SOCIAL MEDIA

How do social media feed algorithms affect attitudes and behavior in an election campaign?

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We investigated the effects of Facebook's and Instagram's feed algorithms during the 2020 US election. We assigned a sample of consenting users to reverse-chronologically-ordered feeds instead of the default algorithms. Moving users out of algorithmic feeds substantially decreased the time they spent on the platforms and their activity. The chronological feed also affected exposure to content: The amount of political and untrustworthy content they saw increased on both platforms, the amount of content classified as uncivil or containing slur words they saw decreased on Facebook, and the amount of content from moderate friends and sources with ideologically mixed audiences they saw increased on Facebook. Despite these substantial changes in users' on-platform experience, the chronological feed did not significantly alter levels of issue polarization, affective polarization, political knowledge, or other key attitudes during the 3-month study period.

What are the effects of machine-learning algorithms used by social media companies on elections and politics? The notion that such algorithms create political "filter bubbles" (*1*), foster polarization (*2*, *3*), exacerbate existing social inequalities (*4*, *5*), and enable the spread of disinformation (*6*) has become rooted in the public consciousness. Because the algorithms used by social media companies are largely opaque to users, there are numerous conceptions or "folk theories" of how they work and disagreements about their effects (*7*, *8*). Understanding how these systems influence key individual-level political outcomes is thus of paramount scientific and practical importance (*9*).

In particular, feed-ranking systems—algorithms designed to optimize the order in which content is presented to a user—have received considerable scrutiny from regulators and the public. But studying the effects of these feed algorithms is challenging. Even with direct access to proprietary code and data, it would be difficult to characterize their impact (*10*) because such algorithms are personalized on the basis of many factors, such as a user's past behavior and predictions derived from the actions of similar users, which leads to complex and potentially heterogeneous effects on content ranking. Furthermore, a well-established counterfactual is not always obvious: Technology companies frequently conduct "A/B tests," or randomized controlled experiments, to refine the user experience, but these are typically designed to evaluate discrete elements such as the weight of individual inputs or how information is displayed in a specific panel (*11*). Evaluating the total impact of a machine-learning feed-ranking system necessitates a well-understood alternative for comparison.

With these challenges in mind, we examined the effect of specific feed algorithms on individuals' political attitudes and behaviors. We did so by conducting randomized controlled experiments within the context of the 2020 US presidential election campaign on Facebook and Instagram, two major social media platforms with more than 3.5 billion combined monthly active users worldwide. We took the algorithmic ranking systems on Facebook and Instagram, as they existed in the fall of 2020, as the status quo (henceforth "Algorithmic Feed"). In a randomly assigned treatment group, users' feeds were ranked in reverse-chronological order (henceforth "Chronological Feed"). Although arranging items in chronological order technically constitutes an algorithm, it is not predictive in the way that prominently scrutinized machine-learning systems, such as those used by social media platforms, are. The simple chronological ranking, in which the most recent item is presented at the top of one's feed, is both easy to implement—it was originally used on both Facebook and Instagram and continues to be an option on multiple social media platforms (*12*)—and matches an alternative currently being proposed in public debates by policy-makers and members of civil society (*13*).

Theory and research questions

Algorithmic effects have rarely been the main focus of quantitative, publicly available research on social media and politics as opposed to other domains (*5*, *12*). Out of necessity, studies have tended to treat social media as a unified "bundle" of features—which includes not only algorithms but also repeated interactions with certain individuals and the ability to reshare content, for example (*14*–*16*)—or to manipulate exposure to specific sources within the platform (*17*, *18*). By replacing the status quo algorithmic ranking system, our experiment allowed us the opportunity to focus on the role of Facebook's and Instagram's algorithms in sorting and ranking content from the "inventory" generated by connections in users' social networks and the posts and interactions that they produce.

This focus permitted us to identify the particular role of algorithmic ranking. Other elements or affordances of the "bundle" of social media features could conceivably be more important. Similarly, although the particular mix and ordering of content that a user sees may be an important factor in shaping political attitudes and behaviors, other determinants of this ranking besides the particular algorithm used—such as user choice or the composition of one's network—could be relevant as well (*19*). To the extent that prior research has documented social media effects on our outcomes of interest (*14*, *15*), a contribution of this study is to determine whether these can be attributed to a key feature of modern social platforms: personalized algorithmic ranking systems.

