

AMENDED Exhibit 985

PLAINTIFFS' OMNIBUS OPPOSITION TO DEFENDANTS' MOTIONS FOR SUMMARY JUDGMENT

Case No.: 4:22-md-03047-YGR

MDL No. 3047

In Re: Social Media Adolescent Addiction/Personal Injury Products Liability Litigation

EXPERT REPORT OF
Arvind Narayanan, Ph.D.
May 16, 2025

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123. Like TikTok, YouTube primarily features video, though it is not restricted to the short form videos TikTok is known for. Like other platforms, YouTube uses both recommendation algorithms and content moderation classifiers to determine what content is recommended on various YouTube surfaces. The surfaces on which recommendations appear include:

Surface	Launch date	What is recommended
Home	Introduced prior to 2012 ⁷⁶	Videos from subscribed creators and non-subscribed creators.

⁷⁶ YouTube Official Blog. New YouTube homepage launches to all users. Jan. 19, 2011. <https://blog.youtube/news-and-events/new-youtube-homepage-launches-to-all/>.

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Watch Next	Introduced prior to 2012 ⁷⁷	Videos from subscribed creators and non-subscribed creators, tailored to the context of the current video that the user is watching.
Search	Introduced prior to 2012 ⁷⁸	Videos from subscribed creators and non-subscribed creators, tailored to the context of the user's search query.
Shorts Player	Introduced in U.S. in March 2021 ⁷⁹	Short form video content from subscribed creators and non-subscribed creators, originally up to 60 seconds in length, later increased to 3 minutes. YouTube recommends Shorts be 15 seconds in length.
YT Kids Home	Launched 2015	YouTube Kids is a separate application featuring a restricted inventory of long form videos and some short form videos. Like the main YouTube app, it has many surfaces.

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125. For many years, YouTube optimized its recommendations system to maximize watch time. Cristos Goodrow, YouTube Vice President of Engineering for Search and Discovery,

⁷⁷ Meyerson. YouTube Now: Why We Focus on Watch Time. YouTube Official Blog. Aug. 10, 2012. <https://blog.youtube/news-and-events/youtube-now-why-we-focus-on-watch-time/>; Marquardt. A new mobile design for your Home. YouTube Official Blog. Apr. 26, 2016. <https://blog.youtube/news-and-events/a-new-mobile-design-for-your-home/>.

⁷⁸ YouTube Official Blog. Your Features Have Arrived! Feb. 27, 2006. <https://blog.youtube/news-and-events/your-features-have-arrived/>.

⁷⁹ YouTube Official Blog. Bringing YouTube Shorts to the U.S. Mar. 18, 2021. <https://blog.youtube/news-and-events/youtube-shorts-united-states>.

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started at YouTube in 2011. At that time, YouTube's recommendation system was optimized to maximize clicks and views. Mr. Goodrow, in a memo entitled "Watch Time, and only Watch Time" proposed instead to optimize the recommendation system to maximize watch time.⁸⁰

Figure 4: Excerpt from GOOG-3047MDL-02185100

I think we need a discussion about watch time, and whether it is our primary goal to increase this measure. Folks across the organization hold a wide variety of positions on this, and I think it will become increasingly difficult to work together without some kind of consensus.

Proposal: All other things being equal, our goal is to increase (video) watch time.

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⁸⁰ GOOG-3047MDL-02185100.

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130. Like the other Defendants, YouTube generates revenue primarily through advertising (about 70%), with subscriptions contributing the remainder (about 30%).⁸⁴ YouTube ads also take the form of videos, some which can be skipped and others which cannot.⁸⁵ The

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⁸⁴ Alphabet Inc. SEC Form 10-K, For the fiscal year ended December 31, 2024. <https://abc.xyz/assets/77/51/9841ad5c4fbe85b4440c47a4df8d/goog-10-k-2024.pdf>, at p35; Alphabet Inc. Alphabet Announces Third Quarter 2024 Results. <https://abc.xyz/assets/71/a5/78197a7540c987f13d247728a371/2024q3-alphabet-earnings-release.pdf>.

⁸⁵ YouTube, Help Center. About video ad formats. support.google.com. <https://support.google.com/youtube/answer/2375464>. Last visited May 13, 2025.

