. There is good evidence that choice pressure can affect decisions. Presenting fake or misleading information, scarcity or popularity claims and messengers (such as fake reviews) can be particularly harmful. A large body of academic research shows that both practices affect consumers' decision-making and may lead to impulsive or unsuitable choices or acquisitions, with a consequent weakening of competition. Choice pressure can also have benefits (for example, providing relevant feedback about product usage or allowing users to leave genuine product reviews).

Figure 12 below shows a set-up screen presented by Microsoft to Windows 10 users which uses the expression “*Use Express Settings*” at a moment when users are likely to be keen to start or continue with their task to push them to synchronize their apps with Microsoft and send data to “Microsoft and trusted partners”.

Figure 12: Windows 10 setup screen leveraging time pressure to favor Microsoft defaults



The following image demonstrates another example of choice pressure, through a prompt for Edge at the precise moment when a user is seeking to download an alternative browser. The prompt refers to Edge as “*the safer, faster browser for Windows 10*” and has the option

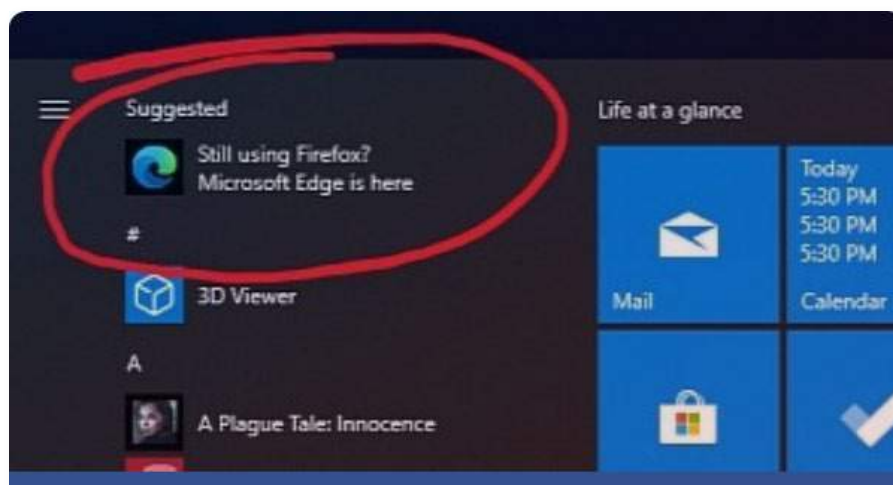
to open Edge in blue, while the button allowing the user to continue their task is greyed-out. This type of practice has been referred to as an “aesthetic manipulation dark pattern”.¹²⁰

Figure 13: Windows 10 modal using choice pressure to push Edge on Firefox users



Similarly, Figure 14 below demonstrates an example of an unexpected advert in the Windows Start menu which asks the user “*Still using Firefox? Microsoft Edge is here*”. The advert, presented by the operating system provider using their privileged position, is designed to nudge the user towards their own product, which is not set as the default.

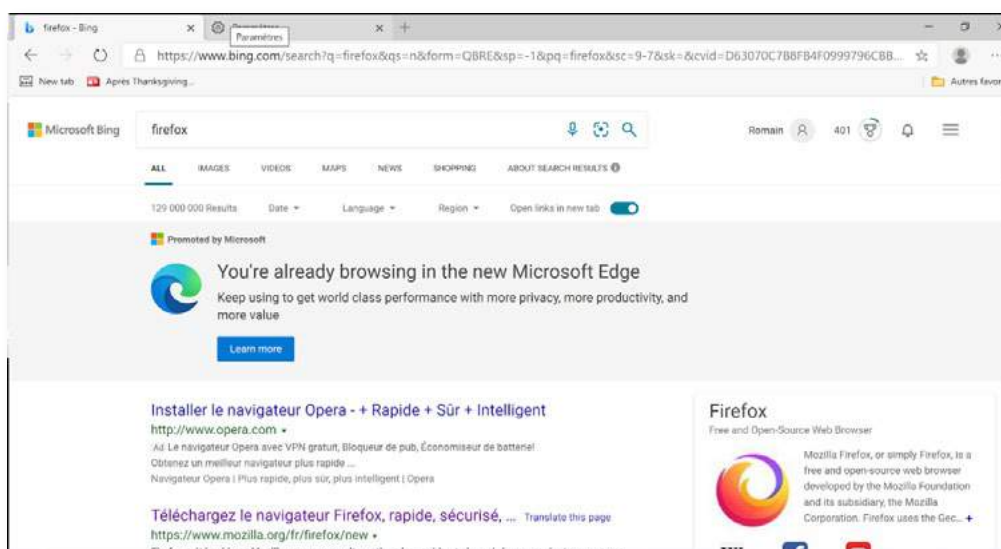
Figure 14: Windows modal using choice pressure to push Edge on Firefox users



120 Luguri, Jamie and Strahilevitz, Lior, Shining a Light on Dark Patterns (March 29, 2021). 13 Journal of Legal Analysis 43 (2021), page 51