Because the impact of these systems is largely unknown, we began with a research question (RQ): How does the Chronological Feed affect the content people see? We formulated this question and subsequent hypotheses in terms of our randomly assigned treatment, in which participants' feeds were ranked in reverse-chronological order instead of by the default algorithm. Aside

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from its policy relevance and simplicity, our choice of the reverse-chronological baseline was intended to maximize the differences in users' feed experiences and thus the likelihood that algorithmically driven changes in content and emphasis could shape politically relevant attitudes and behaviors. Additionally, machine-learning feed algorithms are often thought of as a "black box" because the rules they follow are not transparent. They are also optimized for certain outcomes such as user engagement, and they "learn" from user behavior and adapt over time. By contrast, a chronological feed does not exhibit any of these features because the same rule is applied to all users at all times (*20*).

We focused on three primary hypotheses that represent important public concerns that have been theorized in existing research, tied to three groups of outcomes potentially affected by the altered mix of feed content. The first outcome that we studied is polarization (H1). Scholars have long been interested in the polarizing effects of social media (*21*). Social media feed algorithms could affect political polarization in at least two ways. First, if algorithms use past user behavior to inform output, then perspectives with which a user has engaged in the past may be prioritized in the future, potentially encouraging selective exposure to like-minded political views (*1*, *19*, *22*–*24*). Repeated exposure to like-minded and reinforcing content may foster greater extremity on issue positions (*17*). Thus, we expected the Chronological Feed to lessen issue polarization (H1a). Second, algorithms may deprioritize content from certain parts of a user's network of connections. More specifically, prior work has argued that Facebook's features may encourage partisan stereotyping (*3*, *25*) and influence negative attitudes about outgroups (*26*). As a result, in the US partisan political context, we also expected the Chronological Feed to lessen affective polarization at the individual level (H1b) (*27*).

The second primary hypothesis relates to political knowledge (H2). Feed algorithms could have consequences for political knowledge because news in today's polarized society is often engaging, making news more likely to be encountered both purposefully and incidentally (*28*–*30*). Although people use social media for purposes unrelated to politics (*31*), one-third of Facebook users consume news on the platform (*32*). We expected that moving users out of an Algorithmic Feed would reduce their time spent on the platform and their on-platform engagement, decreasing exposure to political information. Thus, we expected the Chronological Feed treatment to decrease knowledge about the 2020 election campaign (H2a) and decrease recall of recent events covered in the news (H2b).

Our third primary hypothesis relates to political participation (H3), which could be influenced by feed algorithms in several ways.