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amount of time that users spend on YouTube directly translates to ad revenue. The core metrics that YouTube tracks are watch time (over some duration), time spent on the app (over some duration), DAU (daily active users), and variants thereof.

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132. YouTube recognized the limitations of engagement optimization early on. Since 2016, it has included user “satisfaction” alongside engagement as a metric to optimize for. This is a laudable goal, but YouTube’s implementation fell short of the aspiration.

133. Satisfaction is measured in three ways.⁸⁶ Each of those has serious limitations, and my opinion is that YouTube was not able to truly move away from engagement optimization.

134. The first category of user satisfaction metrics is using metrics such as Likes and Dislikes. Although YouTube apparently classifies these as different from “engagement,” this is a distinction without a difference. These are still actions that users take “in the moment,” rather than after reflection or retrospection, and without any communication in the user interface that these actions are being used to tune recommendations. They do not constitute “System 2” signals which better represent users’ forward looking goals and aspirations rather than impulsive decisions.⁸⁷

135. The second category of user satisfaction metrics is Long-Term Value.⁸⁸ This is not clearly defined, but I have gleaned from documents that it is measured in time horizons of 30 minutes, or one day or at most a few days. The concept appears to be intended to capture cases where watching one video in a series may lead to other videos in the series, which means that

⁸⁶ GOOG-3047MDL-00035930.

⁸⁷ Moehring et al. Better Feeds: Algorithms That Put People First - A How-To Guide for Platforms and Policymakers. Knight Georgetown Inst. Mar. 4, 2025. https://kgi.georgetown.edu/wp-content/uploads/2025/02/Better-Feeds_-_Algorithms-That-Put-People-First.pdf.

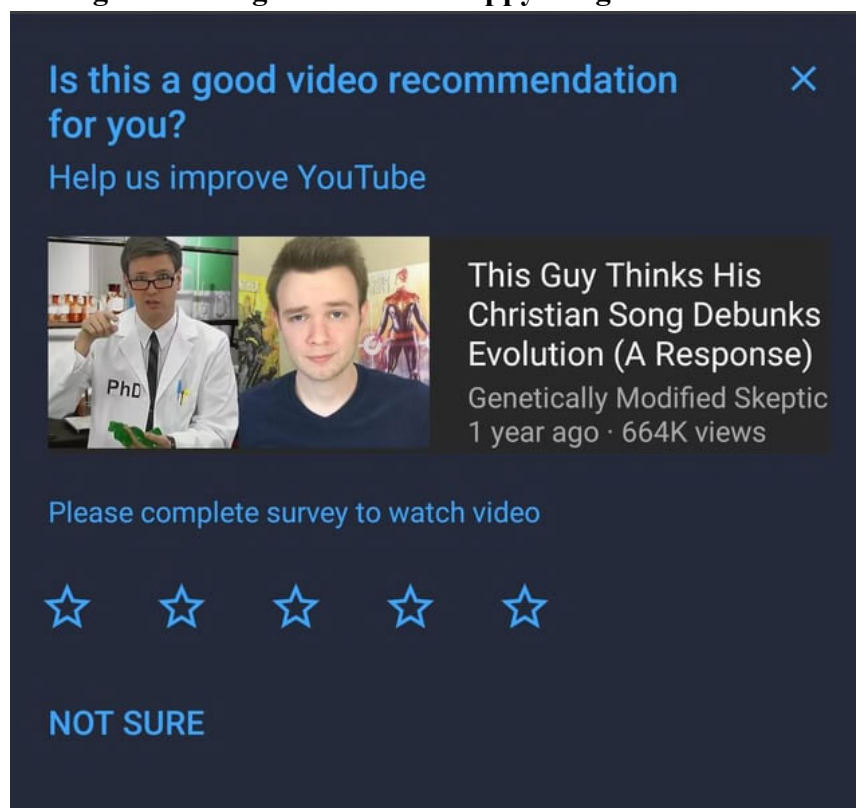
⁸⁸ GOOG-3047MDL-00035930.

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recommending the first video is more valuable (to YouTube) than would appear from focusing purely on that video's watch time. In other words, YouTube's conception of long-term value is not consistent with how that term might be commonly understood and is just another expression of time spent.