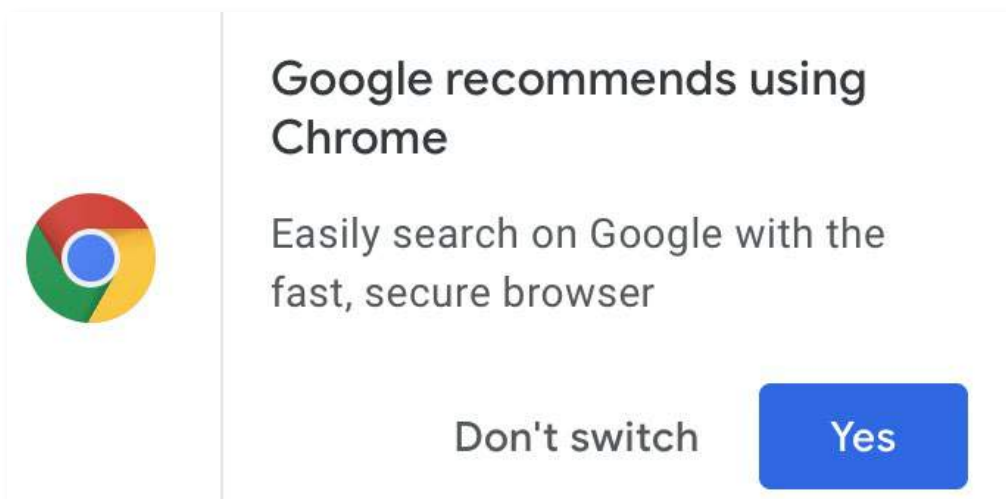
Examples of browser choice pressure also extend to search engines. In the following scenario, a Bing user is displayed an advert at the top of their search engine results page to dissuade them from downloading Firefox and prompted to use the browser which is already pre-installed on their Windows operating system (Microsoft Edge).

Figure 15: Microsoft using choice pressure to dissuade Edge users from switching to Firefox when searching in Bing



As shown in the following image, Google's Chrome browser presents a similar prompt to a Safari user as they access Google Drive. Annoyingly for the user, this prompt appears *every time* the person opens a new Safari window and uses Google Drive unless they take action to select the "Don't switch" option. Many people will inevitably select the bolded "yes" option, even if that outcome is not their intent.

Figure 16: Chrome prompt presented to Safari users visiting Google Drive



HOW ONLINE CHOICE ARCHITECTURE IS USED TO BOLSTER OPERATING SYSTEM BROWSERS AT THE EXPENSE OF ALTERNATIVES

Choice architecture practices by operating systems have made it increasingly difficult for consumers to choose independent browsers and for those browsers to compete for global market share. **Bundling mobile browsers as defaults has clear advantages for platforms and shapes mobile consumer behavior in a way that is difficult to shift.** As the CMA found in its recent Mobile Ecosystems Market Study, Apple directly determines which software is pre-installed and which defaults are set; Google has less direct control, though it exerts strong influence on Android device manufacturers via sizable payments for pre-installation.¹²¹ Similarly, as noted in the European Commission study above, Microsoft exerts a comparable influence on its Windows operating system to push users to Edge. Even where choices are offered to consumers, there are many examples of how choice architecture inhibits people's ability to make effective choices. **Nudges and the design of choices presented by operating systems generally lead to consumer decisions that are in the platform's best interests, and not necessarily those of consumers.**

The influence of operating system providers may also shape social and cultural pressures, which we know can also play a role in people's use of technology. A guiding theoretical framework for research into technology adoption and usage is the notion of "domestication." The domestication framework focuses not just on adoption and use but seeks to understand what "technologies and services mean to people, how they experience them and the roles that these technologies can come to play in their lives."¹²² It seeks to understand the ways in which users adapt (or don't adapt) to fit technologies into their daily lives.

Against that background, domestication theory is a useful lens through which we consider the findings of some of the research presented in this report since it does not assume that technology adoption is simply a series of rational choices. Instead it explores how it is also a social and cultural process. **Contextual, social, and cognitive factors like personal identity, recommendations from friends and family, the comfort people feel with technology, and the influence different choice architecture constructs have on people can affect how they approach and make decisions about the technology in their lives.**¹²³

In research recently conducted, introduced in Part 1 of this report, we found that people with greater comfort (feeling comfortable when taking an action) were more likely to have

121 CMA, Mobile Ecosystems Market Study, Final Report, section 3

122 Haddon, Leslie. "The contribution of domestication research to in-home computing and media consumption." *The information society* 22.4 (2006): 195-203.

123 Mozilla Study

installed a browser or changed a default browser on their device(s). People who expected to be uncomfortable taking these actions were less likely to have done so. We also found that the expectation of needing assistance (e.g. asking someone for help, looking up instructions) reduces the likelihood that people will take these actions. People who expected to need help changing the default on their device are, on average, less than half as likely to have made these changes. And people who expected to need to look up steps to help were a quarter less likely to change defaults as someone who didn't need help. There may be a proportion of people who, despite being uncomfortable or unconfident, do download alternative browsers and make changes to their default settings, but then are faced with and influenced by the messages and prompts shown in the previous section and reverse their decision, whether intentionally or not.