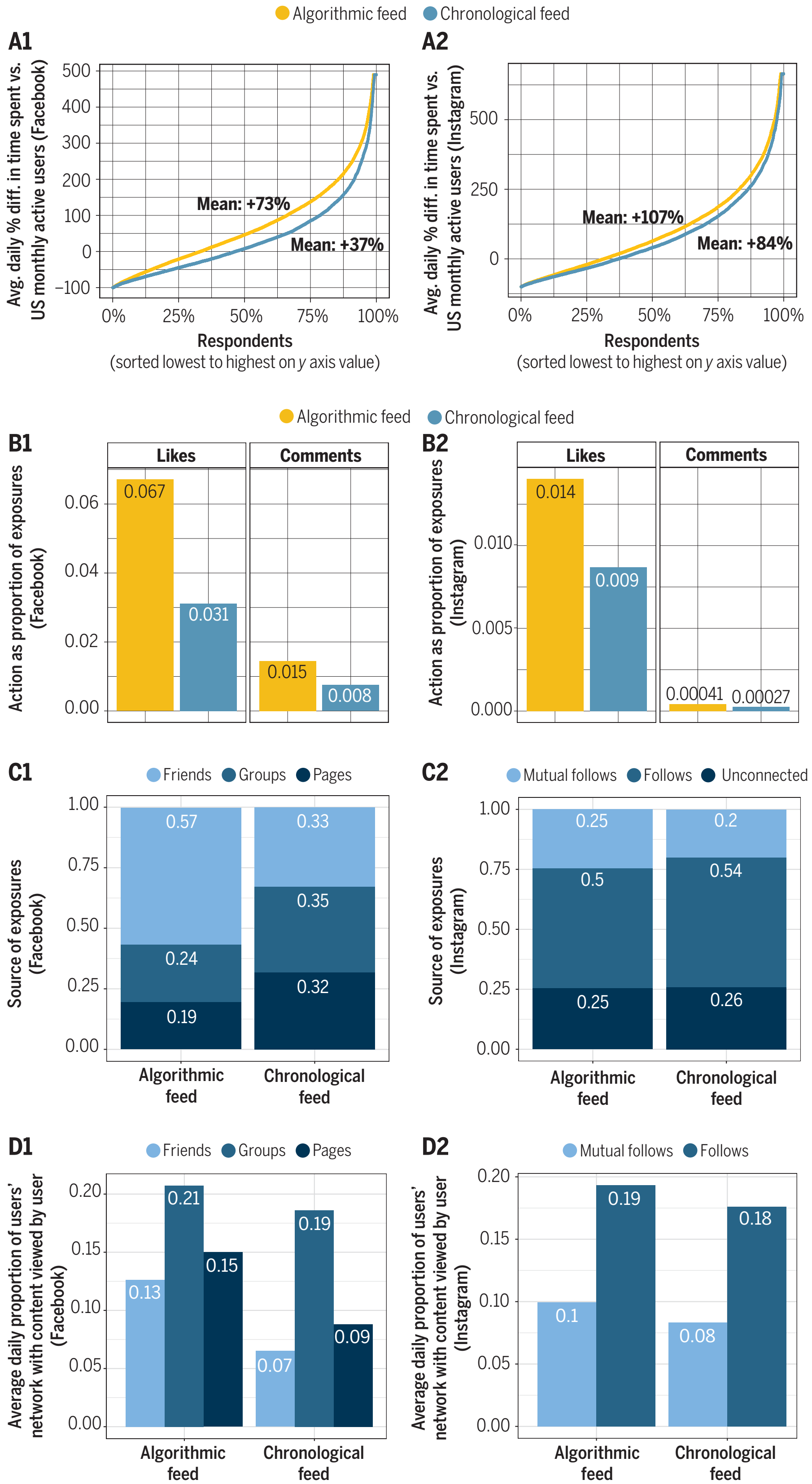

Fig. 1. Comparison of user experience and behavior for Chronological and Algorithmic Feed conditions on Facebook and Instagram. (**A1**, **B1**, **C1**, and **D1**) Facebook. (**A2**, **B2**, **C2**, and **D2**) Instagram. Values are unweighted sample statistics. All differences are significant at the $p < 0.005$ level, except share of exposures from unconnected users on Instagram; confidence intervals are thus not shown.

First, online political engagement may decline simply because overall online engagement declines in the Chronological Feed. Second, political knowledge may empower citizens to participate in the political process (*33*, *34*), and as knowledge declines, so too might participation. Third, social media algorithms may lower the coordination and information costs of mobilization (*11*, *15*, *35*), so that removing such algorithms would diminish participation. Another possible mechanism is that chronological ranking might increase exposure to more cross-cutting perspectives relative to the Algorithmic Feed, which scholars have argued can generate ambivalence and have a demobilizing effect (*36*). We hypothesized that the Chronological Feed would reduce both online and offline forms of political participation (H3a), including self-reported turnout in the 2020 election (H3b) and on-platform political engagement (H3c).

Beyond these three sets of predictions, we prespecified a series of secondary hypotheses pertaining to public concerns but for which we do not have clear theoretical expectations based on prior research [supplementary materials (SM) section 2.2]. The secondary hypotheses cover the effects of the Chronological Feed treatment on factual belief accuracy, online consumption of political news (using behavioral data), trust in traditional and social media, confidence in institutions, perceptions of polarization, engagement with partisan news sources, epistemic political efficacy, vote choice, belief in the integrity of the election, and support for political violence.