136. The third category of satisfaction metrics is about whether users valued or regretted watching certain videos. This is measured through surveys. For example, YouTube might occasionally ask a user whether a recommended video is a good recommendation for them. While this gets closer to measuring value to users, unfortunately, surveys, at least as implemented by YouTube, have major limitations as a way of measuring satisfaction. YouTube acknowledged this: "Surveying actual users somewhat mitigates this issue [the difficulty of measuring user satisfaction] but is also very unreliable."

Figure 6: Image from the "CrappyDesign" subreddit.⁸⁹



⁸⁹ Reddit Crappy Design Subreddit. "YouTube asked me to rate a suggestion, without letting me watch it first." 2019.

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⁹⁰ GOOG-3047MDL-00035930.

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142. Snapchat’s business model is advertising-driven and algorithmically personalized, much like other social media platforms examined. “In 2021, Spotlight ranking [which is engagement-based] improved views and view time +65% and +99% respectively, relative to a heuristic ranking holdout.”⁹¹

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⁹¹ SNAP4522509.

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147. Like the other Defendants' platforms, Snapchat uses proxies for long-term growth and engagement metrics. Internal documents are explicit about this. For example, a 2021 document titled "What should we optimize for in Spotlight" says: "We optimize the viewer experience beyond in-session engagement metrics, although we're comfortable using in-session actions to proxy for longer-term effects."⁹⁹ In other words, although the goal is to optimize the experience beyond a single session, in terms of the ranking algorithms themselves, the metrics are entirely short-term and engagement-based, so the goal of optimizing beyond in-session engagement metrics appears to be aspirational. The same document lists what those metrics are for the Spotlight surface: view time, video completion, "long view" (viewing for more than five seconds), favoriting, sending (sharing), and hiding. As of May 2023, the metrics for both Spotlight and Discover were entirely engagement-based.¹⁰⁰

148. The 2021 document goes on to say that "ideally", Snap should optimize for happiness and "time well spent" by surveying users and modeling the relationship between behavioral data and survey responses. I have not seen evidence that Snapchat has since launched such surveys, whether in Spotlight or in the Stories/Discover surfaces. Snapchat does seem to carry out quarterly satisfaction surveys, but these are different from the kind of video-specific surveys

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⁹⁹ SNAP1086844.

¹⁰⁰ SNAP4298052.

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183. A “YouTube Recommendation Overview” document notes that the system has “strong feedback loops” as it “gets better by training on its own data.”¹³⁷

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¹³⁷ GOOG-3047MDL-00035930.

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D. Rabbit holing as a consequence of algorithm design

212. Another related consequence of the design of Defendants' recommendation algorithms is a phenomenon known as "rabbit holing." Rabbit holing is not a technical term, but drawing on the common understanding of the phenomenon as well as the research literature, I define it as a pattern of social media use in which a user, without intending to, spends a large amount of time consuming an algorithmically recommended feed and later regrets it, with the feed becoming more homogenous over time. Rabbit holing can be considered a form of problematic use characterized by exposure to an increasingly homogenous feed. Rabbit holing can refer to a single session, or it may refer to a pattern that intensifies over a longer period, weeks or months.

213. None of the defendants has provided adequate access to external researchers to study the effects of their products on users and society. As a result, it has not been possible to rigorously test the causal effect of recommendation algorithms on outcomes such as rabbit holing. Despite the inability to test the "end to end" effect of recommendation algorithms, researchers have a good understanding of many specific problematic aspects of the interaction between users and recommendation algorithms, which cumulatively provide a compelling explanation for why rabbit holing is likely to arise. This is also supported by many internal documents from all defendant platforms which recognize the "rabbit hole" phenomenon or related concepts.

214. Given the scope of my report, I limit my discussion of rabbit holing to its algorithmic component although it has a psychological component as well. My key assumption regarding the psychological component is that some users can develop a behavioral proclivity to consume certain content if it is presented in a certain way, even though they do not want to do so, would not actively seek it out, and would regret consuming it. This may arise due to a dissonance between the user's "System 1" thinking and "System 2" thinking.¹⁶⁸

¹⁶⁸ Kahneman. *Thinking, Fast and Slow*. Farrar, Straus and Giroux 2011. Apr. 2, 2013.

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215. Developers of recommendation algorithms are well aware of the tendency of these algorithms to inundate users with a single type of content and, as a result, to suck some of its users into rabbit holes.