We know from choice architecture research that one of the ways defaults can impact user choice is through “implicit endorsement,” where people perceive the default as an endorsement by experts. Device and operating system level defaults are examples of implied endorsements. **People with low knowledge, comfort or confidence around downloading and installing browsers or changing browser defaults who we found were less likely to take these actions are more likely to be influenced by the operating system provider.** They are more likely to follow the signal of an implied endorsement from a manufacturer and thus stick with a pre-installed browser and other defaults, which may not always be in their best interest.

Consumers typically go through several stages in the process of adopting a new product. These include: (1) product discovery; (2) evaluation; and (3) adoption. These stages are assessed in the next section. Barriers to browser adoption occur throughout each stage, pushing people away from adopting a browser that did not come bundled on the operating system.

In addition, we know first-hand from years of research that people who consider switching browsers often encounter barriers which are not related to the OCA presented by platforms. These barriers include things like the inability to port (easily or at all) stored personal data like passwords and bookmarks; not knowing how to change device defaults; and not even knowing that browsers can be changed. This also highlights the importance of interoperability to ensure that, even when consumers are able to find and access independent browsers, their choices are not thwarted and instead facilitated or given effect.

CONSUMER DISCOVERY OF BROWSERS

Brand

Multiple studies suggest that brand awareness is an important factor in the decision to use certain apps as well as how consumers evaluate performance. For example, an early study into search engines found that branding affects overall web search at four stages: (a) search engine selection; (b) search engine results page evaluation; (c) individual link evaluation; and (d) evaluation of the landing page.¹²⁴ Similarly, a 2020 study into privacy indicators for apps found that privacy concerns decrease as an app's popularity increases. In fact, participants deliberately ignored negative privacy indicators due to apps' popularity attributes.¹²⁵

The CMA found a loyalty towards operating systems when considering the cross-ownership of devices. It noted that: “[w]hile there may be more cross-ownership when considering smartphones and tablets with different operating systems, this appears still to be low. For example, a survey provided to us by [a party] showed that [60-70]% of respondents who owned an iPhone also owned a tablet and of those only [10- 20]% had a tablet using another operating system (ie [10-20]% of all respondents who owned an iPhone). Similarly, only [50-60]% of respondents who owned a Samsung smartphone had a tablet and of those only [20-30]% had an iPad (ie [10-20]% of all respondents who owned a Samsung smartphone). This is also consistent with evidence from app developers that only a small proportion of their users access their apps on both Apple and Android devices.”¹²⁶

Specifically in relation to the perception of browsers and performance, Mozilla researchers conducted a study in 2021 into the effectiveness of priming.¹²⁷ This is the idea based on psychological research that people rarely take into consideration all available relevant information when making decisions; instead, to minimize cognitive effort, people draw on a limited subset of information, often consisting of whatever is most accessible and comes to the mind quickly. **This study found that priming about the performance of Firefox (reading articles about Firefox) increased participants' perceived performance of Firefox over the most widely used web browser, Google Chrome.**

These factors point to the platform's brand being at the front of consumer minds when using that platform. It is therefore highly likely to have an impact on the perception and ultimately use of the platform's own browser, particularly taking into account the cross-promotion that

124 Jansen, B. J., Zhang, M., & Schultz, C. D. (2009), Brand and its effect on user perception of search engine performance, *Journal of the American Society for Information Science and Technology*, 60(8), 1572–1595

125 S. Bock and N. Momen “A Study on User Preference: Influencing App Selection Decision with Privacy Indicator” (2020)

126 CMA, *Mobile Ecosystems Market Study*, Interim Report

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occurs between platform products. Operating system providers, particularly Google, have an extensive range of marketing and advertising resources which can be deployed to promote their brand and products; this effectively serves as constant priming for their browser.

The introduction of this Part 2 noted that OCA is a neutral term; there is of course nothing inherently wrong with companies marketing their services. However, where these marketing messages are in fact deceptive design practices used by powerful platforms to undermine consumer choice and prevent switching away from their affiliated browsers, it harms competition and ultimately consumers. Similarly, companies are and should be free to build their brands. But where branding is used by gatekeeper operations systems alongside negative OCA, or brands are built and promoted using harmful design practices, it also leads to consumer harm, including the outcomes described in Part 1 of this report.

In terms of how these factors play into consumer switching behavior: on desktop, people may have a stronger browser preference and, although they may be hindered by the operating system practices outlined above, they may take more effort to select and use a preferred browser. In some cases, the recommendation to use a specific browser may come from an employer or academic institution. Some people may even sync their browser history and preferences to have a unified browser experience across their desktop and mobile devices. We know from our research that 24% of people in the United States who are using Firefox as their main desktop browser also use Firefox as their main mobile browser. Very few people who are *not* using Firefox as their main desktop browser report using Firefox as their main mobile browser.¹²⁸ This not only highlights concerns around the contestability of the mobile browser ecosystem, but it also underlines the importance of effective browser competition and choice on desktop computers.

For consumers using mobile browsers, the combined factors of pre-installation satisfaction, utility, lack of differentiation and inertia mean that they are even less likely to seek out alternative mobile browsers that may better suit their needs, align with their values or offer more privacy and security. Our research shows that some people are unaware of what browser they are using, only that it was pre-installed.