Design and results

This study is the result of a collaboration between Meta and academic researchers outside of Meta (details including funding independence and safeguards against selective reporting of results are available in SM section S11). Because Meta did not financially compensate academics for their work, we acknowledge that the academic researchers selected as part of the research team were fortunate to benefit from the support of their universities and external funding. Study participants were recruited through survey invitations placed on the top of their Facebook and Instagram feeds in August 2020. Participants were users residing in the United States who were at least 18 years of age and who provided informed consent. Users who consented to participate in the study on both Facebook and Instagram were more active than the average monthly active user (SM section S3.1). Users were invited to complete five surveys (beginning in late August, mid-September, mid-October, November immediately after Election Day, and mid-December 2020), share their on-platform activity, and participate in passive tracking of off-platform internet activity. Participants were given the option to withdraw from the study and/or withdraw their data from the study up until the data were disconnected from any identifiers. Additional details on participant recruitment and consent are available in SM section S9.3, and ethics are discussed in SM sections S1.2 and S12.

Participants were randomly assigned to either a status quo Algorithmic Feed control condition in which no changes were made to their Facebook or Instagram feeds or to the Chronological Feed treatment condition, active from 24 September to 23 December 2020, in which the most recent content (defined by the publication date and time of original posts) appeared at the top of those feeds. Both groups received the same level of compensation for participating. Selection and placement of posts from connected accounts such as friends, Pages, and Groups were potentially affected; that of advertisements were not. According to independent estimates, this implies that about 80% of the material presented to respondents on the platform was manipulated as part of the experiment (*37*). The large samples (Facebook: n = 23,391; Instagram: n = 21,373), comprising participants who completed the first two surveys and at least one of the subsequent three waves, allowed for adequate statistical power to detect small effects (for example, for affective polarization, we were powered to detect population average treatment effects with Cohen's d = 0.032 or larger for both Facebook and Instagram). Among participants in the experimental sample, 19.5% did not complete any of our posttreatment survey waves. However, this attrition is not significantly different between treatment and control groups (Facebook, p = 0.83; Instagram, p = 0.35). Additional information on these and other aspects of the study design is available in SM section S1, materials and methods. The study design, measures, and analysis were preregistered at Open Science Framework (OSF) before treatment assignment.

As discussed in the preanalysis plan, our main estimand of interest is the population average treatment effect (PATE), which is weighted by users' predicted ideology, friend count, number of political pages followed, and number of days active, among other variables (SM section S9.5). We also report the unweighted sample average treatment effect (SATE) among consenting participants for transparency. The unweighted sample has a greater proportion than that of the weighted sample of those who are between the ages of 30 and 44, white, female, and liberal; have higher income; and have a college degree (detailed comparisons are available in SM section S3.1). Our PATE estimates were designed to facilitate inferences to the Facebook and Instagram populations assuming negligible treatment-effect heterogeneity by other characteristics. In general, and consistent with (*38*), we found limited effect heterogeneity (SM section S2.3). In case our weighting scheme did not fully account for the greater activity levels in the sample, our estimates correspond to arguably the most relevant subset of users: those who engage the most and generate a disproportionate share of content on the platform (SM section S2.1).

We first characterized the impact of the Chronological Feed treatment on users' on-platform experience (Fig. 1). Engagement, user satisfaction, and news originality are key signals used by the Facebook feed algorithm to determine how to rank content for individual users [more publicly available information is available in (*20*, *39*, *40*, *41*)] (SM section S1.1). We found that users in the Chronological Feed group spent dramatically less time on Facebook and Instagram. Participants in this study spent more time on Facebook and Instagram than did the average US monthly average user of both platforms (Fig. 1, A1 and A2) (comparisons of sample with US monthly active users are provided in SM section S3.1). However, the average respondent in the Algorithmic Feed group spent 73% more time each day on average compared with US monthly active users, and for those in the Chronological Feed group, this value reduced to 37% more (p < 0.005). On Instagram, the average participants in the Algorithmic Feed group spent 107% more time, whereas those in the Chronological Feed group spent 84% more time, compared with US monthly active users (p < 0.005). We observed substitution to other social media platforms in the following ways: On mobile, the mean number of hours that Instagram users in the Chronological Feed group spent on TikTok and YouTube increased by 36% (2.19 hours) and 20% (5.63 hours) over the entire study period, respectively (p < 0.05); for Facebook users, time spent on Instagram increased 17% (1.24 hours) (p < 0.05). For browser usage, we detected no change among Instagram users, but the average number of visits by Facebook users to reddit.com and youtube.com increased in the Chronological Feed group by 52% (16.2 visits, p < 0.005) and 21% (50.1 visits, p < 0.05), respectively.