216. “Carol’s journey to QAnon” refers to a 2019 internal user account study on the Facebook platform whereby a fake user profile of a 41 yr old southern female was created to understand how the ranking and recommendation evolved based on a new user profile with modest inputs regarding interest.¹⁶⁹ An internal report on the findings notes that “[w]ithin 2 days” the platform was suggesting “more exclusively right wing content, and beg[an] to lean towards conspiracy content.”¹⁷⁰

217. Meta has explicitly acknowledged the phenomenon of rabbit holing. Around 2020, the company created a project called Rabbithole to address the problem.¹⁷¹ However, based on the documents I reviewed, I did not find any evidence that this team was able to devise or deploy effective solutions to the problem. As of 2021, Meta’s documents acknowledged that “repetitiveness of content” and “over saturation of trends and audios” is a “major pain point” of Reels compared to TikTok.¹⁷² A 2022 document lists and prioritizes various problems related to teen wellbeing on Instagram.¹⁷³ Teens rabbitholing into SSI [suicide and self-injury] and ED [eating disorder] content is the lowest on the list of 24 problems ranked by priority. “Current product investment” is listed as “low” for this problem.

218. If the specific pattern of spiraling behavior involved in rabbit holing impacts only a small number of users, no matter how severely, it will not show up in aggregate statistics of problematic use. To the extent that Defendants have made efforts related to mental wellbeing and

¹⁶⁹ META3047MDL-207-00033754.

¹⁷⁰ *Id.*

¹⁷¹ META3047MDL-003-00043614; META3047MDL-049-00000126; META3047MDL-047-00990131; META3047MDL-072-00176016.

¹⁷² META3047MDL-014-00405308.

¹⁷³ META3047MDL-034-00161622.

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safety aimed to improve experiences broadly across all users or some large subset of users such as teens, those efforts may not have impacted users affected by rabbit holing. What was distinctive about the Rabbithole project was the recognition of this phenomenon and the attempt (though under-resourced and unfinished) to identify this subset of users and improve experiences for them.

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time spent viewing a post affect future recommendations? The user has no way to find out. This lack of detail limits users' ability to control their feeds.

246. Meta has not disclosed to the public the relative weight given to different types of engagement actions in ranking, which further inhibits users' ability to control their feeds. Facebook has reaction emojis such as "Sad" and "Angry" with negative valence, in addition to "Like" and "Haha" with positive valence. When the user reacts to a post with a negative emoji, it is not even clear to users whether, as a result, they are likely to see more similar posts in the future (positive weight) or fewer similar posts in the future (negative weight). Even when Facebook made major changes to the weight of such reactions (from a high positive weight to zero),¹⁸⁶ there was no public communication.

247. Meta does not tell users why specific posts are shown to them. In 2019, Facebook launched a feature called "Why am I seeing this post?", which Instagram eventually adopted as well.¹⁸⁷ The launch gained significant media attention.¹⁸⁸ However, the feature has been inconsistently implemented between different platforms (such as desktop and mobile devices) and gives users only superficial information, suggesting that its primary purpose has been public relations rather than helping users.

248. Specifically, the feature gives users information that they already have while withholding information that would actually be useful. For example, it tells the user that they were recommended a post because they followed a specific account. But it does not tell the user which

¹⁸⁶ Merrill & Oremus. Five points for anger, one for a 'like': How Facebook's formula fostered rage and misinformation. The Washington Post. Oct. 26, 2021.
<https://www.washingtonpost.com/technology/2021/10/26/facebook-angry-emoji-algorithm/>.

¹⁸⁷ Porter. Facebook's News Feed is starting to explain itself. The Verge. Apr. 1, 2019.
<https://www.theverge.com/2019/4/1/18290195/facebook-news-feed-why-am-i-seeing-this-post-ad-context-interaction>.

¹⁸⁸ *Id.*; Facebook to reveal News Feed algorithm secrets. BBC. Apr. 1, 2019.
<https://www.bbc.com/news/technology-47771922>.

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interests the ranking algorithm had inferred about them. To my knowledge, there has never been a way for users to obtain this information on Instagram or Facebook.