"I think it's Chrome? I never really worried about what browser I had on my phone, actually. It's just the one that's installed by default."

— 23-YEAR-OLD, FRANCE¹²⁹

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Others were unaware that they could download alternative browsers. Some thought that because they owned an Android — or a “Google Phone” — that using Chrome was either required or that it would be the most integrated into their phone.

Moderator: “Have you ever looked into using another browser on your phone?”

Respondent: “To tell you the truth, I don’t even know if that’s possible. I thought with Android you had to use Chrome — like Windows always used to come with Internet Explorer installed.”

— 35-YEAR-OLD, FRANCE¹³⁰

Moderator: “What browser do you use on your phone?”

Respondent: “Google Chrome”

Moderator: “Why do you use that?”

Respondent: “Because it’s integrated into the phone. When you buy this phone from this manufacturer, it automatically comes with Google and then you never really want to nor have the time to have several browsers on the same phone.”

— 29-YEAR-OLD, FRANCE¹³¹

Others were hesitant to download an alternative since they felt their needs were met with their pre-installed browser, or there was not much difference between mobile browsers.

“At this point, many of the browsers are pretty similar. It seemed easy to use and I stuck with it.”

— 32-YEAR-OLD, UNITED STATES¹³²

Digital literacy may also factor into pre-installed mobile browser usage, as many consumers are unfamiliar with the steps to navigate to the app store, create an account linked to a payment method and download apps. As previously noted, our research showed that comfort levels factored heavily into whether consumers were likely to engage with alternative browsers. However, it should be noted that the availability of browser choice and the presentation of that choice is even more important than individual characteristics since these operating system barriers impact all people.

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"I would be intimidated by the word 'setting' ... That sounds like big-time stuff and I should not be messing with it."

— 46-YEAR-OLD, UNITED STATES¹³³

Finally, many participants were concerned about the space they had available on their phones, so downloading an additional browser did not work for them.

"So far, I don't really see the point of having several different browsers on the same phone. Unless the browser is really much more powerful and performs much better than the other one."

— 29-YEAR-OLD, FRANCE¹³⁴

Pre-Installation

While people may be more selective on desktop, research shows that most people tend to use the pre-installed browser on their mobile devices.¹³⁵ The operating system exerts significant influence over the browser that comes pre-installed and the software that consumers use. Operating system providers like Apple and Google say they provide smartphone consumers with a "premium out of the box experience" by providing a suite of pre-installed and default apps.¹³⁶ But these settings clearly influence consumer behavior. For example, a recent survey commissioned by the Australian government found that the main smartphone browser for over 70% of respondents came pre-installed on their phones, and for 55% of respondents it was the *only* browser used. By contrast, the main desktop browser used was pre-installed in 44% of cases.¹³⁷

In its Mobile Ecosystems Market Study, the U.K.'s CMA noted that "[t]here is a strong correlation between the browsers that are pre-installed and/or set as defaults on mobile devices and their usage (as measured by their share of supply)," pointing to Safari's 90% share on iOS and Chrome's 74% share on Android. It also noted the strength of Samsung Internet and Huawei Browser on those companies' devices relative to non-Samsung and non-Huawei devices, as well as the position of Edge on desktop (where it benefits from pre-installation and other preferential treatment on the Windows operating system), compared to its position on mobile, where it does not have the same benefits and has no material market share.¹³⁸

133 Mozilla Study

134 Mozilla Study

135 European Commission decision Google Android, 18 July 2018, paragraphs 900 onwards ("Pre-installation is an important channel for the distribution of mobile web browsers on smart mobile devices").

136 "Appendix G: Pre-Installation, Default Settings and Choice Architecture for Mobile Browsers," n.d., 31.

137 Morgan, Roy. "Prepared for the Australian Competition & Consumer Commission Digital Platform Services Inquiry Third Interim Report September 202," n.d., 123.

138 "Appendix G: Pre-Installation, Default Settings and Choice Architecture for Mobile Browsers," paragraphs 17 to 21.

Moderator: "And, then on this phone what browser are you typically using?"

Respondent: "Just Google Chrome, because that's what's on here, because it's Android."

— 20-YEAR-OLD, UNITED STATES¹³⁹

Moderator: "What browser do you use on your phone?"

Respondent: "I think it's just Google....I just go with what's on the phone."

— 54-YEAR-OLD, UNITED STATES¹⁴⁰

Utility

The smartphone browser is often viewed as a basic smartphone utility. Some people do not give much thought about the browsers pre-installed on their device. As noted above, this reflects the user experience that operating system providers seek to create, to the detriment of browsers not provided by vertically-integrated companies.

"I never thought of using another browser on my phone in all honesty."

— 61-YEAR-OLD, UNITED STATES¹⁴¹

"You use it every day, you never really look at it, you just use it. You never really examine it."

— 31-YEAR-OLD, GERMANY¹⁴²

Moderator: "Do you remember how you came to use Safari on your phone?"

Respondent: "It's the default. I never — like I think I downloaded Chrome once; again, I didn't really use it. It just didn't seem necessary, so I got rid of it."