On Facebook, users in the Algorithmic Feed group liked an average of 6.7% of the content to which they were exposed, whereas those in the Chronological Feed group liked 3.1% on average (Fig. 1, B1); the same pattern of lower engagement for Instagram is shown in Fig. 1, B2 (p < 0.005 for likes and comments on both platforms). The Chronological Feed decreased the relative share of content from friends by an average of 24 percentage points on Facebook and from mutual follows (Instagram relationships in which the account a user follows also follows the user's account) by an average of 5 percentage points on Instagram (p < 0.005; Fig. 1, C1 and C2). The Chronological Feed decreased the share of users' networks of friends, Pages, and Groups from which they saw content on Facebook (Fig. 1, D1); the daily share of content from users' mutual follows also decreased on Instagram ($p < 0.005$ for all comparisons) (Fig. 1, D2). All descriptive statistics on time spent, engagement, exposure, network, and substitution are reported in SM section S2.1.

We next turned to our RQ and examined how the chronological ranking affected the mix of content in users' feeds. These effects mostly did not vary by prespecified subgroups, with the exception of one difference that we note below (all subgroup analyses are provided in SM section S2.3). As shown in Fig. 2, Chronological Feeds contained more content pertaining to politics on average than did Algorithmic Feeds, a difference also reflected in political news content on Facebook. The Chronological Feed treatment reduced the share of content from ideologically "cross-cutting" sources on Facebook (18.7 versus 20.7%, $p < 0.005$) and also reduced the share of content from ideologically "like-minded" sources on Facebook (48.1 versus 53.7%, $p < 0.005$); details on the classification of political ideology, which is not available on Instagram, are available in SM section S7. An exploratory analysis suggests that reductions in both like-minded and cross-cutting content on Facebook are offset by increases in content from moderate friends and sources with ideologically mixed audiences (30.9% in Chronological Feed versus 22.6% in Algorithmic Feed, $p < 0.005$). Both the increase in this middle category and the decrease in posts from like-minded sources in the Chronological Feed are larger in magnitude than the decrease in cross-cutting posts, which is arguably consistent with the Algorithmic Feed promoting an "echo chamber" or "filter bubble" effect (*1*).

The largest relative shifts were in the share of content from untrustworthy sources and content classified as uncivil or containing slur words (more details on classification methods are provided in SM section S7). On Facebook, the Chronological Feed increased the share of content from designated untrustworthy sources by more than two-thirds relative to the Algorithmic Feed (4.4 versus 2.6%, $p < 0.005$), whereas it reduced exposure to uncivil content by almost half (1.8 versus 3.2%, $p < 0.005$). Our analysis of effect heterogeneity (SM section S2.3) reveals that adjusted for variable importance, the reduction of incivility was greater among users with larger inventories, which is a proxy for network size. On Instagram, we did not find a meaningful change in the proportion of users' feeds with uncivil content (1.6 versus 1.6%), but we did find an increase in content from untrustworthy sources like that on Facebook, although smaller (1.6 versus 1.3%, $p < 0.005$). The last content category we analyzed was content with slur words, which was extremely rare to begin with on both platforms according to our classification methods (0.03% on Facebook, 0.02% on Instagram) and decreased even further (by approximately one-half) in the Chronological Feed on Facebook (0.019%, $p < 0.005$).

We then turned to tests of our primary hypotheses (Fig. 3, top). Across both Facebook and Instagram, respondents in the Chronological Feed condition did not express significantly lower levels of affective or issue polarization than of those in the Algorithmic Feed condition ($p \approx 1$ in all cases, adjusted for multiple comparisons), meaning that we did not find support for H1. Additionally, there were no statistically significant or substantive differences between the treatment conditions with respect to election knowledge or news knowledge on either platform ($p > 0.63$ for all estimates), meaning that we did not find support for H2. In all cases, we could rule out effect sizes smaller than those found in previous research (*14*).