249. A 2018 Pew Research Center survey found that the majority of U.S. adults who use Facebook say they do not understand why certain posts but not others were included in their feed, and a 2019 Pew survey found that about three quarters of U.S. adult users were not even aware that Facebook inferred their interests.¹⁸⁹ Meta acknowledges internally that “Most people feel how our algorithms work is a mystery, yet want to be able to shape their experiences. Misguided ‘folk theories’ about how algorithms work shape people’s engagement and can deteriorate their trust.”¹⁹⁰

250. According to testimony from Joshua Simons who worked at Facebook in 2019 when “WAIST” (“Why am I seeing this?”) was deployed, the tool was known to be a “poor representation” of why someone would see a particular post.¹⁹¹ In the opinion of Mr. Simons, based on his experience at the company, the WAIST tool “misrepresented” and was intended to distract users from the real answer.¹⁹² Though the explanations intended to be provided to users were not necessarily false, he described WAIST’s explanations as a “tangential description” that “wasn’t really meaningful” to explain to users why they were seeing what they were seeing in their feeds.¹⁹³

251. Meta rarely publishes its internal research about the impact of its algorithms on society. In 2021 a coalition of more than 300 scientists published an open letter to Mark Zuckerberg

¹⁸⁹ Smith. Many Facebook users don’t understand how the site’s news feed works. Pew Research Center. Sept. 5. 2018. <https://www.pewresearch.org/short-reads/2018/09/05/many-facebook-users-dont-understand-how-the-sites-news-feed-works/>;

Hitlin, Rainie & Olmstead. Facebook Algorithms and Personal Data. Pew Research Center. Jan. 16, 2019. <https://www.pewresearch.org/internet/2019/01/16/facebook-algorithms-and-personal-data/>.

¹⁹⁰ META3047MDL-014-00405308.

¹⁹¹ Simons Dep. 34:22-35:11.

¹⁹² Simons Dep 152: 1-16.

¹⁹³ Simons Dep. 36:1-9.

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calling for Meta to allow researchers to use its data to study child and adolescent mental health.¹⁹⁴ Meta has allowed external researchers to study the impact of its algorithms on the 2020 U.S. elections,¹⁹⁵ but so far has not enabled equivalent access for studying mental health.

252. In fact, Facebook/Meta has a long history of shutting down what little external research about its platforms can be done without its cooperation — usually research pertaining to how it targets advertisements to users. Notable examples include New York University’s Ad Observatory Project¹⁹⁶ and ad transparency tools by investigative news outlet ProPublica, browser maker Mozilla, and advocacy groups Who Targets Me and Algorithm Watch.¹⁹⁷

253. For over a decade I have attempted to study Facebook’s and Meta’s algorithms. With rare exceptions, I have been stymied by the company’s lack of access to its data and systems and legal threats it has made to other researchers.¹⁹⁸ In 2018, I was one of over 200 signatories to an open letter to Mark Zuckerberg calling on Facebook to lift restrictions on digital research and journalism on its platform. The letter had little effect; most of the aforementioned examples are

¹⁹⁴ Przybylski et al. An Open Letter to Mr. Mark Zuckerberg: A Global Call to Act Now on Child and Adolescent Mental Health Science. Oxford Internet Institute, University of Oxford. <https://www.oii.ox.ac.uk/an-open-letter-to-mark-zuckerberg/>. Last visited Mar. 13, 2025.

¹⁹⁵ Research partnership to understand Facebook and Instagram’s role in the U.S. 2020 election. <https://research.facebook.com/2020-election-research/>. Last visited Mar. 13, 2025.

¹⁹⁶ Edelson & McCoy. We Research Misinformation on Facebook. It Just Disabled Our Accounts. The New York Times. Aug. 10, 2021. <https://www.nytimes.com/2021/08/10/opinion/facebook-misinformation.html>.

¹⁹⁷ Merrill & Tobin. Facebook Moves to Block Ad Transparency Tools - Including Ours. ProPublica. Jan. 28, 2019. <https://www.propublica.org/article/facebook-blocks-ad-transparency-tools>; Secrecy at All Costs: A Timeline of Facebook’s Obstruction of Research. MapLight. Sept. 21, 2021. <https://maplightarchive.org/story/secrecy-at-all-costs-a-timeline-of-facebooks-obstruction-of-research/>; Brandom. Facebook shut down German research on Instagram algorithm, researchers say. The Verge. Aug. 13, 2021. <https://www.theverge.com/2021/8/13/22623354/facebook-instagram-algorithm-watch-research-legal-threat>.