— 22-YEAR-OLD, CANADA¹⁴³

Many people see a mobile browser as a basic tool used in day-to-day life to find information. Whereas multi-device users use their desktop browsers for a wide range of activities including accessing social media, communication platforms and entertainment. On mobile, many activities are commonly accessed via mobile apps. **Our view is that the historic lack of**

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competition in mobile browsers and browser engines may help explain why consumers are less aware of the options available to them. These circumstances have persisted for many years: Since 2012, Android and iOS have been the largest operating systems globally¹⁴⁴. And since 2014, Chrome and Safari have been the largest browsers, now accounting for almost 84% of total mobile browser use.¹⁴⁵

Differentiation

Despite considerable investment from browser companies to differentiate their products, some people don't even really know what mobile browser they are using. Or, people may cycle between multiple browsers on a single device without much loyalty if they encounter performance or web compatibility issues. As described in Part 1, many of these issues and lack of differentiation stem from operating system restrictions.

"My phone is--right now, I have Safari up, but sometimes it's--I felt like it was Internet Explorer. I guess Safari. I thought it was Internet Explorer. So--I guess that's what came--I always thought it was Internet Explorer, but it's Safari that's on my phone."

— 30-YEAR-OLD, CANADA¹⁴⁶

Moderator: "How did you come to use Chrome on [your phone]?"

Respondent: "Basically, I told you today--basically, I do Chrome everywhere...Wait, this is Safari. So, actually I really don't mind which."

— 52-YEAR-OLD, JAPAN¹⁴⁷

Inertia

The experience of mobile browsers as basic utilities and the perceived lack of differentiation among them mean that the browser that comes pre-installed on a device is at a huge advantage. This benefits the operating system and not necessarily the consumers. Many people are hesitant to switch to a new browser because they quickly become accustomed to their pre-installed browser and do not have a strong incentive to seek out an alternative, or may be hindered from discovering one. **This conditioning of consumer behavior over a long period of time means that moving away from a satisfactory pre-installed browser is an active choice that takes some amount of cognitive effort.** If people are busy or if the process is too confusing, people put off making a change or decide not to make it all. For many people, it is easier to simply continue with the status quo or put off the decision for a later time.

144 <https://gs.statcounter.com/os-market-share/mobile/worldwide/#monthly-200901-202207>

145 <https://gs.statcounter.com/browser-market-share#monthly-200901-202207>

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"I usually use whatever I use and I don't like to switch browsers just because who does that? (Switching to) Firefox is such a hassle because it's extra work, it's like buying OK bagels right here, or, like, (better bagels) five blocks away. Even though they're better, like, nobody's gonna walk five blocks."

— 34-YEAR-OLD, UNITED STATES¹⁴⁸

Respondent: "To transfer — like I'm sure it's pretty simple. I'm sure Chrome has like the capability to take all that information from Firefox or whatever, but it just — I'm lazy I guess when I use it. So, might as well stick with Firefox for now."

Moderator: "And have you ever considered using Firefox on your phone?"

Respondent: "No."

Moderator: "Okay and why do you think that is?"

Respondent: "Again, because, you know, Safari is the default. It's easiest to use. If for some reason, like there was something I could do with Firefox that I couldn't do with Chrome or with Safari, I would maybe use it. But, right now there, you know, I just don't—there's no utility to it. "

— 22-YEAR-OLD, CANADA¹⁴⁹

"Yeah, I feel like the Chrome on my phone is already there and it's like the easy button."

— 42-YEAR-OLD, UNITED STATES¹⁵⁰

Consumers also differ in capability and desire to make changes. Some people want to customize the software on their devices and change default settings; others don't want to be bothered and prefer the convenience of pre-installed software and default app settings.

Age, literacy, education level, digital skills, web literacy and software familiarity all contribute to people's understanding of their devices, operating systems, software and the internet.

"It's already there. It's a matter of both convenience and then just the idea of adding another one on when that stuff's already there..."

— 42-YEAR-OLD, UNITED STATES¹⁵¹

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CONSUMER EVALUATION OF BROWSERS

We have also seen in our research that privacy and security, although appreciated by many consumers, are not the main drivers during browser evaluation.¹⁵² Rather, **some of the most common criteria for evaluating a new browser includes familiarity, data portability, endorsement by others, and interoperability.**¹⁵³

Familiarity

People often do more to avoid losses than pursue corresponding gains.¹⁵⁴ Many people are hesitant to switch to a new browser because they have become accustomed to their pre-installed browser. Among users who download Firefox as an alternate mobile browser, nearly all are also using Firefox on their desktop computers. Our research shows that in the U.S. less than 6% of people who use a desktop browser other than Firefox report using Firefox on their smartphone.¹⁵⁵ **This suggests that the more people use Firefox or another alternative browser on their desktop computer, the more likely they may be to try that browser on their mobile device.**

"It's [Firefox] not what I'm used to."

— 30-YEAR-OLD, UNITED STATES¹⁵⁶

"I think it's more well known. Just, just in my head. Google, the name. There's not really any difference. I'm just used to using that."