Our third hypothesis concerns self-reported political participation. Our survey-based measure of participation encompassed forms that occur online (such as signing an online petition), offline (such as attending a protest or rally), or both (such as contributing money to a political candidate). Estimates for the Facebook platform suggest an effect close to zero of the Chronological Feed on this index of self-reported political participation ($p = 1.0$). We also did not find a statistically significant difference in the proportion of users who reported voting in the 2020 election between Algorithmic and Chronological Feed groups on Facebook ($p = 1.0$). On Instagram, there was also no detectable effect on either self-reported political participation ($p = 1.0$) or self-reported turnout ($p = 0.64$). However, using on-platform measures of political engagement—for example, posting or liking content classified as political, sharing that you voted, and mentioning politicians and candidates running for office on social media—we found strong evidence that the Chronological Feed had a negative impact on both platforms (Facebook, −0.117 SD, $p < 0.005$; Instagram, −0.090 SD, $p < 0.005$).

We briefly revisit the possible mechanisms for how feed algorithms could influence this online form of political participation. Our proposed mechanisms pertaining to knowledge and cross-cutting perspectives could not directly be evaluated with our design because these potential mediators occurred post-treatment (*42*). We also could not specifically test our proposed

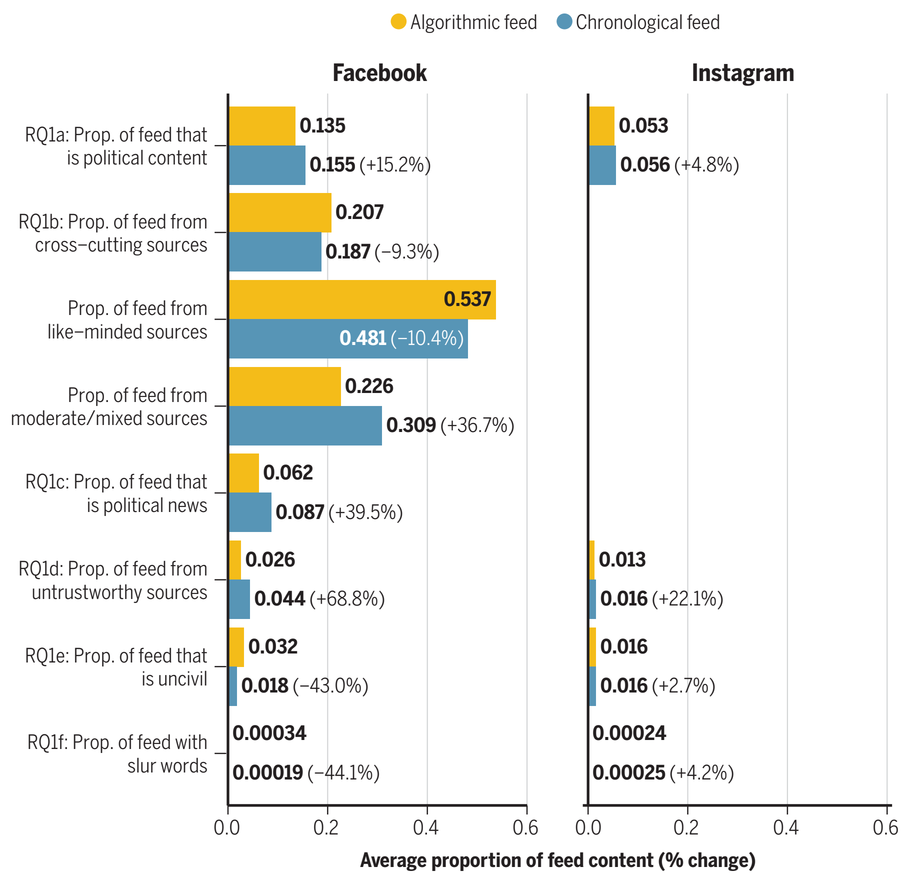

Fig. 2. Estimated changes in prevalence of feed content on both Facebook and Instagram. (**Left**) Facebook. (**Right**) Instagram. Values are average unweighted proportions within each group, with percent changes relative to the Algorithmic Feed control group in parentheses. All differences are significant at the $p < 0.005$ level, except RQ1f for Instagram ($p < 0.05$); confidence intervals are thus not shown. RQ1b and RQ1c were not tested for Instagram because political and ideology classifications are not available on that platform. Fully specified regression models with survey weights are reported in the SM, section S2.2.