¹⁹⁸ Brandom. Facebook shut down German research on Instagram algorithm, researchers say. The Verge. Aug. 13, 2021. <https://www.theverge.com/2021/8/13/22623354/facebook-instagram-algorithm-watch-research-legal-threat>.

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from later years. My own attempt to study Facebook's algorithms in 2021 were foiled by the company's refusal to negotiate reasonable terms of data access.¹⁹⁹

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¹⁹⁹ Kshirsagar. Facebook's Illusory Promise of Transparency. CITP Blog. Aug. 5, 2021. <https://blog.citp.princeton.edu/2021/08/05/facebooks-illusory-promise-of-transparency/>. Facebook is 'not a researchers-friendly space' say academics encountering roadblocks to analyzing its 2020 election ad data. Digiday. May 4, 2021. <https://digiday.com/marketing/facebook-is-not-a-researchers-friendly-space-say-academics-encountering-roadblocks-to-analyzing-its-2020-election-ad-data/>.

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297. One reason why engagement optimization leads to addictive experiences is the aforementioned reliance on “System 1” or implicit signals as opposed to “System 2” or explicit signals. An important way to obtain more System 2 signals is “item level surveys”, which simply refers to the idea of asking users what they would like to see more or less of. The figure shows an example of such a survey by Facebook. A preliminary study using Twitter (now X) found that ranking based on such “stated preferences” can make users more happy and less angry after spending time on their feed.²⁴²

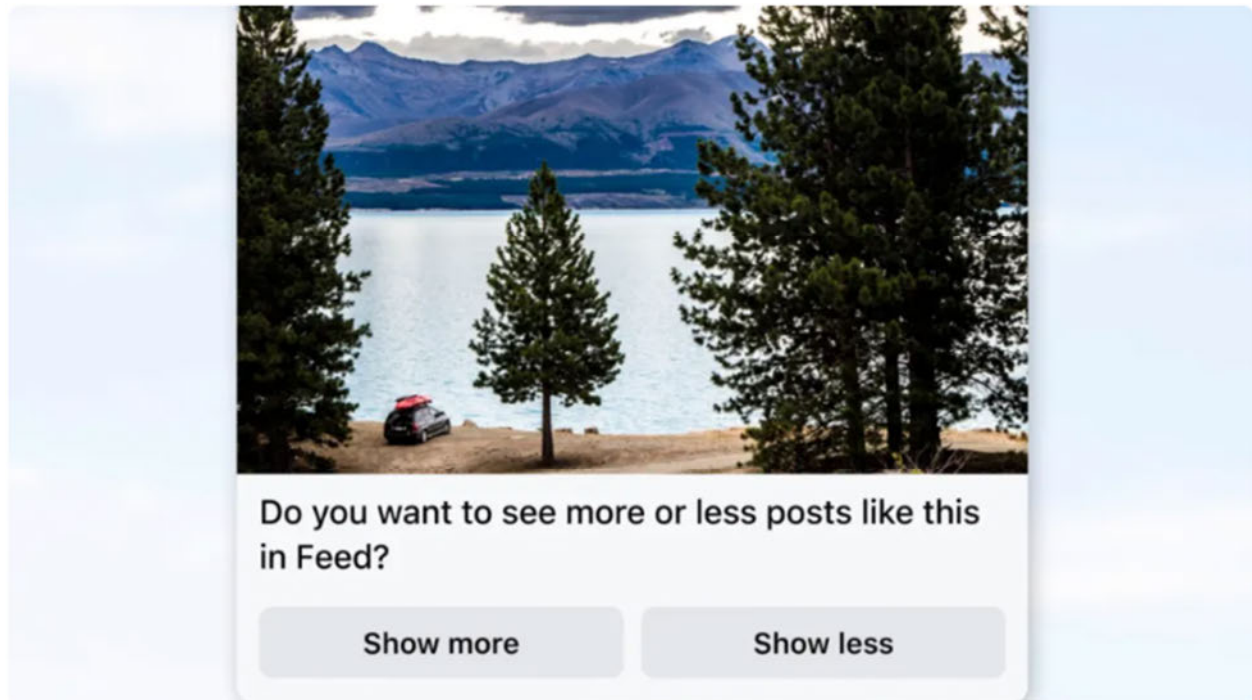
[REDACTED]

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²⁴² Milli et al. Engagement, User Satisfaction, and the Amplification of Divisive Content on Social Media. Cornell University. May 26, 2023. <https://arxiv.org/abs/2305.16941>.