— 28-YEAR-OLD, UNITED STATES¹⁵⁷

Saved Data

Many people fear that changing browsers will cause them to lose years of precious data such as passwords, bookmarks and history. Relatedly, others don't know how to port these to try a new browser or believe it would be too much work. **This magnifies the power of the operating system which can choose either to stifle competition (by doing nothing or even inhibiting switching) or to help consumers (by making porting data easier).**

152 Mozilla Study

153 Mozilla Study

154 Kahneman, Daniel, Jack L. Knetsch, and Richard H. Thaler. 1991. "Anomalies: The Endowment Effect, Loss Aversion, and Status Quo Bias." *Journal of Economic Perspectives*, 5 (1): 193-206.

155 Mozilla Study

156 Mozilla Study

157 Mozilla Study

"I have always used Chrome. so like all the bookmarks and everything is just kind of there already. It's just, I don't want to make a full transition over to anything else because it's just, that's just too much work."

— 32-YEAR-OLD, UNITED STATES¹⁵⁸

"I'm just, like, so moved into Chrome, like I live in Chrome. It has years and years and years of my information and passwords for websites I didn't remember, it just has all my stuff and so that's definitely like keeping me there. There hadn't been a reason to change."

— 47-YEAR-OLD, UNITED STATES¹⁵⁹

Implicit Endorsement

As noted above, when the operating system has set forth specific rules or norms, many people believe that they have been given an implicit recommendation by experts. This also plays into people's evaluation of the products they use. In some contexts, people may even think it is risky to do something different unless they have additional information that would justify changing it.

Interoperability / Bundling

People identify strongly with the *device* they are using to access the internet and not always the specific browser. People care deeply about page load speed, multitab management, battery life, security and whether webpages and services work or break. This last factor of webpages not breaking (i.e. web compatibility), is so critical that people will switch to another browser if enough webpages or services do not perform well.

"I tend to typically use Internet Explorer, although I've been having some problems with it, especially when I'm trying to attach things. So, if I'm trying to attach an e-mail or like attach a document to an e-mail or even one or two times recently I've tried to attach a document for an online application and it hasn't gone through. It'll open up the window, you know, where you can select, but it--and then you'll hit okay, and then nothing will upload. So, it's interesting. So, because of that, I've been switching a bit to Mozilla and to Google Chrome"

— 27-YEAR-OLD, UNITED STATES¹⁶⁰

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"My favorite thing about Chrome is that I can sign in on all my devices."

— 18-YEAR-OLD, CANADA¹⁶¹

"As far as like browsers, this is a Google Pixel, so I kind of have all my information within like the Google system just because it's like cross-compatible, which I like. And I have Google Chrome, as well. So, the fact that all those are synergistic is one of the reasons why I'm like an Android user and like why I predominantly use Google."

— 20-YEAR-OLD, UNITED STATES¹⁶²

Our research shows that many consumers have a perception that Chrome is the browser that works best on Android phones, and that products from the same company will perform better together (e.g. Gmail will work better in Chrome). As shown in Figure 16 above, this messaging is part of Google's cross-product promotion. It is also closely linked to web compatibility issues and the extent to which operating system providers restrict or allow interoperability of third party browsers, including accessing the same features and APIs afforded to their own browsers.

CONSUMER ADOPTION OF BROWSERS

Fully adopting a new browser is not possible unless the operating system allows consumers to choose a new browser default, remove the old browser and pin the desired new browser to the task bar or home screen dock.

Defaults

Defaults are a predefined operating system setting that consumers must take active steps to change. Defaults are not necessarily bad. Without them, consumers would be overwhelmed by numerous active choices, i.e., consumers would need to "build" their device when first activating it. For example, when paying at a restaurant many people find that default tip screens are convenient to save them the time of calculating the correct amount. In another context, the E.U.'s General Data Protection Regulation prohibits pre-ticked boxes for obtaining user consent to process personal data. Thus the default setting is to protect consumer privacy.

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As previously noted, operating system providers often cite the need for a “*seamless and superior out-of-the-box experience*” as the reason for setting their browser as the default.¹⁶³ Research has shown that **defaults can be very effective in influencing choice, particularly when they are: (1) seen by the consumer as conveying what the designer of the user interface thinks they should do; (2) difficult to switch away from; and (3) seen as reflecting the status quo.**¹⁶⁴

This effect of default settings on consumer choice is heightened when combined with other practices. As noted by the CMA: “*Defaults may also be combined with other OCA practices to make them more effective, including sludge (making it hard to change the default), forced outcomes (overriding or seeking to push the consumer to change a default reset by a consumer), framing (not accepting a default may be presented as being risky or unusual)...*”¹⁶⁵ As is clear from the evidence presented in this paper, each of these practices is employed by operating system providers in the context of browser choice.

In some instances, multiple OCA practices are combined with default settings. As demonstrated in figures 8 to 16 above, the user journey for changing default browsers on Windows, iOS and Android devices involves a number of potentially complex steps. Additionally, the relevant option in device settings for switching defaults may not always have intuitive text labels, making it harder for users to search for them.

Moderator: “If you wanted to change your default [browser on Windows], how do you think you would do it?”