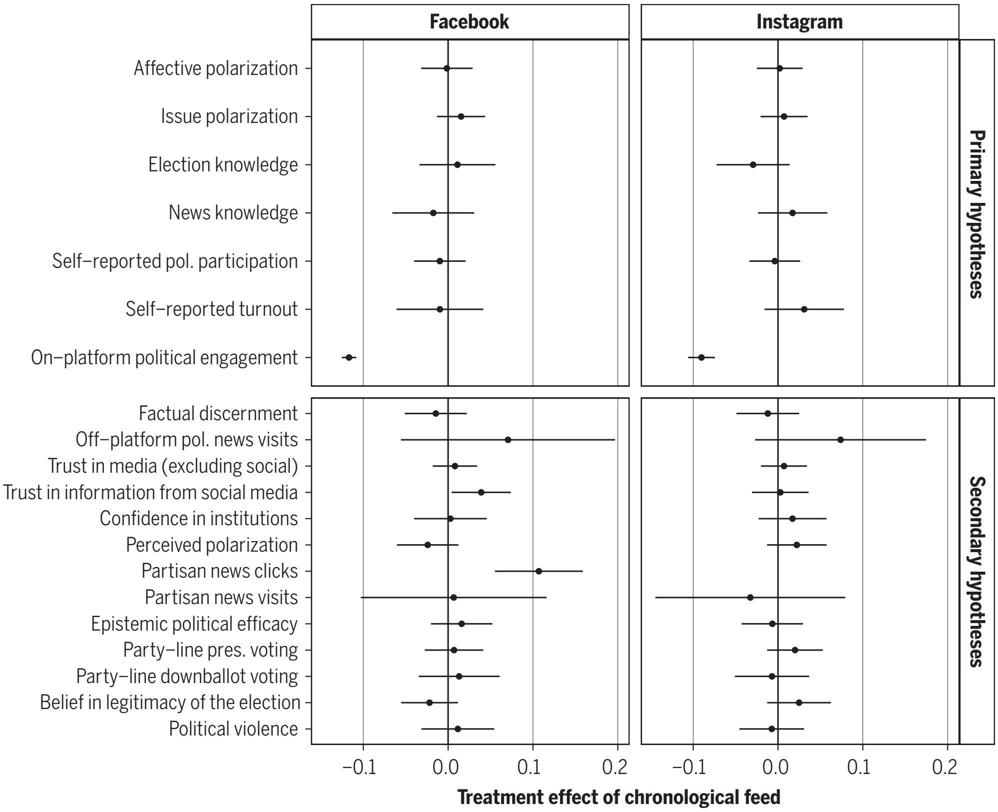

Fig. 3. Population average treatment effects of the Chronological Feed, relative to the Algorithmic Feed control group, on both Facebook and Instagram. (**Left**) Facebook. (**Right**) Instagram. Estimates are presented in standard deviations with 95% confidence intervals (not adjusted for multiple comparisons). Partisan news clicks are estimated only for Facebook because source-level estimates of political ideology are not available for Instagram. pol., political; pres., presidential.

mechanism regarding coordination and information costs of mobilization, which we leave to future research. The remaining mechanism that we proposed was that on-platform participation would decline as a result of an overall drop in online engagement. In SM section S3.2 (tables S82 to S85), we present evidence that decreases in engagement with political content on both platforms are of similar magnitude to decreases in engagement with all content. This is consistent with our analysis of heterogeneous effects, which shows that the decrease in on-platform political engagement is largest among the most active Facebook and Instagram users (SM section S2.3 and figs. S34 and S49).

Last, we tested our secondary hypotheses, which are reported in Fig. 3, bottom. Across nearly all outcomes, we observed no significant differences between the two feed conditions. The treatment does not have statistically distinguishable effects on perceived accuracy of various factual claims, trust in media (either traditional or social), confidence in political institutions, perceptions of political polarization, epistemic political efficacy, belief in the legitimacy of the 2020 election, or political violence. The one exception is that on the Facebook platform, users in the Chronological Feed condition clicked more frequently on political news content from likely partisan sources (0.107 SD, $p < 0.01$). In an analysis that was not preregistered, we found that this was driven by an increase in on-platform exposure to news from the same set of partisan sources (SM section S3.3). Although this may seem inconsistent with our finding that the treatment increased exposure to ideologically moderate or mixed sources, the apparent discrepancy lies in that these latter exposure measures were based on all types of content, whereas our preregistered news clicks measure focused on posts containing political news links only. Given that past research has found that news sources whose audiences are politically homogeneous have lower reliability (*43*), one potential explanation for the difference is that ongoing efforts to down-rank low-quality sources in the algorithmic feed may have reduced exposure to the kind of frequently posted partisan news links that would receive more visibility in a chronological feed.