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Figure 11: An example of a survey

298. Platforms have acknowledged that surveys are a valuable way to improve long-term value to users and minimize harmful outcomes.²⁴³ While YouTube began deploying surveys in 2016,²⁴⁴ the other platforms began doing so more recently — Facebook began to do so in 2019.²⁴⁵ TikTok deployed in-feed user surveys not earlier than 2020, as a document from that year describes the feature as being in progress.²⁴⁶

²⁴³ Gupta. Incorporating More Feedback Into News Feed Ranking. about.fb.com. Apr. 22, 2021. <https://about.fb.com/news/2021/04/incorporating-more-feedback-into-news-feed-ranking/>; Sethuraman et al. Using Surveys to Make News Feed More Personal. about.fb.com. May 16, 2019. <https://about.fb.com/news/2019/05/more-personalized-experiences/>.

²⁴⁴ Goodrow. On YouTube's recommendation system. YouTube Official Blog. Sept. 15, 2021. <https://blog.youtube/inside-youtube/on-youtubes-recommendation-system>.

²⁴⁵ Sethuraman. Using Surveys to Make News Feed More Personal. Facebook. May 16, 2019. <https://about.fb.com/news/2019/05/more-personalized-experiences/>.

²⁴⁶ TIKTOK3047MDL-060-01173050.

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299. Another example of a System 2 signal is explicit negative feedback: buttons such as “see less like this”. When being recommended a post, a user may recall that when they engaged with similar posts in the past, they regretted it later. By giving explicit negative feedback, the user can provide a much stronger negative signal to the algorithm than simply skipping the post. Even if they do end up engaging with the post because of addictive tendencies, they would be able to undo the effect of that action in terms of its impact on the algorithm by providing negative feedback after they engage with it.

300. All of the Defendants’ platforms offer negative feedback features. Unfortunately, in every case, they are hard to access, and users are given no true understanding of what effect if any explicit negative feedback has. In no case are such feedback elements visible directly in the feed, but are instead hidden behind context menus. In contrast, on every platform, implicit interaction elements are directly visible. As a result, the uptake of negative feedback has generally been low, with the vast majority of users not making use of them. For example, a leaked internal Facebook document “Providing Negative Feedback Should Be Easy (And Why This Would Be Game Changing For Integrity)”, revealed that, in 2019, Facebook estimated that there was “[a]t best” 0.5% as much negative feedback as positive feedback.²⁴⁷ The document made the reasons for this very clear:²⁴⁸

Negative feedback is sparse partly because it requires more clicks and more effort, but also because people don’t always know what to do or what those actions mean. There’s also no clear value prop—i.e., if you give us feedback on what you don’t like, we will make sure your feed gets better. **We need to address all of these frictions to have success.**

301. However, as of late 2022, problems remained, and were again discussed internally with regard to Instagram. One document states, “After reading through various signals- and recommendation control-related posts, we’ve identified a few key problems related to signals.”

²⁴⁷ Facebook. Providing Negative Feedback Should Be Easy (And Why This Would Be Game Changing For Integrity). Sept. 26, 2019. https://www.documentcloud.org/documents/21602498-tier1_rank_pr_0919/. At 4.

²⁴⁸ *Id.* at 15 (emphasis in original). Document also produced as META3047MDL-207-00030977.

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The number 1 problem identified is that the user interface for providing feedback, especially negative feedback, is hard to find. As evidence, the document says that the most requested feature by teens was a “Not interested” button, despite already existing. Usage of this feature was “very low”, at 0.5% of Daily Active Users, despite 20%+ of users indicating that their Feed recommendations were “somewhat irrelevant” or “very irrelevant”.²⁴⁹

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²⁴⁹ META3047MDL-072-00310041.

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The undersigned hereby certifies their understanding that they owe a primary and overriding duty of candor and professional integrity to help the Court on matters within their expertise and in all submissions to, or testimony before, the Court. The undersigned further certifies that their report and opinions are not being presented for any improper purpose, such as to harass, cause unnecessary delay, or needlessly increase the cost of litigation.

A handwritten signature in black ink, appearing to read "Arvind N".

Arvind Narayanan, Ph.D.