Respondent: “I’m not sure how I would change it ... see, I don’t know if it is a file or not... this is when I would call [spouse]. I’d just maybe click around until I found it. But yeah, I don’t know where it is or how I would find that.”

— 46-YEAR-OLD, UNITED STATES¹⁶⁶

On iPhone and Android smartphones, the user journeys involve downloading an additional browser from the App Store or Play Store and navigating to the relevant option in the device settings to choose the preferred browser; this can require six to seven steps, depending on the device.

163 CMA, Mobile Ecosystem Market Study, Appendix G, paragraph 13

164 Jachimowicz, J. M., Duncan, S., Weber, E. U., & Johnson, E. J. (2019). When and why defaults influence decisions: A meta-analysis of default effects. *Behavioural Public Policy*, 3(2), 159-186

165 Competition Markets Authority, *Online Choice Architecture: how digital design can harm competition and consumers* (April 2022)

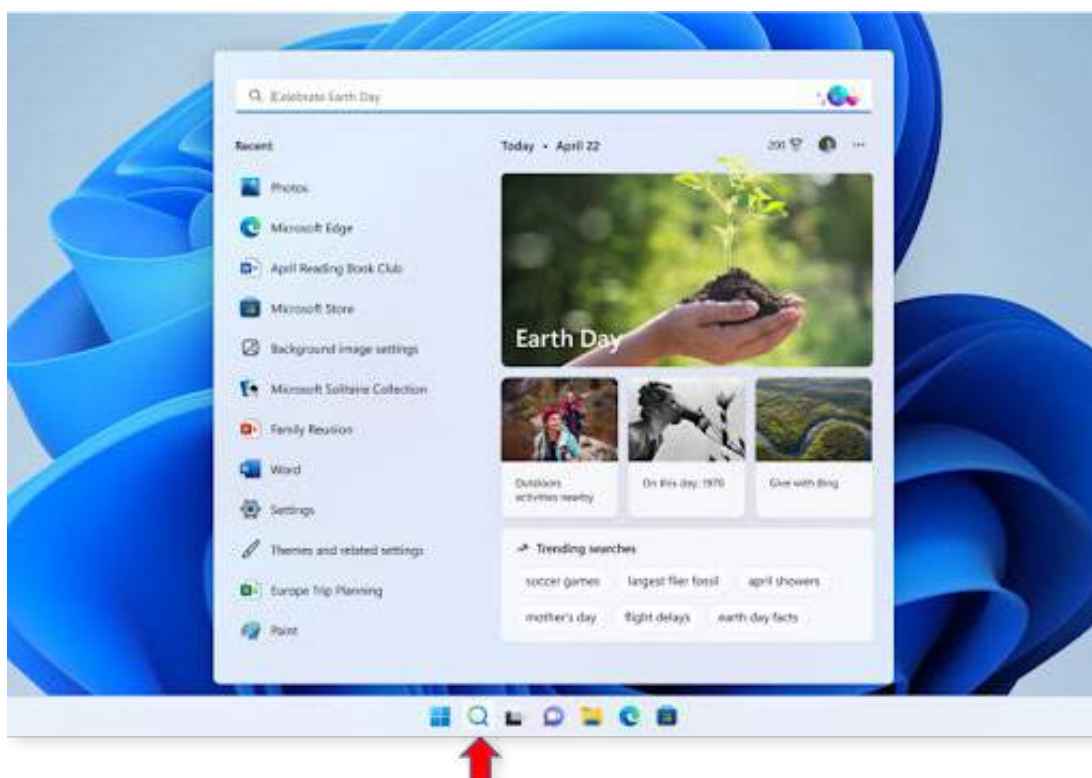
166 Mozilla Study

Our research on interactions with defaults (table 4 above) showed that fewer than half of respondents in the U.S., U.K. and France knew how to change the default browser on their smartphone, and the same was reported on desktop (with the exception of France where slightly more than half - 54% - said they knew how to do so). Unsurprisingly, the proportion of respondents who actually changed their default browsers were far lower - at least 10% and in some cases over 20% lower - than the rates of reported knowledge. Interestingly, respondents from Kenya and India were much more likely to know how to change their default browsers and to do so, underlining the importance of taking account of regional and cultural variances in designing products - and remedies.

Operating System Preferences

Even when an alternative browser is downloaded and selected as default, this decision is not applied in all circumstances; the operating system provider will in some scenarios bypass this decision and present their own browser rather than the selected default and in other cases it will seek to undermine or reverse this decision. For example, performing a “lookup” after selecting text in iOS would historically always open web search results in Safari, regardless of which default browser is selected by the user. Similarly, opening up a web link in the Windows search bar or icon opens Edge - again regardless of the default browser setting (see figure 17 below highlighting the taskbar search icon which opens web links in Edge). As another example, using the search widget on Android will always open results in a Google browser.

Figure 17 - Windows search icon bypassing default browser selection



This demonstration of OCA highlights just some of the practices used by operating systems to preference their own browsers and undermine consumer choice. Lawmakers and policy-makers in some countries have started to take action against deceptive patterns to protect consumers. And others have begun to address the lack of effective competition in digital markets, including through introducing regulation. However, very few have recognized the connection between these issues and the importance of browser competition, or studied the role of OCA practices as a way to implement (or thwart) consumer choice and welfare.