Discussion

We demonstrated that Facebook's and Instagram's feed-ranking algorithms in late 2020 strongly influenced users' experiences on social media. The Chronological Feed dramatically reduced the amount of time users spent on the platform, reduced how much users engaged with content when they were on the platform, and altered the mix of content they were served—for example, decreasing content from friends while increasing content from Pages and Groups on Facebook. Users saw more content from ideologically moderate friends and sources with mixed audiences; more political content; more content from untrustworthy sources; and less content classified as uncivil or containing slur words than they would have on the Algorithmic Feed. Users also participated less in online forms of political engagement. Beyond these platform-specific experiences, however, replacing existing machine-learning algorithms with reverse-chronological ordering of content did not cause detectable changes in downstream political attitudes, knowledge, or offline behavior, including survey-based measures of polarization and political participation. These findings shed light on prior research as well as folk theories about the effects of social media algorithms on politics and elections (*3*).

There are several possible explanations for the disconnect between the large changes in online behavior caused by our treatment and the few discernible changes in political attitudes, knowledge, and offline behaviors in our user sample. It is possible that such downstream effects require a more sustained intervention period (*44*), although our approximately 3-month study had a much longer duration than that of most experimental research in political communication. Our results may also have been different if this study were not run during a polarized election campaign when political conversations were occurring at relatively higher frequencies, or if a different content-ranking system were used as an alternative to the status quo feed-ranking algorithms. Along these same lines, this study was run in a specific political context (the United States), and the results may not generalize to other political systems. That being said, many of the features of the contemporary United States—such as increased polarization, the rise of populism, and the presence of online misinformation—are present in many other democracies. It is possible that the effects of algorithms could be more pronounced in settings with fewer institutionalized protections (for example, a less-independent media or a weaker regulatory environment). Last, the change to the Chronological Feed affected many aspects of users' experiences on Facebook, Instagram, and beyond—for example, decreasing time spent on the platforms, seeing more content from Groups and Pages rather than friends, seeing more and less of different types of content, and increasing time spent on other social media platforms. These factors may in turn have affected each other and have had differing effects on political attitudes, knowledge, and behaviors, so that in aggregate we did not observe discernible changes.

An additional set of limitations concerns the nature of our design: Our research design provides estimates of direct effects on individuals and as such cannot speak to whether social media shapes societal incentives or influences the behavior of other users. For example, if ranking algorithms affect the demand for certain kinds of content, they could influence the decisions of content producers (such as news organizations), civic organizations, and political campaigns, which would feed back into the inputs of the algorithmic system itself. Even more simply, the Chronological Feed experiences that we studied were composed in part of posts shared by other users not in our sample whose behavior was shaped by the standard algorithmic rankings. Our design thus cannot speak to "general equilibrium" effects. If our randomized intervention (Chronological Feed) were to be scaled up to the population of all users, its impact may differ because algorithmic feedback within networks may generate complex-system dynamics. Future research can examine whether some of the strongest effects uncovered in this study—such as the decreased time spent on platform—mediate the relationship between the Chronological Feed and political attitudes and behaviors.

Despite these limitations, the size of the experimental data we gathered is large. For the primary outcomes, our findings rule out even modest effects, tempering expectations that social media feed-ranking algorithms directly cause affective or issue polarization in individuals or otherwise affect knowledge about po litical campaigns or offline political participation. Although the dependent variables we studied are important for democratic health, they are not exhaustive. Future research should explore whether the kinds of ranking algorithms that we studied can produce substantial effects on other outcomes, such as agenda setting or users' own curation habits (*9*).

To the extent that these findings suggest that social media algorithms may not be the root cause of phenomena such as increasing political polarization (*44*), it raises the stakes for finding out what other online factors—such as the incentives created by the advertising model of social media—or offline factors—such as long-term demographic changes, partisan media, rising inequality, or geographic sorting—may be driving changes that affect democratic processes and outcomes.

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SUPPLEMENTARY MATERIALS

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Materials and Methods
Supplementary Text
Figs. S1 to S58
Tables S1 to S96
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