Conclusion

We believe that if people had a meaningful opportunity to try alternative browsers, they would find many to be compelling substitutes to the default bundled with their operating system. These opportunities have been suppressed for years through online choice architecture and commercial practices that benefit platforms and are not in the best interest of consumers, developers or the open web. It is difficult to overstate the impact of years of self-preferring and undermining consumer choice, including its effect on consumer behavior. It is also difficult to estimate the disruptive innovation, alternative products and features, and the independent competitors which have been lost as a result of these practices.

An important incentive for Mozilla's open-source work has always been to level the competitive playing field so that developers and web users can shape their own online experiences. We hope this report is a useful addition to the efforts underway to address the lack of competition and choice in digital markets and to shine a light on the critical role of browsers and browser engines.

Despite the problematic practices described in this report, the fact remains that Amazon, Apple, Google, Meta and Microsoft have created innovative technologies enjoyed by consumers worldwide. They are unavoidable platforms for any developer wishing to reach consumers online. Mozilla endeavors to collaborate with engineers at all of these companies in public multi-stakeholder standards development organizations to build a better internet, in addition to partnering with Google and Microsoft for search, video streaming and malware detection services. Nonetheless, we have a long history of challenging other companies to adopt better practices that benefit the overall internet ecosystem and consumers.¹⁶⁷ Platforms can and should do better for consumers and developers.

As these companies have so far failed to do better, regulators, policymakers and lawmakers have spent considerable time and resources investigating digital markets. They should therefore be in a good position to recognize the importance of browser competition and to act to prevent further harm to consumers from continued inaction and competitive stagnation. We call on them to enforce the laws which already exist and the laws and regulations which will soon come into force. And where existing laws and regulations are lacking, we call for them to be introduced and their importance for the future of the internet to be highlighted. Regulators, policymakers and lawmakers in many jurisdictions can take this moment to create a new era in the internet's story — one in which consumers and developers benefit from genuine choice, competition and innovation.

167 <https://blog.mozilla.org/en/mozilla/news/big-tech-cant-outrun-demands-for-accountability/>

Next Steps

Having researched and set out the issues at length in this paper, we are currently working on the next stage: proposing solutions that will enhance competition and consumer choice. Many of the harms identified in this report are caused by particular online choice architecture and software design. As such, the assumption is that they can also be addressed through *alternative* online choice architecture and software design. However, the remedies that have so far been deployed have had many limitations and have largely failed. Our aim is to publish further work in this area in the coming months.

Annex 1: Survey Methods

Panel-survey study of people 18 years old or older. Panel samples aimed to match interlocked quotas for census-based proportions for age, sex, and geographic region of residence. The survey was fielded online with the questionnaire built and distributed on Alchemer using panel samples provided by Cint.

Potential sampling limitations: In the United States, United Kingdom, and France samples provided by Cint matched well with census-level representation. Younger people were over-represented in the Indian and Kenyan samples.

Table 10 : Survey data collection details

	Australia	U.S.	U.K.	France	India	Kenya
Data Collection	9/2021	3/2022	3/2022	4/2022	4/2022	4/2022
Respondents	2647	1223	1186	1188	1705	1087
Language(s)	English	English	English	English and French	English and Hindi	English and Swahili

Respondents completed a questionnaire that asked about the smartphone and laptop/desktop devices they used; their knowledge of and attitudes toward the web browsers and search engines that were installed, used, and set as the defaults on their devices; and how they controlled the settings on their devices. The questionnaire was designed to replicate a 2021 study commissioned by the Australian Competition and Consumer Commission and

add detail to the findings. In the ACCC study, respondents owned or were the main user of BOTH an internet-enabled smartphone and personal computer. In all other surveys, respondents were eligible if they owned or were the main user of an internet-enabled smartphone, personal computer, or both. In all surveys, tablets were excluded.

Table 11 : Margins of error with 95% Confidence Interval for Sample Estimates

Margins of error with 95% Confidence Interval for Sample Estimates						
	Australia ¹⁶⁸	U.S.	U.K.	France	India	Kenya
Smartphone users	n/a	±1.9-3.1%	±1.9-3.2%	±1.9-3.1%	±1.5-2.5%	±1.8-3.1%
Laptop/Desktop users	n/a	±2.0-3.4%	±2.2-3.7%	±2.0-3.3%	±1.5-2.6%	±2.1-3.5%
Residents	n/a	±1.7-3.4%	±1.6-4%	±1.7-2.8%	±1.7-2.6%	±1.8-3.0%

Statistical Significance

The multiple logistic regression models were evaluated using the Likelihood-Ratio Test which compares the null and saturated model deviances using a χ^2 significance test. Each model reported on was significant at the $p < 0.001$ level.

The probabilities reported were derived from the log-odds ratio coefficients from the multiple logistic regression models. These coefficients were significant at the $p < 0.05$ level. Model parsimony was favored over total variance explained and predictors were removed that did not significantly increase the total variance explained by the model.

168 Margin of error and confidence intervals not reported by ACCC for Australia.

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